MODEL DEVELOPMENT OF INTEGRATED WEB-BASED RADIOLOGY INFORMATION SYSTEM WITH RADIO DIAGNOSTIC IMAGING MODALITY IN RADIOLOGY DEPARTMENT

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ABSTRACT

The utilization of information technology in health care information systems tends to be slower compared with the other areas. Some of the reasons are because of these areas have special characteristics which are: 1) the data and information in the medical information systems consist of many data types, such as alphanumeric, graphics, images, and sounds; 2) health workers are always mobile in performing their duties; 3) the source data is not only coming from the physician or health worker but also could be obtained from high-tech medical equipment; 4) when an error occurs in any health care data processing could caused death to the patient. The main function of the medical information system is not only used for management purposes but it also used for managing clinical data that will be useful for the development of medical science. Radiology department is one of the hospital departments that use many computerized systems. Therefore, the implementation of information systems in radiology departments will provide tangible benefits to patients and the health care service provider itself. The objective of this study is to develop a model of a web-based radiology information system based on medical workflows and integrated with the radio diagnostic imaging modality. The research method used on this study is data collection through literature review, interviews, observations, and surveys/questionnaires, as well as information systems analysis and design methods using Object Oriented approach with Unified Process and system modeling using Unified Modeling Language. Through an understanding of the radiology workflow and analysis of current system in operation, we will build a model of a web-based Radiology Information System which is integrated with radio diagnostic imaging modalities. Utilization of web-based radiology information system integrated with radio diagnostic imaging modality will optimize workflow in radiology department to become leaner. In addition, the results of the examination can be managed easily, reported correctly, and archived better.

Keywords: *Radiology Information Systems, Web-based, Radiology Workflow, Unified Modeling Language, Imaging Modality*

1.   INTRODUCTION

Nearly all people working in a hospital have an enormous demand for information that needs to be fulfilled to achieve high-quality, efficient patient care. Hospital management needs up-to-date information about the hospital's costs and services. The quality of information processing is also important for the competitiveness of a hospital. A hospital's information systems can thus he regarded as its memory and nervous system [1]. As the different information needs of the various groups are often based on the same data, the processing of information should be integrated. If hospital information systems are not systematically managed and operated, their development tends to proceed in a disorderly fashion. This, in turn, leads to consequences such as low data quality and integration, increased costs of patient care, and a reduced quality of care. For this reason, well-educated health informatics specialists, with the knowledge and skills to systematically manage and operate information systems, are needed to appropriately and responsibly apply information and communication technology to the complex information-processing environment.

The use of IT - particularly in a hospital's clinical departments - should not be an end in itself. On the contrary it should be geared toward making

everyday interactions with patients faster, safer, and better. IT should thus be targeted at optimally supporting the whole patient process and should not be limited by departmental boundaries. Workflows that cross departmental boundaries must be viewed from an overall patient-oriented perspective. This is the only way to reduce the friction found at organizational interfaces.

However, very unfortunate the utilization of information technology in health care information systems tend to be slower compared with the other areas [2]. Some of the reasons are because of these areas have special characteristics which are: 1) the data and information in the medical information systems consist of many data types, such as alphanumeric, graphics, images, and sounds [3], [4]; 2) health workers are always mobile in performing their duties; 3) the source data is not only coming from the physician or health worker whose recorded the patient's condition but also could be obtained from high-tech medical equipment that generates the digital and analog data or information; 4) every department in the hospital has a specific business process and different from one department to another department; 5) many medical and general standards that must be followed; 6) when an error occurs in any health care data processing could caused not only financial loss but it can cause death to the patient. The main function of the medical information system is not only used for management purposes but it also used for managing medical data that will be useful for the patient care as well as the development of medical science.

One of medical support services in hospitals is radiology examination that is done in a radiology department. Radiology department is one of the hospital departments that use many computerized systems. Therefore, the implementation of information systems in radiology departments will provide tangible benefits to patients and the health care service provider itself.

