This is the peer reviewed author accepted manuscript (post print) version of a published work that appeared in final form in:

Jabin, Md Shafiqur Rahman, Magrabi, Farah, Hibbert, Peter, Schultz, Tim, Runciman, William 2019 'Identifying and classifying incidents related to health information technology in medical imaging as a basis for improvements in practice', IST 2019 - IEEE International Conference on Imaging Systems and Techniques, Proceedings, article no. 9010109, pp. 1-6

This un-copyedited output may not exactly replicate the final published authoritative version for which the publisher owns copyright. It is not the copy of record. This output may be used for non-commercial purposes.

The final definitive published version (version of record) is available at:
https://doi.org/10.1109/IST48021.2019.9010109

Persistent link to the UniSA Research Outputs Repository:
https://researchoutputs.unisa.edu.au/11541.2/141964

General Rights

Copyright and moral rights for the publications made accessible in the UniSA Research Outputs Repository are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognize and abide by the legal requirements associated with these rights.

- Users may download and print one copy for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the persistent link identifying the publication in the UniSA Research Outputs Repository

If you believe that this document breaches copyright, please contact us and provide details. We will remove access to the work immediately and investigate your claim.

Identifying clusters and themes from incidents related to health information technology in medical imaging as a basis for improvements in practice

Md Shafiqur Rahman Jabin
Australian Centre for Precision Health
University of South Australia
Adelaide, Australia
rahmy027@mymail.unisa.edu.au

Farah Magrabi
Australian Institute of Health Innovation
Macquarie University
Sydney, Australia
farah.magrabi@mq.edu.au

Peter Hibbert
Australian Institute of Health Innovation
Macquarie University
Sydney, Australia
peter.hibbert@mq.edu.au

Tim Schultz
Adelaide Nursing School
University of Adelaide
Adelaide, Australia
tim.schultz@adelaide.edu.au

William Runciman
Australian Centre for Precision Health
University of South Australia
Adelaide, Australia
william.runciman@unisa.edu.au

***Abstract*— Beyond identifying and counting the things that go wrong, understanding how and why they go wrong requires qualitative research, especially for low-frequency events. The purpose of this study was to identify and characterize patient safety and quality issues related to health information technology (HIT) in medical imaging by collecting and analyzing incident reports through the lens of thematic analysis. In this article, we analyze 5 clusters: staff related issues (16%), issues with diagnosis (15%), HIT incidents that involved "paper record" (12%), information and communication related (4%), and "action taken" related issues (4%). Human factors involved people failing to scan forms into the computer system (consents, requests, bookings, questionnaires, assessments, treatments and prescriptions), and another 4% involved failure to enter verbally imparted information into the system (about infectious patients, cancelled cases, and the status of reports). All of these problems had their genesis in human errors and violations. Human factors were found to cause more deleterious effects than technical factors. Of three instances of deaths caused by diagnostic issues, two were triggered by human factors, missed diagnosis. However, "staff or organizational outcome" was evenly distributed for both human and technical factors. It was therefore important to identify and characterize these incidents related to health information technology in medical imaging through the lens of thematic analysis, to provide a basis for improvements in preventing issues and improving clinical practice.**

Keywords—*medical imaging, health information technology, incident reports, thematic analysis, safety and quality*

I. Introduction

Safety and quality are now on the agenda of modern healthcare systems. The costs of healthcare associated harm are not only an economic burden, but also manifest as individual suffering and harm to society as a whole. Healthcare facilities aspire to being "high reliability organizations" [1]; incident reporting systems, which allow healthcare personnel to report adverse events and near misses to provide information for improving the safety and quality of care, comprise one approach to realizing these aspirations [2].

Medical imaging, although a vital part of healthcare, also is susceptible to substantial risks to the safety and quality of care, which may be difficult to foresee due to rapid change and high reliance on modern technology. Communication breakdowns, heavy workloads and system complexity, all contribute to the likelihood of safety and quality problems [3].

There is evidence that health information technology (HIT) can cause quality and safety problems if poorly designed, implemented or managed. HIT has recently been implicated as one of the major problems by the US Food and Drug Administration (FDA) [4] and England's National Programme for IT (NPfIT) [5]. However, HIT is also a crucial and integral part of medical imaging that has now been widely deployed.

Capturing information after something has gone wrong, for example, from incident reports, allows the types of things that go wrong to be identified and characterized, with their human and system-based contributing factors, paving the way for preventive and corrective strategies to be devised.

