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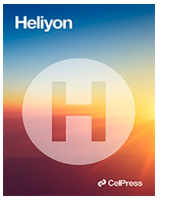

Research article

Development of minimum data set and dashboard for monitoring adverse events in radiology departments

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ABSTRACT

Background: To reduce the risk of errors, patient safety monitoring in the medical imaging department is crucial. Interventions are required and these can be provided as a framework for documenting, reporting, evaluating, and recognizing events that pose a threat to patient safety. The aim of this study was to develop minimum data set and dashboard for monitoring adverse events in radiology departments.

Material and methods: This developmental research was conducted in multiple phases, including content determination using the Delphi technique; database designing using SQL Server; user interface (UI) building using PHP; and dashboard evaluation in three aspects: the accuracy of calculating; UI requirements; and usability.

Results: This study identified 26 patient safety (PS) performance metrics and 110 *PS*-related significant data components organized into 14 major groupings as the system contents. The UI was built with three tabs: pre-procedure, intra-procedure, and post-procedure. The evaluation results proved the technical feasibility of the dashboard. Finally, the dashboard's usability was highly rated (76.3 out of 100).

Conclusion: The dashboard can be used to supplement datasets to obtain a more accurate picture of the PS condition and to draw attention to characteristics that professionals might otherwise overlook or undervalue.

1. Introduction

Patient safety (PS) is a vital component of care quality in the healthcare system. Even in complex, high-risk contexts, the PS allows

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healthcare stakeholders to operate without harming patients [1]. Medical errors are one of the leading causes of death worldwide, with millions of victims [2]. A divergence from the expected norm, regardless of any injury, is defined as an error [3].

In a study, Karami et al. explained that "clinical adverse impacts can be categorized as a spectrum ranging from near-miss events to sentinel events. A near-miss event is defined as an event characterized by the detection and correction of an error before harm reaches the patient, and a sentinel event is an unexpected occurrence involving death or serious physical or psychological injury, or the risk thereof" [2].

According to Larson et al. maintaining and enhancing safety levels requires the development of a system and culture that can intelligently integrate personnel with technology and procedures to produce a safer patient care environment [1].

Advances in health information technology in complex environments such as medical imaging departments (MIDs) have the potential to improve service delivery and reduce errors [4].

Errors in medical imaging procedures have a high risk of causing injury [5] and can occur at any point in the imaging chain and across all modalities [6,7]. This topic has been the focus of numerous investigations. In a study, Morbi et al. revealed that vascular interventional radiology techniques carry numerous safety hazards and have a high rate of adverse events. A mistake in interventional radiological procedures, according to Melvin et al. can result in sudden mortality, limb or organ loss, or serious bleeding [8,9].

Incorrect radiation doses to patients, misdiagnosis, disrupted treatments, the patient on the request, insufficient or erroneous clinical facts provided, illegible handwriting, injection of incorrect radiopharmaceutical/contrast medium/drugs, severe reaction to contrast medium, wrong identification of a patient's images, faults in a radiologist's report, considerable overexposure, failure to act on a rogue patient, and failure to meet the requirements, the wrong side or site, the wrong technique, and the wrong patient are just a few examples of these errors [5–13].

To address the mistakes and prevent near miss and sentinel events, it is essential to learn from them. According to the statement of the Joint Commission, all healthcare organizations must have a comprehensive strategy for identifying and addressing safety risks. Patient safety in medical imaging procedures can be improved by using a system to assist staff in monitoring and identifying probable PS-related occurrences, as well as reporting adverse events [14]. To achieve this goal, obtaining critical data should be instilled in the culture of healthcare organizations as part of their daily operations. In addition, effective procedures for carrying them out and regulating them should be created [15].

This study introduces the steps of the development of a dashboard for monitoring adverse events for MIDs before (pre), during (intra), and after (post) an imaging procedure to abate the errors. Since to achieve this system, having a proper minimum data set (MDS) is necessary, we first focus on the determination of the minimum data set, then we start to produce the dashboard. Indeed, we moved from information management to information technology.

2. Material and methods

In this qualitative and developmental research, a multi-method approach including interviews, structured observation, questionnaires, and workplace walkthroughs has been employed, divided into three steps:

Step 1: Analysis of the Status Quo.

After observation and investigation, we found no systematic or electronic method to monitor PS in the MIDs of the study site, and some paper-pencil forms would be used for PS checks. Therefore, we decided to develop an electronic system for tracking *P*S-related indicators in MIDs.