2. THE RESEARCH PURPOSE AND BENEFIT

The objective of this study is to develop a model of a web-based radiology information system integrated with the radio diagnostic imaging modality and clinical administration based on medical workflows. The specific purposes of this study are as follows:

a. To enable effective and efficient clinical operations in medical imaging practices.

b. Allows the practice to receive physician orders electronically accurate, safely, and efficient.

c. Efficiently performing the requested imaging procedure through expanding integrated radiology information model that is based on a workflow to strengthening health service.

The Radiology Department is concerned with provision of images of the body for the diagnosis of disease with or without the use of radiation by providing fast, quick, and accurate imaging diagnostic. Most of the times, radiology department become the symbol of pride from many hospitals because the high technology diagnostic service could become the marketing equipments that are used to appeal doctors as well as patients. It needs to be concerned that with high technology equipments and high investment capitals in radiology department, so service quality needs to be increased so that there will no time and resources wasted, and decrease of producing mistakes in doing the health service implementation. Medical information is the most important aspects in healthcare. Because of that, the health information management becomes one of the prime attentions from hospital departments, especially for radiology departments. With the advancement of information technology, not just adapting computerization process as the answer from the simplicity of exchanging medical information among departments, but also give hope with automation in medical management.

Based on analysis above, several factors which are this main research purpose can be concluded as follow:

a. The quality of health service in radiology department services need to be increased by giving accurate, on time, and relevant radiology treatment; and accelerating workflow of health workers.

b. To increase the effectiveness and efficiency of health service, there is a need to build radiology information system model which are integrated and comprehensive.

As the first step in building integrated radiology information system model, there is a need to develop radiology information system with integrated interface with the radio diagnostic imaging equipments that are cheap and handy.

3. RESEARCH METHOD

In carrying out this research, it is used data collection method as well as analysis method and

information system design that will be explained as follow.

3.1 Data Collection Method

In carrying out this research, it is used data collection method as well as analysis method and information system design. The data collection method that is used in this research is:

a.   Literature review

Collecting the theories that are relevant with research objects and support the analysis that is conducted to get the solution from problems that are faced in radiology units in a number of hospitals in Jakarta.

b.   Interview

In this method, the interview is executed directly to a few speakers that are consist of patients, doctor sender, radiographers, radiologist doctor, administration staffs, Hospital Managements, by doing a discussion that is related to the ongoing system together with the faced problems.

c.   Observation

In this method, writer does an observation against radiology process which is undergone in Royal Taruma Hospital, Jakarta, Indonesia. Radiology process that is observed is a workflow that is working in radiology units.

d.   Survey / Questionnaire

This method is done by making questions that will be used by writer to gain data from the sources directly with asking questions procedure and spreading questionnaire to a few hospitals that are around Jakarta.

3.2 Information System Analysis and Design Method

Analysis method and system design that is used in this research is an object-oriented method with Satzinger's approach (2008) where researchers use UML (Unified Modeling Language) to the modeling that consists of: Activity Diagram, Event Table, Use Case Diagram, Domain Class Diagram, Three Layer Sequence Diagram, Updated Class Diagram, and User Interface [5].

UML diagram above is used to analysis documentation and system design. For the development of radiology information system application based on this web, the researchers use the programming language such as PHP and MySQL as the database.

4.   LITERATURE REVIEW

4.1 Medical Information Science Discipline

The health care information systems or HCIS is data management, process, people, and interacted information technology for collecting, processing, saving, and preparing information as a needed expense to support health care organization [6]. The relational complexity of medical and ecology has on gone to the big necessity position and responsibility growth to all users and working factories in this field.

In this practice, based on the wide area coverage, health care information system generally can be differentiated to be two, which are: public health care information system, and hospital health care information system. The former is related to the general health care management in national scales. Usually it is handled by government through health minister. Including the inside parts, there are health warranty information system. The special one is called hospital Information System (HIS). HIS is defined as a computer system that is planned for simplify management medical information and administration of all hospitals, and to increase health quality [7].

Clinical information systems is support equipment for nurses and doctors that has patients. These information system modules are as follow:

▪   Census Management: a system that gives general pictures and renews all patients' data that are related to a bunch of doctors. General function is including the acceptance of new patients, patient transfer to other clinics or wards, homecoming patients. Other included transfer process in here is outpatients with inpatients.

