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Efficiency and Effectiveness of an Innovative RIS Function for Patient Information Reconciliation Directly Integrated with PACS

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Abstract In RIS-PACS systems, potential errors occurring during the execution of a radiologic examination can amplify the clinical risks of the patient during subsequent treatments, e.g., of oncologic patients or of those who must do additional treatments based on the initial diagnosis. In Reggio Emilia Province Diagnostic Imaging Department (REDID) we experienced different strategies to reduce clinical risks due to patient reconciliation errors. In 2010, we developed a procedure directly integrated in our RIS-PACS that uses Health Level 7 (HL7) standard messaging, which generates an overlay with the text "under investigation" on the images of the study to be corrected. All the healthcare staff is informed of the meaning of that overlay, and only the radiologist and the emergency services staff can consult these images on PACS. The elimination of image overlay and of any access limitation to PACS was triggered to confirm of the right correction made by RIS-PACS system administrator (SA). The RIS-PACS integrated tool described in this paper allows technologists and radiologists to efficiently highlight patient exam errors and to inform all the users to minimize the overall clinical risks, with a significant savings in costs. Over the years, we have observed a steady decrease in the percentage of reconciled studies. Error reconciliation requires an effective and efficient mechanism. The RIS-PACS integrated tool described in this paper enables technologists and radiologists to quickly and efficiently highlight patient exam errors and inform all the users. Next generation of RIS-PACS could be equipped with similar reconciliation tools.

Keywords RIS · PACS · Quality assurance · Patient information reconciliation

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Background

Among the various branches and specialties in medicine, diagnostic imaging is perhaps the one that has most benefited from advances in IT over the last few decades. Since the introduction of RIS-PACS, many of the limitations in system evolution that were initially considered as major obstacle, like memory storage capability on RAID, network bandwidth, or image processing performance, have been overcome or have disappeared.

The context in which a PACS system is now part is the element that has significantly changed compared to the initial prospects. Once a simple radiology department information system, PACS has now become a reference "guide" for diagnosis and treatment in almost all hospital units.

This change in perspective means that the “distribution” of “errors of execution” (following the World Health Organization (WHO) error classification, which occur when the correct decisions are made but the execution of the decision is flawed) can amplify and increase the clinical risk for the patients.

The WHO declared in 2000 that “the problem is not bad people; the problem is that the system needs to be made safer” [1]. It was thus necessary to shift the focus away from

the individual providers and their errors to a system-wide perspective. In this new scenario, the implementation of existing standards and the definition of the processes described by IHE Patient Information Reconciliation Profile (PIR) became a reference point [2].

Radiology departments in the past used films and thus a sticker and a pen were enough to correct a laterality error or to correct the misidentification of a patient.

In our digital era, however, the speed and ubiquity of transmission of radiological information to other departments such as operating rooms, has added a critical determinant when the information is affected by errors, incomplete, or unavailable [3–8].

The timely reaction to events represents a key point that can heavily influence the work of clinicians.

In light of this, in 2010, REDID undertook a series of activities and countermeasures aimed to reduce error propagation risks based on the indication in the "Bulletin of the Security Systems RIS-PACS" adopted by of the Emilia-Romagna Regional Health Service (SSR) in 2009.

REDID includes two public healthcare companies: the Azienda Ospedaliera S. Maria Nuova—IRCCS (ASMN-IRCCS) and the Azienda USL (AUSL) of Reggio Emilia. ASMN-IRCCS is a 900-bed regional acute hospital located in Reggio Emilia, Italy. The AUSL has 5 hospital facilities located throughout the province of Reggio Emilia, with a total of 800 beds. REDID performs about 410,000 examinations every year (about 190,000 and 220,000 examinations in ASMN-IRCCS and AUSL, respectively). In Fig. 1, the workload of each hospital is reported in terms of patient type, and in Fig. 2, in terms of acquisition modality.

In ASMN-IRCCS Radiology Department, there are 3 CTs (4, 64, and 128 slices), 3 MRIs (1 T, 1.5 T, and 0.23 T), 4 ultrasound scanners (US), 5 computed radiography (CR) systems, 3 direct radiography (DR) systems, and 4 mammography (MG) units; the AUSL has 5 CTs (4, 4, 6, 16, 32 slices), 3 MRIs (1.5 T, 1.5 T, and 0.4 T), 7 MGs, 7 USs, 12 CR units, and 8 DR units.

