J Digit Imaging (2016) 29:425–427
DOI 10.1007/s10278-016-9860-6

# Notification System to Address PACS Filter Deficiencies and Ensure Timely Interpretation of Neonatal Exams

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Published online: 19 January 2016


**Abstract** Filtered radiology worklists can result in exams that slip through the cracks and do not get interpreted. We discovered an error that caused neonatal exams to not be displayed on our worklists, and therefore, these exams were not interpreted in a timely fashion. Because of familiarity with our departmental data, we were able to rapidly build a notification tool to alert us to these exams. This tool resulted in clinically significant impact on interpretation turnaround time and care of neonates in our hospital.

**Keywords** PACS · Clinical application · Data extraction · Health level 7 (HL7) · Quality assurance · Quality control · Radiology workflow

## Background

Many radiology departments use a Picture Archiving and Communication System (PACS)-driven workflow where exams are opened for interpretation from a worklist provided by the PACS. A variety of filters can be implemented to provide a custom worklist that is relevant for a section or even an individual radiologist. There has been little formal documentation in the literature specifically describing errors that can result from implementation of these filters, but any PACS administrator knows it is critical to ensure that such filters used in a radiology department provide coverage over all performed exams such that all exams performed are interpreted. Indeed, many authors have described efforts to monitor undictated and unsigned reports which indicate that exams can and do slip through the cracks, in some cases likely due to PACS filtering [1–4].

Recently, the pediatric radiologists in our department discovered a critical issue in our PACS-driven workflow. Exams performed on neonates the same day of birth were not displayed on pediatric worklists that were filtered by age. This resulted in some embarrassing situations where priority exams ordered on neonates were not addressed in a timely manner, and only after referring clinicians called requesting a report. To our knowledge, there was no significant impact on clinical care or a change in clinical outcome as a result, but it is easy to imagine how this might have occurred. We were not able to quickly correct what we felt was a critically important error in the PACS interface, so we implemented our own notification solution to alert our radiologists to these exams.

## Methods

Our study was exempted from review by our Institutional Review Board.

We currently receive a real-time Health Level 7 (HL7) feed from our Radiology Information System (RIS) (Siemens) [5] of all information relevant to our radiology departmental workflow on a secure server using Mirth Connect (Mirth Corporation) [6] as our HL7 engine. This data is utilized in various forms for quality improvement, operational analytics, workflow improvement, educational tools, and research.

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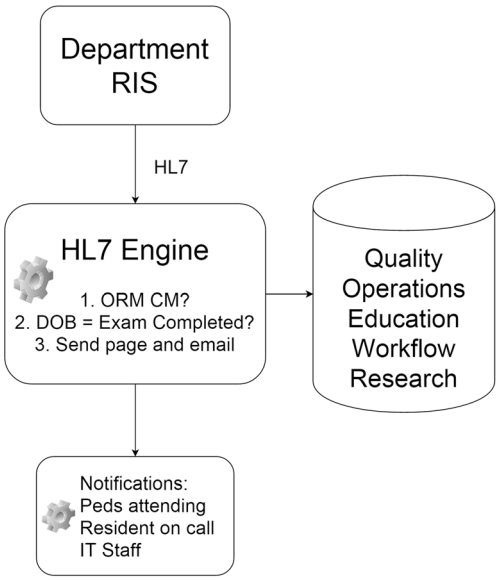


**Fig. 1** Logic introduced to departmental HL7 message flow to create newborn notification tool

Included in this data are exam status and completion information as well as relevant patient demographics.

We can then filter for exam completion (ORM CM) messages and within that subset look for exams that were completed on the same day as the patient's date of birth. We developed a Mirth Connect channel within a matter of hours that identified these messages and then made a system call to send pages and emails via a Bash (Gnu) [7] script to our pediatric radiologists, our resident on-call pager, and several of our IT staff to help ensure the completed neonate exam would be interpreted in a timely manner (Fig. 1).

After implementation, we analyzed turnaround times, as defined by time from exam completion to radiologist report, for these exams before and after intervention using custom MySQL (Oracle) [8] queries with web-based visualization using the Sinatra Ruby-based library [9] and the Highcharts Javascript library [10].

## Results

We analyzed final turnaround time (time from exam completion to final report) for neonates who had exams completed on the same day of birth between March 2012 and June 2015 and graphed these as a scatter plot over time (Fig. 2). On initial evaluation of all turnaround times, we did not notice any major changes after the implementation of our tool. However, we realized that this was confounded by several factors that likely masked any improvement: our residents use a worklist overnight that is not based on age and therefore is not vulnerable to this filtering error; final turnaround times for exams read at night do not accurately reflect how quickly a resident preliminary report was generated; and final turnaround times for exams read overnight commonly, and expectedly, range up to 12–15 h as our residents provide evening and overnight coverage while our attendings are not in-house at all times.