▪   Clinic Documentation as well as Electronic Medical Records (EMR). EMR is a clinic information system in a hospital that has central part in patient caring. EMR is the main data repository from clinic information system. This system scan data from all patient visits, which are diagnosis, command, results, nursing schedule, service payment, etc. It is also a law document, so the changes are cared in a long term.

▪   Ordering: Physician Order Entry or Provider Order Entry (POE, also called CPOE for Computerized POE)

The workflow based on a number of patient health care scenarios:

- Patient registration
- Examination request, examination and scheduling planning.
- Examination, data entry, and report documentation, picture acquisition, and examination up data management
- Saving and archiving picture and report.
- Picture query and access, and picture viewing and processing.
- Administration data entry, preparing service statistics, medical material supply management, and others.

4.2 General Activities in Radiology Examination

Radiology examination workflow is very distinct from one modality to another. A few types of modality commonly used for radiology examination, each modality offer diagnostic possibilities that are different, depends on the symptoms that are experienced by the patients. Here is a few modalities can be explained concisely: Conventional X ray, Ultrasonography (USG), Computer Tomography (CT). Magnetic resonance Imaging (MRI), Angiography, Radioscopy or Fluoroscopy, Positron Emission Tomography / Computer Tomography (PET/CT), and Nuclear Medicine (NUC).

Moreover, each individual institution can do the same examination but in different way of doing. Even though there are variations in imaging diagnostic method, intervention technique, and modality, these activities are part of every radiology examination in general; it is identical with any radiology department [8]:

1. Registration and Informed Consent. The process of capturing the clinician's request for performing a procedure. This includes the patient's clinical history and indications for the requested examination. The order entry process can be managed directly by the radiology department. This process is migrating to computer-based systems that directly capture the clinician's instructions. Computerized decision-support processes can be integrated into the selection and approval of appropriate procedures for a given clinical presentation.

2. Preauthorization: the process by which an insurances provider provisionally approves reimbursement for an examination. In some practices, using a third-party "appropriateness" tool or process provides required authorization. The specific requirements for approval vary by state, insurer, proposed examination, and patient's level of clinical acuity.

3. Scheduling. Managing the modality worklist: a process of automatically transferring the patient's procedure information directly to the imaging modality. Utilization of the modality worklist eliminates the manual entry of patient information into the imaging console, which reduces manual data entry errors and facilitates greater fidelity of RIS/PACS data flow.

4. Accessing patient's records. Gathering patient demographic and insurance information. This information is necessary to provide continuity of care, to access a patient's prior imaging studies, and to allow proper billing at the conclusion of the procedure.

5. Patient transportation / mobilization

6. Examination preparation. Creating an accession/procedure/exam order number: a process to manage the performance of an examination. An accession number is typically issued by the time the patient arrives into the radiology department but could be issued when the imaging order is received. The accession number coordinates with PACS/RIS to ensure reports are linked to proper examinations in PACS. The preparation also included scheduling of ordered procedures. This will involves the scheduling of the ordered procedure as well as maintaining a list of both scheduled procedures and available appointment openings.

7. Examination execution. The radiology technologist performs the scheduled procedure and tracks (time stamps) the process steps of examination performance.

8. Follow–up examination. This will be included managing coding workflow process. It is the process by which completed results receive CPT and ICD-9 coding information regarding performed examination, patient history, and indications required by insurance providers to receive reimbursement for the examination.

9. Reporting. Managing the interpretation workflow: a process by which completed cases are provided to the radiologist for interpretation. Management systems create and maintain radiologist task lists (or worklists) of unread procedures available for interpretation.

10. Archiving.

11. Result Distribution (Picture and Report): the process that informs the ordering clinician of the availability and result of procedure interpretation. This also includes a process for making results available directly to the patient (required for Meaningful Use). Results include both images and report. The notification and

communication of unexpected results are also an important component of the results distribution process.

12. Managing reimbursement workflow: the process by which the completed and coded procedure is transmitted to the responsible insurance provider or patient for payment.