Step 2: Development of a Minimum Data Set.

The correct definition of metrics is a critical subject in developing a dashboard. We have already determined the key performance indicators (KPIs), associated metrics, and their descriptions for PS in the MID in the two articles mentioned [2,15]. In the present study, we used them (Appendix 1). We needed to define a MDS to calculate most of these KPI metrics. For this purpose, the following stages were defined:

First, a variety of items must be checked to monitor PS before, during, and after an imaging procedure. The dashboard's content is made up of these data pieces, known as the "minimum data set." In this regard, at first, we collected the existing paper-based forms. Then a literature review [5,16–51] was conducted using scientific databases such as Medline (PubMed), Web of Science, Scopus, ProQuest Health, and Google Scholar.

Keywords such as "medical imaging" and/or "radiology department," along with "patient safety performance indicator," "patient safety incident," "patient safety information system," "near-miss occurrences," "sentinel events," and "patient safety monitoring system," were used for searching.

Later, semi-structured interviews were conducted with five radiologists focused on the task sequence and the information needed to complete the PS checking process (including pre-, intra-, and post-procedure checking). At the end, the extracted MDS were located in the pre-, intra-, and post-procedure parts, and an electronic questionnaire was created.

Second, the Delphi technique was used to confirm these items by a panel of experts (n = 30) comprised of radiologists, medical physicists, and radiology technicians with more than 5 years of professional experience. Chain-referral sampling was used to choose the experts. It is a technique of non-probability sampling.

Experts were emailed the electronic questionnaire. They were asked to determine whether or not an item was required in this process. In addition, an open-ended question was added to the questionnaire to elicit additional data points. Delphi ended after one round because of the lack of additional recommendations in the first round.

For each item, the mean scores of the experts' opinions were determined; a mean score of more than 50 % meant that the item was acceptable, while a mean score of less than 50 % indicated that the item was not acceptable [52]. A list of MDs for use in the dashboard

Table 1
The minimum data determined from the Delphi technique.

Row	Indicators	Required Data			agree		disagree	
					NO.	%	NO.	%
Data Elements Related to pre Procedurerowhead								
1	**Patient Scheduled**	Arrival Time			16	53	14	47
2		Real-Time of Imaging			23	77	7	23
3	**Physician Order**	Physician's Name			19	63	11	37
4		Physician Specialty			21	70	9	30
5		Ward			19	63	11	37
6		Type of Modalities		CT Scan	15	50	15	50
7				Nuclear Medicine	15	50	15	50
8				Radiography	18	60	12	40
9				Interventional Imaging	23	77	7	23
10				Cardiovascular Imaging	22	73	8	27
11				Angiography	20	67	10	33
12				CT Angiography	17	57	13	43
13				Heart Scan	16	53	14	47
14				Peripheral Vascular Imaging	18	60	12	40
15		Physician Signature			25	83	5	17
16		Request Time			17	57	13	43
17		Request Date			23	77	7	23
18	**Universal Protocol**	Patient Identification		Medical Record Number	20	67	10	33
19				Patient's Name	28	93	2	7
20				Father Name	20	67	10	33
21				Age	25	83	2	17
22				Sex	22	73	8	27
23				Address	15	50	15	50
24				Phone Number	22	73	8	27
25		Procedure Identification		Side	24	80	6	20
26				Site	26	87	4	13
27	**Medical History**	Illnesses		Current Illnesses	24	80	6	20
28				Past Illnesses	24	80	6	20
29				Surgery	21	70	9	30
30		Drug		Drug Use	20	67	10	33
311-				Medication allergy	29	97	1	3
322-				Adverse drug reactions	21	70	9	30
33		Imaging		With Contrast	24	80	6	20
34				Without Contrast	22	73	8	27
35	**Patient Training and Preparation**	Patient Training		How to Imaging	22	73	8	27
36				Imaging Time	18	60	12	40
37				Preparation of Patient	25	83	5	17
38				Lack of Training	18	60	12	40
49		Patient Companion		Without	15	50	15	50
40				Type of Companion	26	87	4	13
41		Patient's Condition		Inpatient	18	60	12	40
42				Outpatient	17	57	13	43
43				Emergency	26	87	4	13
44				Extra Emergency	19	63	11	37
45		Type of Preparation	Medication	Oral Administration	20	67	10	33
46				Injection of Contrast Material	24	80	6	20
47			Non-Medication	Full Bladder	22	73	8	27
48				Fasting	21	70	9	30
49				Menstruation	16	53	14	47
50				Lack of Metal Objects	23	77	7	23
51		Patient Appropriate Coverage			23	77	7	23
52		Type of Patient Transfer		Stretcher	19	63	11	37
53				wheelchair	13	43	17	57
54				Oxygen Equipment	22	73	8	27
55				Anesthesia Equipment	17	57	13	63
56				Without Equipment	6	20	24	80
57	**Medication Labeling**	Patient's Name			21	70	9	30
58		Drug Name			15	51	15	49
59		Drug Dose			26	87	4	93
60	**Hand Hygiene**	Hygienic Procedure		Waterless Alcohol	18	60	12	40
61				Gloves	22	73	8	27
62				Lack of Hygienic Procedure	17	55	13	45
63	**Radiation**	Patient's Age			19	63	11	37
64		Pregnant or Non-Pregnant			29	97	1	3