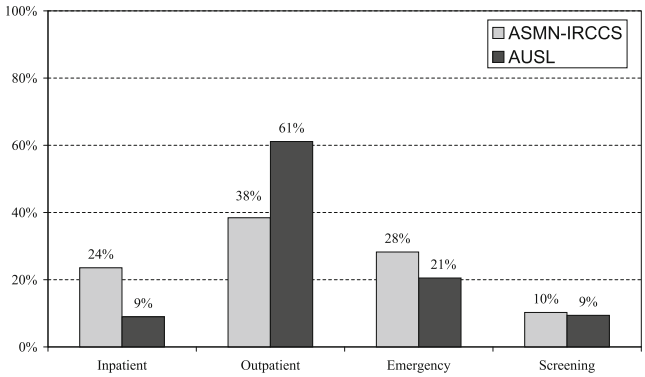

Fig. 1 Percentage of examinations divided by type of patient and by company (ASMN-IRCCS or AUSL). The data refer to year 2011

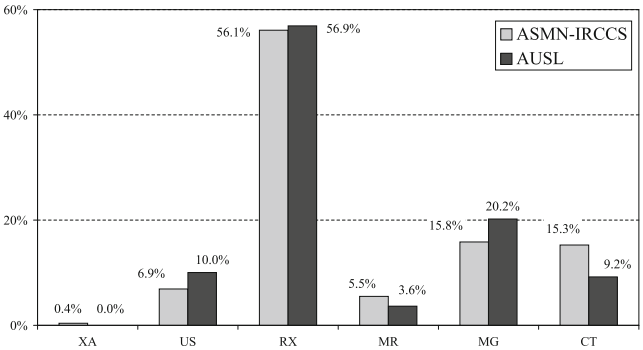

Fig. 2 Percentage of examinations divided by type of modality and by company (ASMN-IRCCS or AUSL). The data refer to year 2011

It is worth noting that in ASMN-IRCCS, outpatients account for 38% of the workload, emergency patients for 28%, inpatients and day hospital patients for 24%, and breast screening patients for 10%. The same workload partition is 61%, 21%, 9%, and 9%, respectively, for AUSL (Fig. 1).

About 60% of these imaging exams, both in ASMN-IRCCS and AUSL, are traditional radiography procedures (RX), digitally acquired with computed radiography (CR), or direct radiography (DR) systems. In ASMN-IRCCS, 15.3% of the examinations is computed tomography (CT) procedures, 10% ultrasound (US), 15.8% mammography (MG), and 5.5 % magnetic resonance (MR) scans. In AUSL, the percentages are 9.2 %, 6.9%, 20.2%, and 3.6%, respectively, as reported in Fig. 2. At ASMN-IRCCS, the relative percentage of exams performed in the morning work shift (from 0730 to 1330), the afternoon shift (from 1330 to 1930), and the night shift (from 1930 to 0730—only for emergency examinations) are approximately 50%, 40%, and 10 %, respectively. For the AUSL, these percentages are 60%, 35%, and 5%, respectively. These data reflect that ASMN-IRCCS is a second-level hospital while those of the AUSL are first-level hospitals.

A. Error Types and Their Relative Clinical Risk

On the basis of our experience, the most common errors that occur in a radiology unit can be categorized in four types (Table 1).

Materials and Methods

A. Reconciliations Request

a. Paper Form (from 2003 to 2006)

Filmless workflow (RIS-PACS) started in 2003 at ASMN-IRCCS; the technologist who discovered an error (e.g.,

Table 1 List of common errors occurring in a radiology unit, with description, level of associated risk, and notes regarding the relative critical issues