II. The Need for Qualitative Research

Beyond identifying and counting the things that go wrong, understanding how and why they go wrong requires qualitative research, especially for low-frequency events. Collecting qualitative data about things that go wrong, in the form of free narrative or anecdotes, allows: understanding of their context within healthcare; identification and analysis of associated risks; identification of contributing factors, trends and patterns; and the development of preventive and corrective strategies [6]. There are two broad approaches to analyzing free narratives – a deductive approach which involves classifying the key aspects of a story by fitting them to existing frameworks, and an inductive approach which involves extracting themes identified in the narratives and then categorizing them and determining the relationships between them [7].

Qualitative research allows us "to understand and represent the experiences and actions of people as they encounter, engage, and live through situations" [8], and may allow hypotheses to be developed for testing by quantitative research [9]. Qualitative research is indicated when very little information is provided or known about the topic for analysis – often because the events in question occur infrequently, or if there is a need for a flexible, practical method for data collection and analysis. Some of the attributes of using a qualitative approach in incident analysis have been summarized by Runciman in 2002.

The purpose of this study was to identify and characterize patient safety and quality issues by collecting and analyzing medical imaging incident reports, with a particular focus of HIT through the lens of clusters of medical imaging incidents from three sets of medical imaging incident reports (craft-based, hospital-based and staff-based).

III. Methods

We identified sources of information about things that had gone wrong in relation to medical imaging. These comprised two sets of pre-existing voluntary incident reports and convenience samples of interviews with radiology staff.

The free-text narratives from 4,963 incident reports and 100 interviews were collected; 4,915 were included for analysis and 48 were excluded. Inclusion criteria were that they involved medical imaging and had patient safety or quality implications. Exclusion criteria were inadequate details for coding or no free text description. For example, if an incident could not be classified into at least one incident type, it was excluded.

A special targeted search was undertaken using a set of keywords and an algorithm for identifying health information technology (HIT) related incidents. In total, 436 HIT related incidents were identified.

After deductive analyses – fitting the information into three frameworks for classifying and coding in accordance with the International Classification for Patient Safety (ICPS) and the 18 steps, and health information technology classification system (HIT-CS), the incidents were subjected to inductive analysis. The deductive analyses are beyond the scope of this study.

Apart from the deductive analyses using existing frameworks (the ICPS, the HIT-CS and the 18 steps) inductive analysis was used to extract additional information about the HIT incidents. Inductive analysis comprised familiarization with the narratives, and then highlighting and extracting any potentially relevant concepts, as represented by keywords and phrases. Then, categories from the ICPS, HIT-CS and workflow process were examined to check that the concepts identified did not fall under any of these frameworks. The list of new concepts was then examined to identify broader patterns (themes). The next phase of inductive analysis involved reviewing these themes to check if they made sense and grouping them wherever possible under parent themes. Most of these parent themes were then further grouped into clusters [7]. The thematic analysis for the 436 HIT incidents was performed by MSRJ, and 10% (n=44) was cross- checked by WR. Results were tabulated using the frequency of occurrence of each cluster identified.

IV. Results

Apart from the deductive analyses using existing frameworks (the ICPS, the HIT-CS and the 18 workflow steps) thematic analysis was used to extract additional information about the HIT incidents. In all, 1194 keywords or phrases were extracted from the 436 incident reports which described potentially relevant concepts. These concepts were grouped into 206 themes, which were further grouped into 48 parent themes. Parent themes of similar nature were further grouped into 13 clusters; some (5) single parent themes stood alone and were considered along with the clusters (incidents affecting multiple patients, issues with diagnosis, types of examination, miscellaneous, and treatment venue) [10]. Of these 13 "clusters", 8 are listed in Table I, and 5 are discussed in more detail. We cross-checked incidents (n=44; 10%) and demonstrated good interrater coding agreement for the thematic analysis.

The clusters of incidents that are discussed further are listed in Table I. A single incident may contain more than one cluster (or theme). The frequency of each cluster was calculated with the 436 HIT incidents as the denominator.

In this article, we are going to discuss the clusters of staff related issues, issues with diagnosis, HIT incidents that involved "paper record", information and communication related, and "action taken" related issues. Other clusters are beyond the scope of this article.