(*continued on next page*)

Table 1 (*continued*)

Row	Indicators	Required Data		agree		disagree	
				NO.	%	NO.	%
65		History of Radiation		21	70	9	30
66		Duplicate Imaging Procedures		24	80	6	20
Data Elements Related to Intra- Procedurerowhead							
1	**Vital Signs Control**	Blood Pressure		23	77	7	23
2		Heart Rate		22	73	8	27
3		Respiration		18	60	12	40
4		Allergy		22	73	8	27
Data Elements Related to Post-Procedurerowhead							
1	**Image Labeling**	Patient's Name		29	97	1	3
2		Procedure Side		25	83	5	17
3		Procedure Site		22	73	8	27
4		Time of Procedure		16	53	14	47
5		Date of Procedure		27	90	3	10
6		Number of Images		19	63	11	37
7		Time of Image Delivery		18	60	12	40
8		Type of Image	Delay	21	70	9	30
9			Non- Delay	19	63	11	37
10		Image Delivery	Paper	16	53	14	47
11			CD	17	57	13	63
12			System	19	63	11	37
13	**Image Reporting**	Patient Name		29	95	1	5
14		Radiologist Name		28	93	2	7
15		Radiologist Signature		27	90	3	10
16		Attending Physician Name		20	67	10	33
17		Date of Interpretation		25	83	5	17
18		Time of Interpretation		15	50	15	50
19		Delivery of Critical Results Reporting		15	51	15	49
20		Time of Delivery of Critical Results Reporting		21	70	9	30
21		Type of Report Submission	Electronically	18	60	12	40
22			Manually	18	60	12	40
23		Image Presentation	With Report	27	90	3	10
24			Without Report	17	56	13	34
25		Receive of report by	Patient	16	53	14	67
26			Physician	16	53	14	47
27			Resident	17	57	13	63
28	**Complications**	Nephropathy		28	89	2	7
29		Fracture		15	50	15	50
30		Dislocation		17	57	13	43
31		Infection		15	50	15	50
32		Pneumothorax		19	63	11	37
33		Intravenous Rupture		21	70	9	30
34		Blood Pressure Changes		20	67	10	73
35		Dizziness		21	70	9	30
36		Nausea or Vomiting		22	73	8	27
37	**Patient Fall**	Without Injury		17	57	13	43
38		With Injury		23	77	7	23
39		Falling Type	From Bed	23	77	7	83
40			While Ambulating	15	50	15	50

was produced based on the final panel's rating.

Step 3: Development of the Dashboard.

First, the entities and their relationships were graphically represented using ERD (Entity Relationship Diagram) and UML (Unified Modeling Language) diagrams (class, activity, and sequence).

Second, the web-based user interface was designed in the PhpStorm 2016 programming environment using Laravel, which is one of the PHP language frameworks. In addition, Html5, Css3, Jquery, and vue. js were used in the design of dashboard software. The database was also developed using MySQL software, which is fully compatible with the PHP programming language.

About the data feeding of the dashboard, the hospital information systems in the study site could only enter limited information, such as demographic information, medical record number, physician's name, and hospitalization wards, into the dashboard. Therefore, some data had to be entered manually.

Third, three types of evaluations were used to test the dashboard, as follows:

- The validation of the metrics calculation: These computations were done both manually and by machinery (using the dashboard) to guarantee that the PS metrics were calculated correctly. Finally, the results of the two procedures were compared. The validation was carried out by one of the team's researchers.