No.	Error category	Description	Level of associated clinical risk	Notes
1	Patient personal data variation/merge	The same patient is admitted twice in the system, with 2 different patient IDs assigned to him/her	The risk is medium	The referral needs to be informed in order to re-evaluate patient studies on the basis of integrated (merged) information/studies available. The presence of automatic merge procedure must be carefully assessed and controlled
2	Assign images/study to another patient and episode	Images/studies are associated to another—wrong patient.	The risk is very high	It is important to highlight this in real time to all the users and to fix it as soon as possible in order to prevent any inopportune patient treatment. The referral needs to be informed in order to re-evaluate the image on the basis of previous information/studies available
3	Assign images/study to another episode for the same patient	The image sent to PACS is referred (accession number) to the wrong episode/access	The risk is high	It is important to highlight this in real time to all the users and to fix it as soon as possible. The referral needs to be informed in order to re-evaluate the image on the basis of previous information/studies available
4	Wrong image projection/laterality	The image sent to PACS is not properly identified in terms of laterality or projection type (e.g., the AP instead of PA)	The risk is very high	It is important to highlight this in real time to all the users and to fix it as soon as possible in order to prevent any inopportune patient treatment.

patient misidentification) filled out a paper form made available by RIS-PACS system administrators (SA).

The filled-out form was left in a mailbox and periodically picked up by the SA, who subsequently proceeded to perform the task of reconciliation requested and then filed the form in the archive.

The SA was present from 0800 to 2000 from Monday to Friday and from 0800 to 1400 on Saturdays.

There was no feedback control on the activities performed (e.g., checking if the new patient identification/reconciliation was really correct or performed as requested).

It was not possible to point out in real time or to highlight the error to clinicians who consulted the images under reconciliation on the PACS.

The yearly cost of this service was 200,000 € (VAT excluded), which included fees related to the training of users.

b. Intranet Request (from 2006 to 2010)

In 2006, with the start up of AUSL's PACS, the reconciliation requests were computerized, using Microsoft Windows® SharePoint Services. A digital form was published on the hospital intranet; when a technologist discovered a patient misidentification, he/she filled out this form after logging into the intranet with his/her hospital's user credentials.

The platform used was RIS-PACS-independent and consequently the electronic form needed to be filled out manually.

The completed form was immediately available to the SA, who subsequently proceeded to perform the task of reconciliation requested. The SA was present from 0800 to 2000 from Monday to Friday and from 0800 to 1400 on Saturdays.

The workflow involved e-mail messaging. E-mails were sent:

- to the applicant when the request was inserted—"ticket request"
- to the SA (the e-mail contents with the request detail—a link to the filled-out form)
- to support services (e.g., users responsible for reports and iconographic CDs provided to the patient)
- to the applicant at the end of SA activities, in order to check the corrections made.

The reconciliation activity was considered closed once the feedback control was carried out by the applicant.

As in the previous case, it was not possible to point out in real time or to highlight the error to clinicians over the PACS.

The yearly cost of this service was 140,000 € (VAT excluded).

c. RIS/PACS Integrated Request (from 2011)

In 2010, during the RIS-PACS project update, a reconciliation request tool was integrated directly into the RIS and PACS (using RIS-PACS standard HL7 messaging).

The technologist who discovers a patient misidentification can fill out a reconciliation request form directly on RIS "with just a click of the mouse" on the study that needs to be corrected.

The technologist, after having highlighted the exam study requiring reconciliation, can open a request page that

already contains the data referring to the study selected; the technologist can then choose the type of error and complete the form with the correct data. Finally, the technologist confirms the request with his/her credentials, and can opt to specify the person who can confirm whether the correction made by the SA was successful.

The reconciliation request confirmation triggers an event (via HL7) on the PACS, which generates an overlay on the images of the study to be corrected. The overlay shows the text "under investigation." All healthcare staff has been informed about the meaning of that overlay. The request application also involves that accessibility and viewing limits be applied to the study under investigation: these images can be consulted on PACS (the overlay "under investigation" is continuously present) only by the radiology, emergency, and operating room staff.

The request is immediately available to the SA on the RIS, who subsequently proceeds to carry out the task of reconciliation requested. The SA is present from 0800 to 1400 from Monday to Saturday. From 1400 to 0800 the next working day, the requests remain in the state to be taken over by the SA.

On the RIS, the study under investigation remains branded/marked with a symbol (a wrench) in different colors:

- red, if the examination is under reconciliation (the request must still be taken over by the SA);
- yellow, if the correction made by the SA is waiting confirmation from the applicant;
- green, if the study has been reconciled by the SA and the correction validated by the applicant.