TABLE I. Clusters (extracted from thematic analysis) included for discussion

Clusters included for discussion	**n**	**%**
Issues with patient details	132	30
Incidents affecting multiple patients' management	105	24
System issues	92	21
Staff related issues	70	16
Issues with diagnosis	65	15
HIT incidents that involved "paper record"	54	12
Information or communication related	15	4
"Actions taken" related	15	4

A. Staff Related

This cluster was associated with a theme of staff related outcomes (Table I). The theme 'type of cluster' does not bear any important information in terms of HIT incidents. "Staff confusion" was associated with a few other themes, such as issues with patient details and diagnosis. For example, confusion about same name or date of birth of two patients led to a staff member making a wrong entry. A couple of incidents reported that staff found clinical notes confusing and they could not proceed with patient care.

Six incidents described that the radiology professionals were 'not aware' of system issues, such as PACS malfunction. Five incidents described that the staff 'could not locate' documents required because of a system issue. Four incidents described that radiology professionals, such as

radiographers and radiologists, were frustrated because of not being able to see images or report results.

B. Issues with Diagnosis

HIT incidents related to issues with diagnosis accounted for 15% (n=65) of the 436 HIT incidents (Table I), of which 63% (n=41) comprised 'delayed diagnosis' (Table II). Incidents related to diagnosis triggered by HIT systems had significant impacts on patient care; and were associated with three patient deaths. Examples of each type of diagnostic incident are given in Table III; the deaths were described in Table IV.

TABLE II. TYPES OF INCIDENTS RELATED TO DIAGNOSIS AND THEIR FREQUENCIES

Diagnosis	**n**	**%**
Delayed diagnosis	41	63
Misdiagnosis	13	20
Missed diagnosis	11	17
Total	65	

TABLE III. TYPES OF INCIDENTS RELATED TO DIAGNOSIS AND THEIR RELEVANT EXAMPLES

Diagnostic incidents	**Examples**
Delayed diagnosis	Significant lag and inability to produce reports due to 2 CT computers not working caused delayed diagnosis.
Misdiagnosis	Issue with the Dictaphone resulted in not picking the word "no" because the radiologist reported 'no evidence of large volume pneumoperitoneum on a supine film', but the final report was typed as 'evidence of large volume pneumoperitoneum on a supine film'- therefore resulting in a misdiagnosis.
Missed diagnosis	Inability to see pneumothorax for chest x-ray on lower resolution computer by the ICU consultant, resulting in a missed pneumothorax.

TABLE IV. EXTRACTS FROM EACH PATIENT DEATH DUE TO ISSUES WITH DIAGNOSIS FOR HIT INCIDENTS

Issue (death)	**Examples**
Missed diagnosis	Apparent renal colic patient seen in ED. Pain settled and booked for CT of kidneys, ureters and bladder. No report ever received, although carcinoma of a kidney had been seen on the images. Nephrectomy at another hospital 9 months later. The patient died.
Delayed diagnosis	A patient had headaches/tenderness over frontal & maxillary sinuses and was scheduled for CT examination. It was postponed to next day due to technical problems with equipment. The patient died the next day from cerebral craniopharyngioma.
Missed diagnosis	ED consultant and registrar only detected the calculus - on the side of the patient's pain - and missed the tumor. Radiologist reported the tumor but failed to alert ED staff of additional abnormal findings on the side opposite to patient's presenting symptoms. Hard copy of the report was not sent to ED, because the system required the Director's name on request, but instead had the chief medical officer's name on the request, so the report went to "no man's land" and thus was not put through the normal checking process. The patient (luckily) represented 3 days later with recurrence of pain and the chief medical officer at the time checked the electronic report and discovered the missed diagnosis. However, the patient later died from the tumor.

C. HIT Incidents that Involved "Paper Records"

Human factors issues involving the interface between paper records and the HIT imaging management system accounted for 12% (n=54) of the 436 HIT incidents (Table I). For example, consent forms not being scanned into the computer system led to problems mediated by their absence in the HIT system. Of the incidents involving paper records, 70% involved 'consent form' (n=21, 39%) or 'request form' (n=17, 31%) (Table V).

TABLE V. TYPES OF "PAPER RECORD" INVOLVED IN HIT INCIDENTS AND THEIR RELEVANT FREQUENCIES

Types of "paper record"	**n**	**%**
Consent form	21	39
Request form	17	31
Booking form	4	7
Film/ mark-up	4	7
Safety questionnaire	2	4
Report/ assessment form	2	4
Treatment sheet/ script	2	4
Contrast form	2	4
Total	54	

For consent forms, 81% (n=17) comprised 'consent form not scanned'. For request forms, 59% were 'duplicated request form' (35%) or 'wrong patient or exam detail in request form' (24%) (Table VI).