Fig. 1. The screenshot of the main tabs of dashboard.

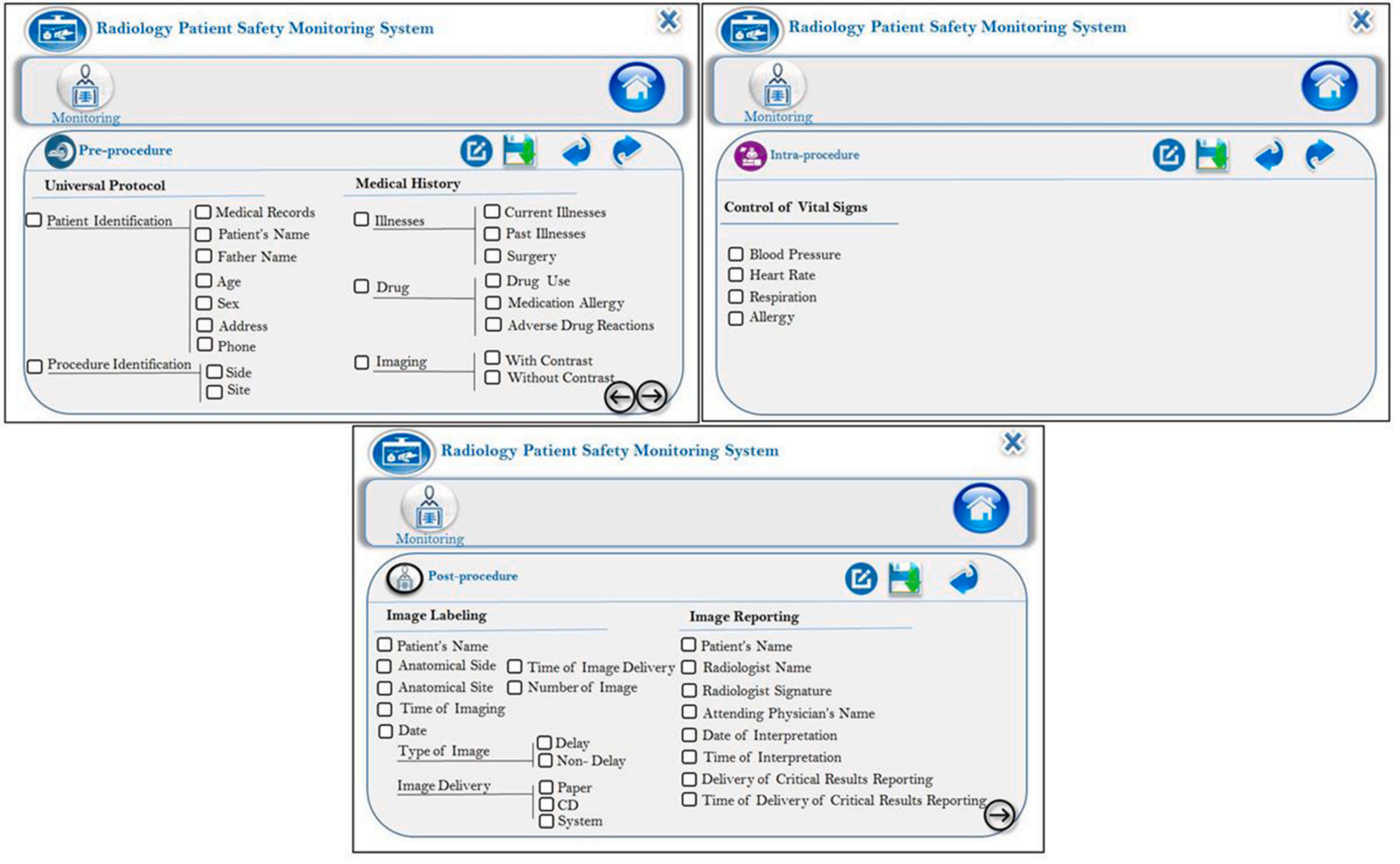

Fig. 2. The screenshot of the pre, intra, and post procedure menus.