The reconciliation activity is considered closed once feedback control has been carried out by the applicant or his/her delegate. This final event (applicant confirmation of the correctness of operations made by the SA) triggers the elimination of the images overlay and any access limitation on PACS. The yearly cost of this service is 85,000 € (VAT excluded).

In addition, it is worth noting that our region has introduced an incident reporting procedure starting from February 2012. The reconciliation requests made on the RIS represent the starting point for the incident reporting form compilation.

Results

A. Percentage of Reconciled Studies

Table 2 reports the number of examinations stored on PACS in ASMN-IRCCS and AUSL and the percentage of reconciled studies (indicated as "% reconciliation" calculated as the ratio between the number of reconciliation requests and the number of examinations stored) from 2008 to 2011.

Figure 3 shows the descending trends in the percentage of reconciled studies for ASMN-IRCCS and AUSL (all the hospitals).

B. Error Type Distributions

Table 3 reports the error type distributions of ASMN-IRCCS and AUSL (year 2011). The relative error type distribution for the two companies is quite similar and the most frequent error is wrong image projection/laterality selection (Fig. 4).

C. Time Elapsed Between the Reconciliation Request and Error Correction

Table 4 and Fig. 5 report the median time elapsed between a reconciliation request and its execution (SA correction), referring to the intranet request (year 2008) and the RIS/PACS-integrated request (year 2011) for each error type: the weighted average times (for all the types of error requests) are 12.4 and 13.7 h, respectively.

Table 2 The number of examinations stored on PACS and the percentage of reconciled studies in ASMN-IRCCS and AUSL from 2008 to 2011

Healthcare company	Hospital	2008		2009		2010		2011	
		# exams sent to PACS	% reconciliations	# exams sent to PACS	% reconciliations	# exams sent to PACS	% reconciliations	# exams sent to PACS	% reconciliations
AUSL	Castelnovo ne' Monti	30,213	0.52%	31,641	0.43%	30,527	0.39%	30,646	0.35%
	Correggio	30,675	0.60%	32,792	0.52%	30,498	0.28%	31,394	0.25%
	Guastalla	52,207	0.48%	53,480	0.36%	53,359	0.29%	54,339	0.27%
	Montecchio	41,961	0.73%	43,043	0.65%	43,117	0.51%	46,345	0.41%
	Scandiano	43,939	0.54%	45,677	0.53%	46,402	0.43%	48,782	0.33%
	All hospitals	198,995	0.58%	206,633	0.50%	203,903	0.38%	211,506	0.32%
ASMN-IRCCS	ASMN	147,867	0.38%	151,274	0.36%	150,308	0.34%	154,620	0.29%

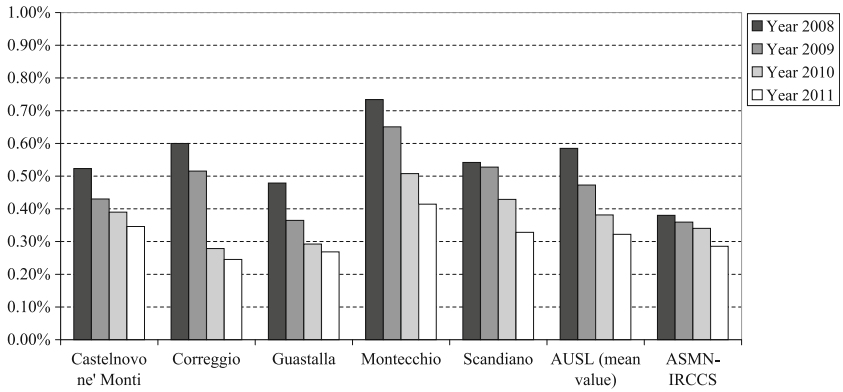

Fig. 3 Descending trend of the reconciliation requests for ASMN-IRCCS and AUSL (all the hospitals and mean value) from 2008 and 2011

D. Incident Reporting

In the first 8 months of 2012, the REDID filled 103 incident reporting forms. Among these, 28 events were related to errors due to events for which there were a reconciliation request on the RIS. All of them were attributable to errors of category (as defined in Table 1) # 2 (5) and # 4 (23). The 28 events highlighted produced results of "minor nonconformity" (intended as a not adversely affect—only registered) in 16 cases, and "near miss" events (unplanned event that did not result in injury, illness, or damage) in 12 cases.