TABLE VI. TYPES OF "PAPER RECORD" INVOLVED IN HIT INCIDENTS AND THEIR RELEVANT FREQUENCIES

Incident involving "paper record"		
Consent form	***n***	***%***
Consent form not scanned	17	81
Consent form not filled in	3	14
Consent form not signed	1	5
Total	21	
Request form	***n***	***%***
Duplicate request form	6	35
Wrong patient/ exam detail in request form	4	24
Request form not scanned	3	18
Inadequate patient detail in request form	3	18
Wrong patient sticker in request form	1	5
Total	17	
Booking form	***n***	***%***
Booking form not filled in	2	50
Wrong patient detail in booking form	2	50
Total	4	
Film/ mark-up	***n***	***%***
Patient film not available	3	75
Patient's mark-up sent via post	1	25
Total	4	
Safety questionnaire form	***n***	***%***
Wrong information in safety questionnaire	2	100
Total	2	
Report/ assessment form	***n***	***%***
Report not signed	1	50
Nursing assessment not available	1	50
Total	2	
Treatment sheet/ script	***n***	***%***
Treatment sheet not signed	2	100
Total	2	
Contrast form	*n*	*%*
Contrast form not scanned	2	100
Total	2	

These incidents were associated with failures to carry out routine duties, possibly caused by distraction, inattention, and/ or multi-tasking. They resulted in additional staff or organizational workload to locate patients' case notes or chase forms between departments, and created additional paperwork, causing delays in patient management and treatment. Examples are given in Table VII.

TABLE VII. TYPES OF "PAPER RECORD" INVOLVED IN HIT INCIDENTS AND THEIR RELEVANT EXAMPLES

Issues involving "paper record"	Examples
Consent form	
Consent form not scanned	The consent was not scanned onto computer system and the staff had to chase case notes caused delay in patient's imaging.
Consent form not filled in	The consent form was not filled in, found in the case notes. Staff required additional documentation.
Consent form not signed	Incomplete consent form in the ARIA- not signed and page of third-party consent attached to patient manager.
Request form	
Duplicate request form	A repeat chest x-ray was done the next day because of duplicate referrals.
Wrong patient/ exam detail in request form	Request form dropped off to Nuclear Medicine by orthopedics for a dual-energy x-ray scan. Name, UR number and date of birth did not match.
Request form not scanned	Request forms not being scanned into PACS for several patients.
Inadequate patient detail in request form	Insufficient information on request form caused delayed imaging.
Wrong patient sticker in request form	Referring doctor put in request form with completely wrong patient sticker on request for full spine x-rays.
Booking form	
Booking form not filled in	A booking form was added to the electronic system but not filled in. A new booking form was sent to the radiology officer and registrar to complete.
Wrong patient detail in booking form	Wrong patient information on booking form caused the staff chasing for correct form.
Film/ mark-up	
Patient film not available	Patient film was unavailable. An anonymous note found 2 days later stating that the digitizer (used to copy films) was jamming that and the original patient films (in hardcopy) had been left in the X-ray dept.
Patient's mark-up sent via post	A patient's care path was not added to the electronic system and no electronic reminder was generated. The patient was overdue because the patient's mark-up was sent in a plastic sleeve via post.
Safety questionnaire form	
Wrong information in safety questionnaire	Received MRI safety questionnaire that incorrectly stated that the patient did not have aneurysm clips.
Report/ assessment form	
Report not signed	Radiology consultant did not sign the report working the ED. Radiology registrar found this and approached the consultant.
Nursing assessment not available	No nursing assessment document was attached in the electronic ordering system, which led to the registrar and the nurse chasing information.
Treatment sheet/ script	
Treatment sheet not signed	Treatment sheet delivered to machine without radiology officer's signature on the script.
Contrast form	
Contrast form not scanned	A contrast form was not scanned in to computer system, due to which reporting was not completed because of incomplete information.

D. Information or Communication Related

Information or communication related incidents accounted for 4% (n=15) of the 436 HIT incidents (Table I). Infection or patient alerts accounted for over 1% (n=6) of the 436 HIT incidents: two incidents reported that infection alert was not documented and two reported that patient (infection) alerts were not filled in the system. These incidents caused delayed detection of infection, and confusion among the radiographers and radiologists regarding treatment planning of the patients.