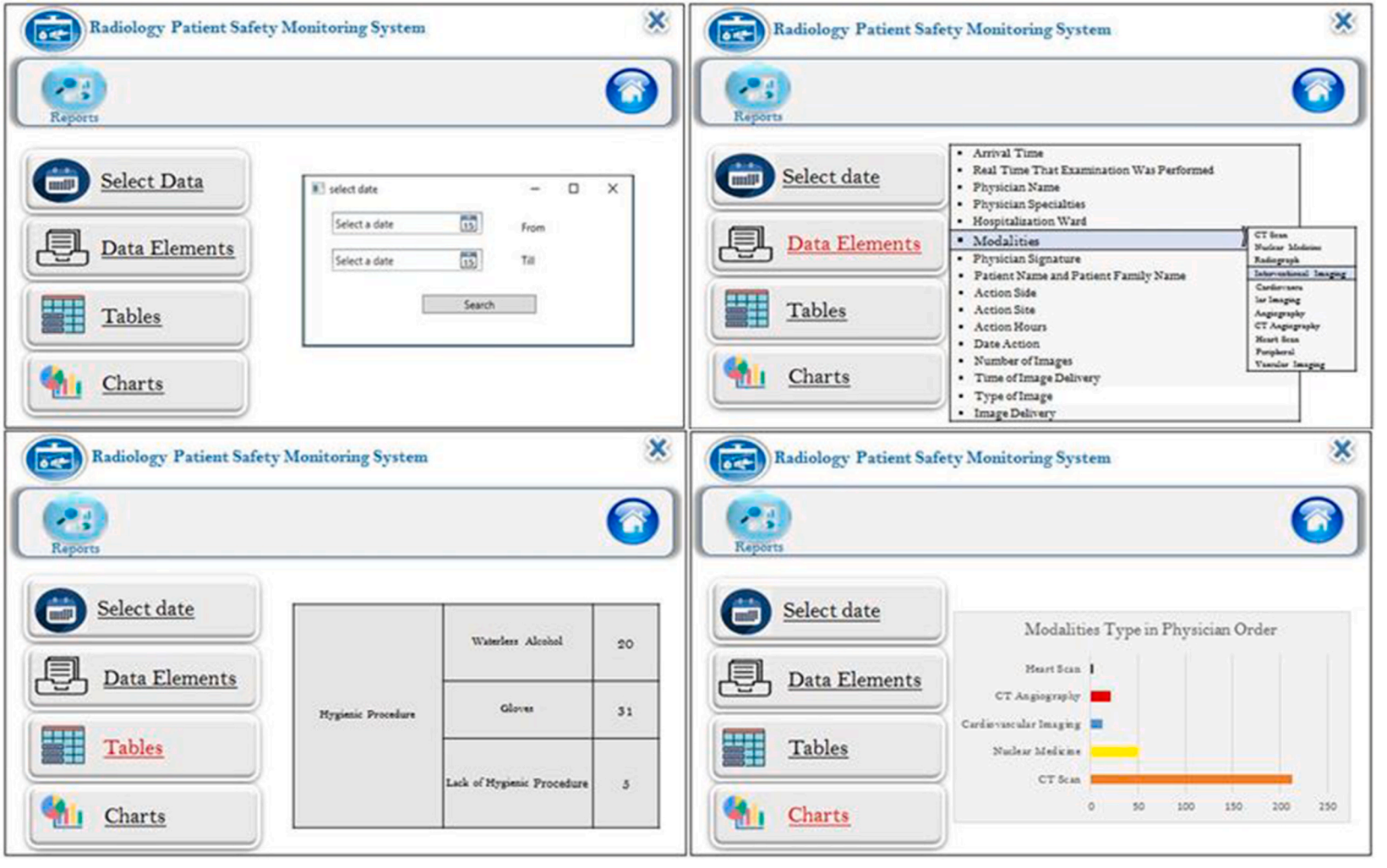

Fig. 3. The screenshot of the report formats.

Table 2
Results of the survey about the usability of the RPSMS.