Discussion

A. Percentage of Reconciled Study

The percentage of requests for reconciliation (Table 2) was of the same order of magnitude for both smaller hospitals that hospitals for medium to large size, even with respect to instrumental equipment articulated, complex, non-homogenous, or not always in the state of the art.

The descending trends (Fig. 3) of this percentage could indicate that the learning curve of a digital workflow has improved over the years.

ASMN-IRCCS Hospital, which inaugurated PACS in 2003, has a decreasing trend in the error reconciliation percentage (relative to last 4 years), while that of the AUSL is less evident, though constant.

Table 3 Error type distributions of ASMN-IRCCS and AUSL in 2011

Error category distribution (year 2011)	ASMN-IRCCS	AUSL
Patient personal data variation/merge	9.9%	11.9%
Assign images/study to another patient and episode	12.7%	14.3%
Assign images/study to another episode for the same patient	10.6%	11.9%
Wrong image projection/laterality	66.7%	61.9%

In 2010, the decrease in the Correggio Hospital's percentage of reconciled studies was probably due to the transfer of its radiology department to a new facility equipped with almost entirely new image acquisition equipment.

On the basis of our experience, a reasonable indicator of "good practice" is assumed to be a percentage of reconciled studies ranging from 0.2% to 0.3%. Further multicentric studies are needed in order to confirm this assumption.

B. Errors Type Distribution

The most frequent error is wrong image projection/laterality selection, accounting for two thirds of all the errors. A more detailed analysis could be conducted in order to determine the proportion of laterality errors and projection selection errors.

The risk related to this type of error is very high; when wrong patient image assignment error is added, the errors that can lead to a high clinical risk are about the 80% of total errors.

The need for a real-time highlight to all the users who consult images and reports, along with rapid error correction, is essential and needs to be integrated and systemic.

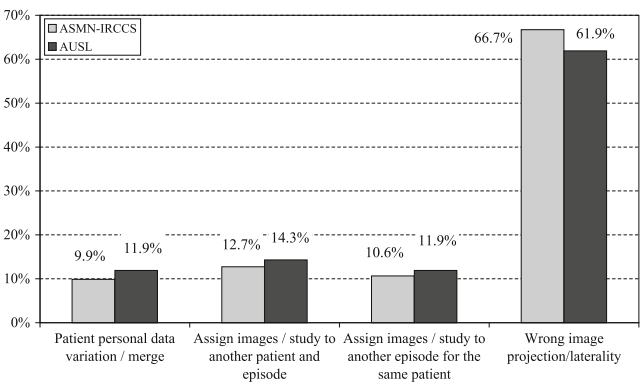

Fig. 4 Percentage of distribution of errors for the different types in the two Healthcare companies (ASMN-IRCCS and AUSL)

Table 4 Time elapsed between the reconciliation request and the error correction for the different category error

Error category	Request execution time (hh:mm) vs modality		Variation	
	RIS-PACS Integrated	Intranet	h:mm	%
Patient personal data variation/merge	14:42	12:59	1:43	12%
Assign images/study to another patient and episode	14:42	13:15	1:27	10%
Assign images/study to another episode for the same patient	14:59	11:18	3:41	25%
Wrong image projection/laterality	7:42	5:42	2:00	26%
Weighted average	13:40	12:24	1:15	9%

C. Time Elapsed Between Reconciliation Request and Error Correction

The correction times for RIS/PACS integrated solution are longer than those of the intranet-based request procedure: this is clearly dependent on the different service delivery of PACS System Administrator, better described in the "Materials and Methods" sections.

It is worth noting that even if the onsite presence of the SA decreased from 12 to 6 h a day, the differences in the time elapsed between the reconciliation request and the error correction did not reflect an equally significant decrease (about 10% in weighted average times). This might be explained by multivariate factors, including the different workload distribution in daily work shifts (hospital/radiology department activity is mostly concentrated in the morning, when the SA is on site).