Verbal communication accounted for 1% (n=4) of the 436 HIT incidents. Incomplete (verbal) communication caused confusion and extra workload between staff because this communication was not documented. For example, a CT scan was ordered for the patient at midnight by the ED staff, however when the surgical registrar reviewed the patient, he was not aware that the radiology registrar had cancelled the scan verbally overnight; this had not been documented. The next day, this patient's request form was still on the system and the patient was about to have the scan, when the overnight radiology registrar saw the form and remembered it had been cancelled.

Three incidents described 'incomplete' status of the documents. For example, the first set of ultrasound images were sent for review by the radiographer. However, these went to the radiologists "to be reported" on the PACS worklist without checking or verification by the radiographer. This was assumed to be a modality system error, rather than human error, as it happened repeatedly. Two reports involved conflicting information communicated between radiology professionals – one was about a CT examination and the other was report dictated by a radiologist.

E. "Actions Taken" Related

This cluster accounted for 4% (n=15) of the 436 HIT incidents (Table I). Four incidents reported that staff had to perform manual tasks, such as manual handling of duplicate requests or manual entry of patient details in cases of system issues (ordering system was not working). Four incidents were fixed by the staff, for example missing or wrong patient identifying details were fixed by a medical officer and resent to the radiology department. Four incidents reported that system issues, for example, non-specific defects of a voice recorder were fixed by rebooting.

System issues were associated with a theme related to actions taken to manage the incidents, (a deviation from standard protocol or work-around). Three incidents reported that the radiation oncology patient information system ARIA (Oncology Information System) was having server/IT/software issues which prevented patient treatment on that day. Emergency patients required treatment, but this was not able to be planned and carried out in the department according to the standard protocol. To ensure patients were still treated, new treatment plans were decided in consultation with the radiation oncologist and planned and delivered outside of ARIA without any image verification, deviations from the standard protocol.

V. DISCUSSION

Medical imaging is now an integral part of modern healthcare, and radiologists are intimately involved in diagnosis, treatment and management in both emergency and radiology departments [11]. The increases in efficiency of imaging with IT systems, whilst undeniable [12], have not kept pace with the increases in volume and complexity of the workload, or with the expectations of the healthcare professionals who work in the system, who struggle with

dysfunctional systems [13-15]. Expectations may also not be met with respect to fixing problems or upgrading the systems [16] to address problems with system speed, configuration, connectivity and functionality [17].

The relationship between medical imaging and health information technology is complex and dynamic, and Australia suffers from the same inefficiencies and failures as documented in the United States [15], where anticipated savings from investing in new systems were not realized [18] and sufficient patient harm was caused to prompt warnings and admonishments from the Joint Commission which monitors sentinel events and accredits hospitals in the US [19].

For this study, we collected and analyzed things that had gone wrong with medical imaging, with a particular focus on the HIT incidents, as a basis for attempts to identify what is going wrong and what steps should be taken to prevent such issues in the future. Embarking on examining what had gone wrong over seven years, through the lens of 436 HIT related incidents, we used thematic analysis to extract information that is relevant to the specific issues.

On thematic analysis, 12% involved people failing to scan forms into the computer system (consents, requests, bookings, questionnaires, assessments, treatments and prescriptions), and another 4% involved failure to enter verbally imparted information into the system (about infectious patients, cancelled cases, and the status of reports). All of these problems had their genesis in human errors or violations, although less than 10% of the problems were violations, such as not following guidelines or procedure.

The fact that staff described "work-arounds" in reports suggests that technical administrative support was inadequate for system failures. Incidents were also caused by system functionality issues, such as not being able to compare images, problems with voice recognition software, the launching of new systems, and with problems following attempts at system integration, all of which cause delays and "rework".

A. Issues with Diagnosis and "Paper Records"

Human factors were found to cause more deleterious effects than technical factors. Of three instances of deaths caused by diagnostic issues, two were triggered by human factors, missed diagnosis. However, staff or organizational outcome was evenly distributed for both human and technical factors.

Our results are consistent with the findings by Magrabi et al who found that human factors were four times more likely to result in harm to patient than technical factors. The same study also reported three patient deaths [5]. Patient deaths due to health information related incidents have been reported in several other studies [4, 17, 20-22].