Row	Groups	Metrics	Yes		No	
			NO.	%	NO.	%
1	Suitability for the tasks	Support the user to perform all daily tasks	5	% 100	0	%0
2		Matching data entry with user tasks	5	% 100	0	%0
3		Crossing minimal bottlenecks to perform a task	5	% 100	0	%0
4		Display all required information on one page	5	% 100	0	%0
5		Easy access to needed commands to perform tasks	5	% 100	0	%0
1	Self-descriptiveness	Equipped with data dictionary and metadata	5	% 100	0	%0
2		Comprehensibility the meaning of messages and commands	5	% 100	0	%0
3		Provide practical examples to explain tips	5	% 100	0	%0
4		The terminology used in software reflects that of environment	5	% 100	0	%0
5		Clarity of screen data fields and commands	5	% 100	0	%0
1	Controllability	Easy and fast return to start menu	5	% 100	0	%0
2		Stop running modules at any time				
3		Easy to navigate between screens	5	% 100	0	%0
4		Go through a set of fixed steps to perform tasks	5	% 100	0	%0
5		Enter a letter, character, or code to access menu items quickly	0	%0	5	% 100
1	Conformity with user expectations	Easily accomplish the tasks due to the well designed and coordinated software	5	% 100	0	%0
2		Estimation of the required time to perform the task	5	% 100	0	%0
3		Lexical and semantic integrity in different sub- systems	4	%80	1	%20
4		Use the same keys to perform specified tasks	5	% 100	0	%0
5		Display issued messages in a specified part of the screen	5	% 100	0	%0
1	Error tolerance	Request user approval when performing tasks	5	% 100	0	%0
2		Provide useful information about getting out of the wrong situation	5	% 100	0	%0
3		System alert about potential error situations	5	% 100	0	%0
4		Quick identification of the data entry errors	5	% 100	0	%0
5		Easy return to the previous (last) action in case of a mistake	5	% 100	0	%0
1	individualization Suitability	Customize forms, screens, and menus as desired by the user	5	% 100	0	%0
2		Adjust the amount the screen tailored to user needs	5	% 100	0	%0
3		Conformity of field order with the current process	0	%0	5	% 100
4		Set up input/output devices tailored to user need	5	% 100	0	%0
5		Adjust the system speed according to the tasks	5	% 100	0	%0
1	Learning Suitability	Quick and easy learning to work with software	3	%60	2	%40
2		Easy to re-learn after no long-term use of the system	5	% 100	0	%0
3		Access the description to use the system when needed (Online or offline Help)	5	% 100	0	%0
4		Uses the software at first without asking colleagues	3	%60	2	%40
5		Recall details and tips for proper use of the system	5	% 100	0	%0

- Verification of the user interface: The user interface (UI) was evaluated by five IT specialists using the ISO 9241-10 standard to guarantee that all UI requirements were fully met. This standard relates to office work with visual display terminals and ergonomic criteria. This checklist included 50 criteria organized into seven primary axes: suitability for the tasks; self-descriptiveness; controllability; compliance with user expectations; error tolerance; suitability for individualization; and suitability for learning [53]. The evaluators were familiar with these topics. They used test data to run the system and compared its features and capabilities to ISO 9241-10. In the end, the problems were found and documented. Evaluation data were analyzed using descriptive statistics in Excel.
- The usability evaluation: The usability of the dashboard was evaluated using the System Usability Scale (SUS) by ten real users, including radiologists, radiology nurses, and educated radiology technicians who had passed international computer driving license (ICDL) courses. The number of evaluators was ten because most usability issues are detected by five users, so the number of samples should be between five and twelve [54]. In a 2-h workshop, the participants were initially exposed to the dashboard functionalities. To avoid bias, they worked independently with the dashboard and completed the SUS questionnaire. One of the researchers acted as an observer and collected comments, questions, and ambiguities from them.

2.1. Consideration

This study was approved by the Research Ethics Committee of the Kashan University of Medical Sciences Research Council (code of ethics: IR. KAUMS.REC.1395.32). Also, this study was conducted following the guidelines of the Declaration of Helsinki. By the opinion of the above-mentioned Ethics Committee and given the fact that no information about participants is provided in this paper, participants who participated in Delphi and usability studies gave verbal consent to participate in this research.

3. Results

The following are the overall findings based on the work steps:

In step one, 26 PS performance metrics and their corresponding definitions were selected from prior studies (Appendix 1). After the literature review, 143 important data elements were extracted. Following the Delphi phase, 110 of them were chosen and divided into 14 main groups for the three checking processes (pre-, intra- and post-). The selected MDS are listed in Table 1.

In step two, the dashboard was developed as a prototype software tool for monitoring and managing safety in MIDs, as shown in Figs. 1–3.

Tabs (pre-, intra- and post-) contain a collection of data sets relating to safety that are linked to KPI indicators. A drop-down list box was proposed for checking the safety items for each patient.