We then focused on only those exams read by an attending pediatric radiologist without the assistance of a resident as those pediatric attendings typically use an age-based filter to focus only on pediatric patients (Fig. 3). For this analysis, the turnaround time was initially quite low overall, ranging from 4 to 193 min, until April 2013 when there was an abrupt increase in turnaround times as high as 1093 min (18 h). In retrospect, we realized this coincided with a major PACS upgrade performed in the spring of 2013 which we now believe introduced the age-filtering error. After the implementation of our notification tool in May 2014, most turnaround times improved dramatically and immediately back to near baseline below 200 min as compared to before our PACS upgrade. We did notice a

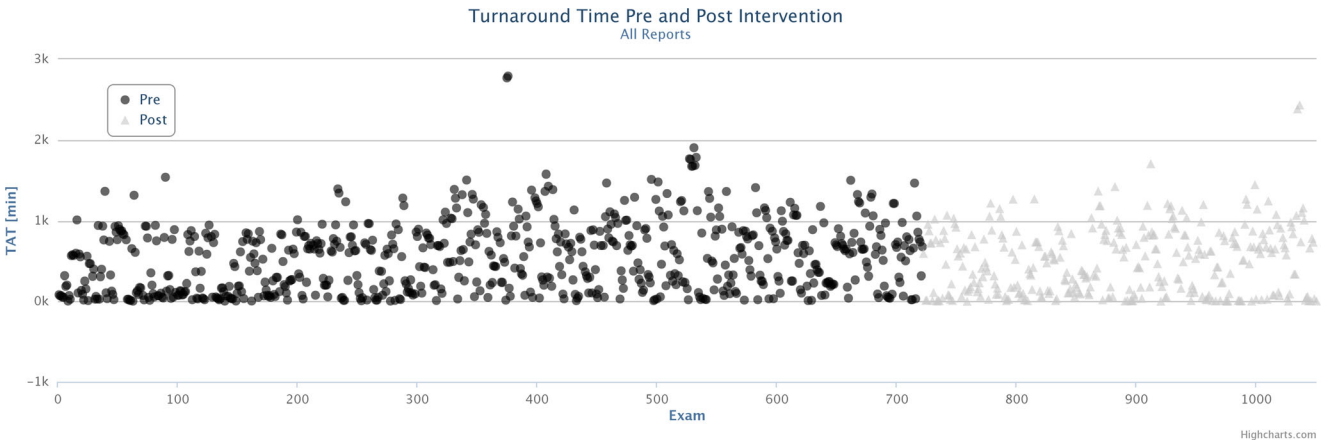


**Fig. 2** Final turnaround time (exam completion to final report) for neonates who had exams completed on the same day of birth between March 2012 and June 2015

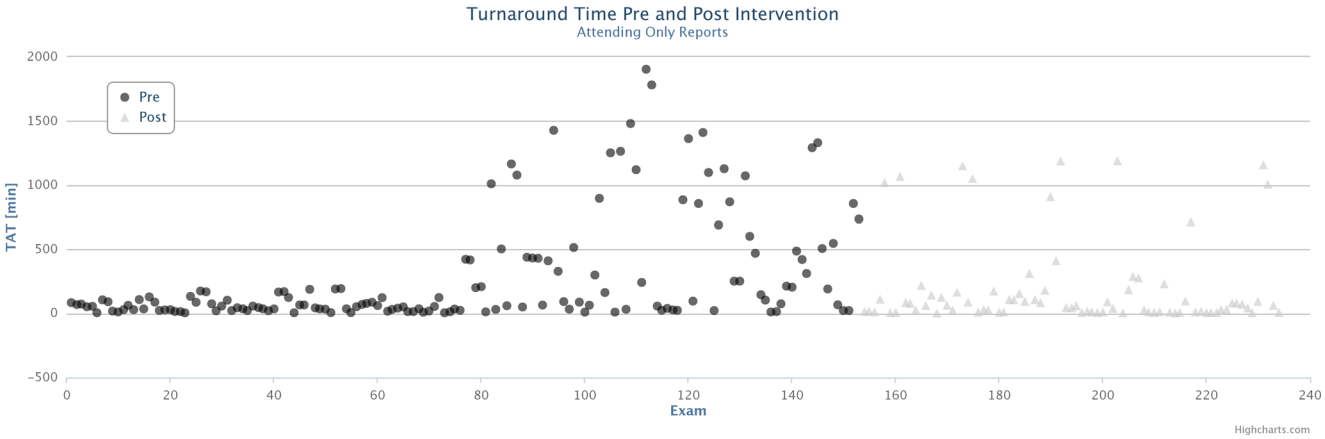


**Fig. 3** Final turnaround time (exam completion to final report) for neonates who had exams completed on the same day of birth between March 2012 and June 2015 limited to reports generated by attending radiologists only

few persistent outliers after our implementation with turnaround times at or above 1000 min, which upon further analysis were revealed to be associated with several of our radiologists that did not typically provide pediatric coverage and who were not included in the first version of our notification system. Because of the initial success and high satisfaction of our system, we added these radiologists and plan to continue to use the system indefinitely or until the PACS filtering error is corrected.

## Discussion

Having access to and familiarity with our departmental data allows us to create helpful tools for a variety of purposes and importantly allows us to improve our workflow with clinically significant impact. We were able to create a notification system in a matter of days that importantly and positively impacted our ability to serve an important and vulnerable population, namely neonates, and the referring clinicians taking care of these patients. Such tools can substantially augment a radiology department's existing vendor supported technology.

## Conclusion

We developed a notification system that alerted us to exams missed on an age-based PACS filter and have demonstrated significant and positive clinical impact to a vulnerable population as a result.

**Acknowledgments** Patty Cantillon, Cirrelda Cooper, M.D., Earn-Chun Christabel Lee, M.D., Frank Volberg, M.D., and the Georgetown Radiology residents who utilized these notifications.

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