In this study, many issues were local, such as consent form not scanned, duplicate request or booking form being generated, due to not discarding the electronic records. Others were more systemic such as software glitches or 'network server down'. Many led to the need for more documentation, phone calls or follow up, and even repeated or unnecessary examinations, posing harm to patients.

B. Staff, Information and Communication, and "Action Taken" Related Issues

The cluster related "actions taken" were identified and summarized into 4 themes and 15 categories. These overlap with the 'staff or organizational outcomes' category above. Nevertheless, staff related actions were recorded for 16% of incidents (notifying people, revising plans), device related actions for 7% (providing devices), and organization related actions in 5% (mainly arranging for access to a service and notifying the relevant people). It is clear that, although not many medical imaging incidents had serious outcomes for the organization, patients or staff, there were many in which working conditions were rendered frustrating, with delays and rework affecting both patients and staff. Details of some of the actions taken are provided in the relevant cluster identified from thematic analysis and include work-arounds, such as staff members rebooting computers and other devices, and staff ensuring that patient treatment could proceed by doing manual calculations for radiation oncology treatments when the system was "down". Such workarounds are commonplace in clinical practice but are required so often that they are not regarded as worthy of an incident report in the vast majority of cases.

Although HIT related interventions may improve communication and improve information transfer, it also causes unintended consequences, such as slowing follow-up of abnormal diagnostic images and sometimes hampering clinical workflow and communication [23]. Our evidence showed that interpersonal conflict and much paperwork was caused because of HIT related administration glitch.

C. Strengths and Limitations of Incident Reports and Interviews for Gathering Information

The structure of each incident database is different. A standard reporting system would be ideal. The interviews were conducted only by the principal investigator and no second interview was conducted to ensure the validity of the information acquired from the participants; some interviews took place in an open hall at conferences, rather than in a booked room; and some interview sessions only lasted for a couple of minutes.

Incident reports collected by the interviews were limited by the content knowledge of reporters, were made up of subjective impressions, and were subjected to substranded personal bias by the participants, who also showed a lack of willingness to read interview guidelines (the participant information sheet). Reporters generally demonstrated little knowledge of and interest in HIT issues. Another limitation of the interview process was participants' willingness to participate. Two interviews ended up with no incident reports, as the participants claimed not to have experienced any.

D. Strengths and Limitations of Thematic Analysis

The strength of conducting analyses in this way is that there is no *a priori* framework into which the information has to be fitted. The framework is generated by the concepts that emerge, and grouped into categories, which share common features. The concepts can end up being classified into more than one conceptual framework, depending on the agenda and the potential application of the framework, once the concept extraction has been completed. Despite subjectivity in the analysis, the strength of this approach is that it provides detailed information that is relevant to the specific problem in question.

Additionally, thematic (inductive) analyses are useful for extracting information which may not be evident using deductive analyses (the ICPS, HIT-CS). This new information can then be added to that derived from the existing deductive classification systems.

VI. Recommendations

Based on these considerations and those arising from the literature, reports and findings, the following recommendations are made with respect to medical imaging systems for HIT. It is highly desirable to:

1) Set up a training process and ensure funding – for initial and ongoing training of the clinical staff for incorporating upgrades, local fixes by setting aside sufficient paid time.

2) Ensure the 3Cs (Corrrect patient, correct site and correct procedure) protocol – is carried out by radiology personnel at a 'time out' immediately before any imaging or other procedure, so that any mismatch of a patient's identity can be dealt with and documented in the patient's record.

3) Ensure effective communication – between radiology professionals for improving teamwork, collaboration and shared leadership.

We prioritized the recommendations based on the risks associated with human factors which caused severe or moderate harm to the patients and affected a moderate number of staff and patients.

VII. Conclusion

Medical imaging is a crucial part of modern healthcare systems and, with health information technology (HIT) for managing both images and documents, has emerged as a complex socio-technical system. Despite many benefits, these systems can cause new and unforeseen consequences such as delays, corruption of information, and harm to patients, including patient death. It is therefore important to identify clusters and themes which characterize medical imaging incidents, with a particular focus on HIT through the lens of thematic analysis, to provide a basis for improvements in preventing issues and improving clinical practice.

VIII. References

[1] J. Braithwaite, W.B. Runciman, A.F. Merry, "Towards safer, better healthcare: harnessing the natural properties of complex sociotechnical systems", Qual Saf Health Care, vol. 18, pp. 37-41, 2009.