Furthermore, all KPI data could be further filtered using a variety of selection parameters, including modality, dates (day, week, month, or year), examination, and encounter type. The dashboard dynamically re-visualizes the data in real time after the user selects these filters or a combination of filters.

In step three, first, the correctness of KPI metric computations was individually examined and verified. Second, Table 2 gives an overview of UI verification.

Third, the result of the usability evaluation using SUS showed the users' satisfaction was at the targeted level (76.3 out of 100), according to Table 3.

Table 3
Results of SUS measurement.

Row	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Scores
R1	**5**	**1**	**5**	**4**	**5**	**1**	**5**	**1**	**5**	**4**	**85**
R2	**2**	**2**	**4**	**5**	**5**	**2**	**4**	**1**	**4**	**1**	**70**
R3	**5**	**2**	**1**	**2**	**4**	**1**	**5**	**1**	**4**	**4**	**70**
R4	**5**	**1**	**4**	**1**	**5**	**4**	**5**	**1**	**5**	**5**	**80**
R5	**5**	**1**	**5**	**4**	**5**	**1**	**5**	**1**	**5**	**4**	**85**
R6	**4**	**1**	**5**	**2**	**1**	**4**	**1**	**1**	**4**	**4**	**57.5**
R7	**5**	**2**	**4**	**4**	**4**	**2**	**4**	**2**	**4**	**4**	**67.5**
R8	**5**	**1**	**5**	**4**	**5**	**1**	**5**	**1**	**5**	**4**	**85**
R9	**4**	**1**	**5**	**4**	**4**	**1**	**5**	**2**	**4**	**2**	**80**
R10	**5**	**1**	**5**	**4**	**5**	**1**	**5**	**1**	**4**	**4**	**82.5**
Total of scores											**762.5**
Average											**76.3**
Result of evaluation:								**Threshold**		**Threshold**	
Acceptable(76.3)								**100**	**85**	**65**	**0**
								Recommended range			
								Not-acceptable			**0–64**
								Acceptable			**65–85**
								Excellent			**85–100**

R= Respond.
Q = Question.

4. Discussion

All healthcare institutions, according to the Joint Commission, must have a comprehensive strategy for identifying and addressing safety risks. PS in medical imaging procedures can be improved by using a system to assist staff in monitoring and identifying probable *P*S-related occurrences, as well as reporting adverse events [55,56].

In Reason's Swiss Cheese Model of Medical Error, Brook et al. proposed a diagnostic radiological error classification system that considers personnel, communication, cause, and impact. Their system was designed to detect hidden system weaknesses to reduce the likelihood of future errors and the repercussions of such failures. In this regard, we employed all of Karami's safety-related metrics [15], which included all of the components of the cheese model, for the dashboard.

Swensen et al. created a radiological quality value map that traced the patient's path from the referring physician's office to the radiology department and covered the significant phases of ordering, performing, and reporting an examination. This map is a starting point for understanding ways to improve radiologic examination and intervention in terms of safety, reliability, quality, and appropriateness [40].

Accordingly, we decided to design this dashboard to monitor and measure the safety indicators at three stages: pre-procedure (before the patient enters the radiology department), intra-procedure (when the patient is ready for the procedure), and post-procedure (after the procedure and before the patient exits the radiology department).

Multiple studies [32,35,45,51,57,58] have shown that various strategies and technologies have been used to improve the quality and safety of MIDs. For example, Schultz et al. developed a web-based radiology-specific event reporting system. During its initial development, this system detected and addressed significant safety risks and flaws constructively and straightforwardly [32].

Koetser et al. developed a specific radiological patient safety system (RADPASS) checklist for interventional radiology. This checklist has two parts: A (Planning and Preparation) and B (Procedure). The latter part comprises checks just before starting a procedure (B1) and checks concerning post-procedural care immediately after completion of the procedure (B2). The use of the RADPASS checklist reduced deviations from the optimal process by three-quarters and was associated with fewer procedure postponements [57].

In another study, Schultz et al. offered two methods for standardizing work procedures. The first was a checklist for a time-out routine that would comply with the Universal Protocol and reduce interventional procedure errors. The latter was a flow chart used to evaluate pregnant patients' radiological imaging that exhibits lean standardization of a work process to avoid errors [35].