For the RIS/PACS integrated request system, the main advantage is the timeless propagation of error notification to the PACS system and, therefore, to all potential users. Further, the medical–legal implication of the RIS/PACS integrated solution is that it allows complete traceability of the error (including operator responsibility), starting from its discovery/recognition to its management, and to its correction/solution.

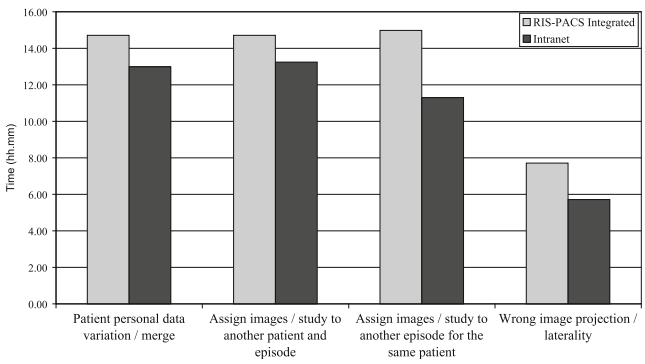

Fig. 5 Median time elapsed between a reconciliation request and its execution for the two approaches: the new RIS-PACS integrated (year 2011) and former intranet-based form (year 2008)

D. Incident Reporting

The RIS integrated reconciliation requests represents the starting point for managing errors and monitoring relative trends, but also promoting initiatives for improvement for the staff members activities. The timely indication of errors directly on the PACS prevents error in patient treatment as could be demonstrated by the outcome of incident reporting analysis mentioned above. Further analysis on a larger dataset should be conducted to corroborate this assumption. The economic aspects arising from the costs of a different onsite availability of the SA could represent a not negligible target.

Conclusion

In our digital era, the transmission speed of radiological information to other departments outside the radiology department and the hospital limits has become a critical factor when the information is affected by error or is incomplete or unavailable.

The current speed of information propagation, including that of errors, requires immediate and effective counteraction to safeguard the availability and consistency of clinical information. A timely response to events is therefore mandatory, as it can heavily influence the work of clinicians, and thus potentially result in incomplete or inappropriate therapy. This risk may be more critical for cancer patients in particular, and for all those patients who must undergo additional treatments based on the initial diagnosis.

Error reconciliation requires an effective and efficient mechanism. The RIS-PACS integrated tool described in this paper enables technologists and radiologists to quickly and efficiently highlight patient exam errors and inform all the users. Further, over the last 7 years, in our experience the evolution of error reconciliation tools has led to significant savings. This multifunctional approach via integrated electronic form is more convenient, provides an audit trail, and captures the event and relevant timestamp that permit and provide documentation. Ideally, the next generation of RIS-PACS could be equipped with similar reconciliation tools, to

be realized in a smart and truly integrated way using the communication standards available.

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References

1. The World health report 2000 - Health systems: improving performance. Available at http://www.who.int/entity/whr/2000/en/whr00_en.pdf. Accessed 14th July 2012
2. IHE Technical Framework, Volume I, Integration Profiles. Available at http://www.ihe.net/Technical_Framework/upload/ihe_tf_rev8.pdf. Accessed 14th July 2012
3. Golfieri R, Pescarini L, Fileni A, Silverio R, Saccavini C, Visconti D, Morana G, Centonze M: Clinical Risk Management in radiology. Part I: general background and types of error and their prevention. Radiol Med 115:1121–46, 2010
4. Centonze M, Visconti D, Doratiotto S, Silverio R, Fileni A, Pescarini L, Golfieri R: Clinical Risk Management in radiology. Part II: applied examples and concluding remarks. Radiol Med 115:1147–64, 2010
5. Lobo-Stratton G, Mercer T, Polman R: Patient exam data reconciliation tool. J Digit Imaging 19:60–5, 2006
6. Reiner BI: Medical Imaging data reconciliation, Part 1: Innovation Opportunity. J Am Coll Radiol 8(9):622–5, 2011
7. Reiner BI: Medical Imaging Data Reconciliation, Part 2: Clinical Order Entry and Imaging Report Data Reconciliation. J Am Coll Radiol 8(9):720–4, 2011
8. Reiner BI: Medical Imaging Data Reconciliation, Part 3: Reconciliation of Historical and Current Radiology Report Data. J Am Coll Radiol 8(9):768–71, 2011