[2] J.E. Anderson, N. Kodate, R. Walters, A. Dodds, "Can incident reporting improve safety? Healthcare practitioners' views of the effectiveness of incident reporting" Int J Qual Health Care, Vol. 25, pp. 141-50, 2013.

[3] N. Hannaford, C. Mandel, C. Crock, K. Buckley, F. Magrabi, M. Ong, "Learning from incident reports in the Australian medical imaging setting: handover and communication errors", Br J Radiol, vol. 86, 2013.

[4] F. Magrabi, M.S. Ong, W. Runciman, E. Coiera E, "Using FDA reports to inform a classification for health information technology safety problems", J Am Med Inform Assoc, vol. 19, pp. 45-53, 2012.

[5] F. Magrabi, M. Baker, I. Sinha, M.S. Ong, S. Harrison, M.R. Kidd, "Clinical safety of England's national programme for IT: a retrospective analysis of all reported safety events 2005 to 2011", Int J Med Inform, vol. 84, pp. 198-206, 2015.

[6] W. B. Runciman, "Lessons from the Australian Patient Safety Foundation: setting up a national patient safety surveillance system--is this the right model?", Qual Saf Health Care, vol. 11, pp. 246-51, 2002.

[7] B. Virginia, V. Clarke, "Using thematic analysis in psychology", Qual Res Psych, vol. 3, pp. 77-101, 2006.

[8] R. Elliott, C.T. Fischer, D.L. Rennie, "Evolving guidelines for publication of qualitative research studies in psychology and related fields", Br J Clin Psychol, vol. 38, pp. 215-29, 1999.

[9] C. Bernard, An Introduction to the Study of Experimental Medicine. New York: Dover Publications, 1957.

[10] S. R. Jabin, T. Schultz, P. D. Hibbert, F. Magrabi, C. Mandel, W. B. Runciman, "Identifying and characterising problems arising from interactions between medical imaging and health information technology as a basis for improvements in practice", unpublished.

[11] E. R. Ranschaert, "The Impact of Information Technology on Radiology Services: An Overview", J Belg Soc Radiol, vol. 100, 2016.

[12] M. D. Ralston, R.M. Coleman, D. M. Beaulieu, K. Scrutchfield, T. Perkins, "Progress toward paperless radiology in the digital environment: planning, implementation, and benefits", J Digit Imaging, vol. 17, pp. 134-43, 2004.

[13] G. W. Boland, "Stakeholder expectations for radiologists: obstacles or opportunities?" J Am Coll Radiol, vol. 3, pp. 156-63, 2006.

[14] G.W. Boland, A. S. Guimaraes, P. R. Mueller, "Radiology report turnaround: expectations and solutions", Eur Radiol, vol. 18, pp. 1326-8, 2008.

[15] N. Gulati, "Challenges Faced by Australian Radiologists while Working with Conventional Imaging Workflow Solutions", Report No.: 9837-48, 2013.

[16] E. Coiera, F. Magrabi, Information system safety. Guide to Health Informatics, USA: CRC Press, Taylor & Francis Group, 2015.

[17] G.M. Castro, L. Buczkowski, J.M. Hafner, "The Contribution of Sociotechnical Factors to Health Information Technology-Related Sentinel Events", Jt Comm J Qual Patient Saf, vol. 42, pp. 70-6 2016.

[18] Congressional Budget Office, "Technological Change and the Growth of Health Care Spending", 2008.

[19] The Joint Commission, "Moving Quality Improvement from a Project to a Way of Leading an Organization", J Qual Patient Saf, vol. 42, 2016.

[20] F. Magrabi, S. T. Liaw, D. Arachi, W. Runciman, E. Coiera, M. R. Kidd, "Identifying patient safety problems associated with information technology in general practice: an analysis of incident reports", BMJ Qual Saf, 2015.

[21] J. P. Santell, J. G. Kowiatek, R. J. Weber, R. W. Hicks, C. A. Sirio, "Medication errors resulting from computer entry by nonprescribers" Am J Health Syst Pharm, vol. 66, pp. 843-53, 2009.

[22] K. C. Cheung, W. van der Veen, M. L. Bouvy, M. Wensing, P. M. van den Bemt, P. A. de Smet, "Classification of medication incidents associated with information technology" J Am Med Inform Assoc, vol. 21, pp. e63-70, 2014.

[23] D. F. Sittig, H. Singh, "A new sociotechnical model for studying health information technology in complex adaptive healthcare systems", Qual Saf Health Care, vol. 19, pp. i68-74, 2010.