On the other hand, Rafiei et al. mentioned that "a well-designed checklist should effectively address the underlying failure modes for the adverse events that occur in any particular operational environment. In addition, the checklist should be designed to facilitate the reliable execution of the control strategy for those failure modes. Also, they emphasized that patient safety is better served by allowing local teams to build a checklist from a list of items that match the operational requirements of their working environment." [58].

Gottumukkala et al. employed a video monitoring and feedback system to establish a checklist-based scoring system to rigorously assess compliance, measure performance, and improve the time-out procedure in pediatric interventional radiology. This system improved time-out performance significantly and could address frequent failure scenarios [51].

Also, in research, Corso et al. designed the "Time-Out" safety checklist to improve PS. This checklist had the potential to decrease adverse events in the first year of usage and increase healthcare team involvement and *P*S-related knowledge [45].

Consequently, we identified e-checklists for controlling and preventing adverse events. This is due to the fact that PS data collection using paper-and-pencil forms was frequently accompanied by rising workloads (especially in the areas of data processing and storage), inaccuracies in data entry, and a high reliance on human resources.

Afterward, we developed the dashboard as e-monitoring software with pre-determined parameters to control safety in different aspects and modalities. The dashboard alerts for error prevention and reports adverse events in table and chart formats.

As shown in some studies, systems' usability, feasibility, and effectiveness are usually explored in a pilot test after some time [59–70]. As can be seen from the findings of UI verification, all participants disagreed with the criterion "no need for a navigator to see the information" in the category "controllability." Whereas a dashboard should show all of the data on a single screen at a glance, for the filling of the e-checklist, it was required to navigate to the data.

In the category "suitability for individualization," the capability to "attach comments to indices" was not confirmed. In light of this, it was attempting to add a feature that would allow users to add comments to indices.

In the "suitability for learning" category, participants explained that it was important to learn how to use the system. An instructional file was prepared for users to remove the problems.

The evaluators also discovered some spelling mistakes, which were all fixed. Finally, they found the dashboard to be user-friendly and capable of meeting the primary UI requirements.

In the usability study, some participants explained that the number of items to be checked in the pre-, intra-, and post-procedure tabs is both enormous and time-consuming. Accordingly, the feature of disabling the checking of some items depending on the type of modalities, patients, and other parameters was added to remove this problem.

It's worth noting that the impact of the dashboard on improving PS in the MID was not assessed in this study.

The review of literature allowed us to determine the MDSs to develop a dashboard for monitoring adverse events in MID. After developing the dashboard; its usability testing showed us its functional deficiencies to fix. Since this research was only a development of dashboard, we did not have any measurable outcome of the intervention.

5. Study limitations

Given that the main objective of this dashboard's development is to adhere to safety indicators and enhance the quality of the MID's services, it is recommended that this system include features like systematic training instructions and scientific resources for each intervention in the form of a decision support system (DSS), integration with other hospital information systems, the ability to filter or modify system reporting based on user and department manager access levels and demands, and the capacity to attach various files to the system.

6. Conclusion

This study provides a picture of how to manage health information to achieve health information technology that can effectively make changes in routine work. Understanding workflow, information flow, and provider needs can play a critical role in developing strategies to design an effective e-monitoring system.

This dashboard can display a more accurate picture of PS status and highlight aspects that would otherwise go unnoticed or underestimated by clinicians. For this purpose, healthcare stakeholders must apply a practical implementation strategy for routine data collection.

Acceptance of the PS e-checklist and dashboard by staff can pave the way to extend the dashboard data collection from pre-, intra-, and post-procedures. Maybe the staff considers it an increasing workload. Therefore, they should be educated and justified. This study was focused on information management and the functionality steps needed to develop a dashboard for monitoring adverse events in MIDs and, in the end, provide visibility of useful and vital information for improving safety in this complex environment. We postponed determining the system's impact and only addressed the problems that arose during the testing phase in response to user comments. In order to evaluate its impact in the future, we will conduct a new research plan.

Certainly, by increasing its use, more feedback will be received from users, which can then be utilized to improve its effectiveness. Depending on the feedback, maybe more advanced functionality will be added to the dashboard, or some of its features will be eliminated.

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Data availability statement

Data included in the article, supply material, or cited in the article. Also, the datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

CRediT authorship contribution statement

Mahtab Karami: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Nasrin Hafizi:** Software, Methodology, Formal analysis, Data curation. **Ali-Mohammad Nickfarjam:** Visualization, Software. **Soheila Refahi:** Writing – review & editing, Validation, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e30054.

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