4.3 Characteristics of Service at Radiology Department

As the diagnosis main component for a huge amount of patients in a hospital, radiology department has characteristics as follow:

- A vast and important communication, working together and coordination from all of them who are involved.
- Many different workflows and treatment methods (such as ultrasonography, conventional radiology diagnostic, fluoroscopy, angiography, CT, MRI, and nuclear medicine).

Workflow is very dependent to technology and how high the innovation level in imaging method, diagnostic, and therapy.

4.4 Radiology Information System (RIS)

RIS is a department information system in the scope of hospital information system. Thus, RIS is not an autonomy system but an integrated system with each other for medical procedural instead. There are two main exchanges in RIS process with other systems such as RIS has to communicate with PACS (Picture Archiving and Communication System) that is responsible for internal procedure that is conducted in radiology departments. RIS also interacts with HIS (Hospital Information System) to do patient information collection, renewing medical report for new testing and payment procedural process.

4.4.1 The Function of RIS

RIS is derived from detailed everyday workflow analysis results in radiology department and solutions that have been done by survey in every part fully [9]. This service is supported by 4 functions which are:

- Patients are visiting administrations to do registration.
- Patients that will do examination can do scheduling.
- Patient radiology examination report.
- Allocate the diagnostic document in accordance with the request.

There are also 2 groups that participate in RIS as follow:

- External, referral doctors will do examination request, imaging, and wait radiology examination results.
- Internal, radiology staffs or radiology doctors will do examination requests and respond in accordance with the diagnostic documents that are produced.

4.4.2 RIS Module

Here are a number of important features that is in RIS according to the recommendation from The Royal College of Radiologists [10]. The main feature of RIS are: Registration, Preparation, Examination, request and scheduling, Cancellation, Patient records, Examination reports, Search engines, Film Tracking, Supplies Management, Warning, and Payment Charge.

A RIS must be able to receive and process electronic referrals through integration with an electronic remote requesting (ERR) systems. But, it should be possible to enter non-electronic referral as well.

5. RESULT AND DISCUSSION

5.1 Radiology Workflow

This part will explain about the general workflow in radiology diagnostic world in a department or radiology unit in a hospital. Therefore, it will be discussed about how IT implementation with radiology information system application web – based can reduce traditional problems that are experienced by radiology departments in its role as service provider in other departments.

The design of the propose web – based radiology information system shown in Figure 1, Figure 2, and Figure 3. Figure 1 shows the Use Case diagram of the system, There are 6 actors on this systems consists of referral doctor, radiologist, radiology technician/radiographer, clerk, cashier, and nurse. The systems Class Diagram shown in Figure 2 and the main user interface shown in Figure 3.

5.1.1 Registration and Informed Consent Current Situation

Radiology service workflow is started from register process and informed consent as the first step. The basic steps are signing and preparing patients in radiology department are the same for scheduled and emergency patients, as well as for

inpatients and outpatients. This step is very important because the next quality from radiology examination report is very dependent on the accuracy of the early information.

Optimized situation

The doctor who requests the radiology examination can order/ask radiology service through Computerized Physician Order Entry or Computerized Provider Order Entry / CPOE).

For instance, the benefit of using operational CPOE for management can include:

- Simple tracking process for the necessary cost by each doctors as a result of the request of examination service
- On time workflow tracking to mark the effect on ALOS (Average Length of Stay)
- Comprehensive Documentation to facilitate the service payments
  The benefits of CPOE for doctors are:

- Simple tracking system from examination status
- The bigger efficiency for examination request service
- Clearer documentation and easier access for patient medical records

5.1.2 Scheduling

Current Situation

In the second step, called scheduling, nursing wards called radiology assistant that is responsible for examination scheduling by managing agreement using facsimile or order forms. Whereas for emergency scheduling, generally it is conducted through telephone. As the patient who needs a few examinations, chronological order of the examination is very important, for example, the check up that is conducted by swallowing the barium cannot be done after gastroscopy.

Figure 1. Use Case Diagram.

Optimized Situation

With this fully integrated radiology information system (RIS), centralized single schedule can be accessed from every workstation. Because of that, it's no longer needed to managing separated book deal for every modality. The scheduling can be conducted from wards, through web based applications, directly in RIS. RIS scheduling reduces the involved people in scheduling process, so that it will decrease the consumed time for communication.
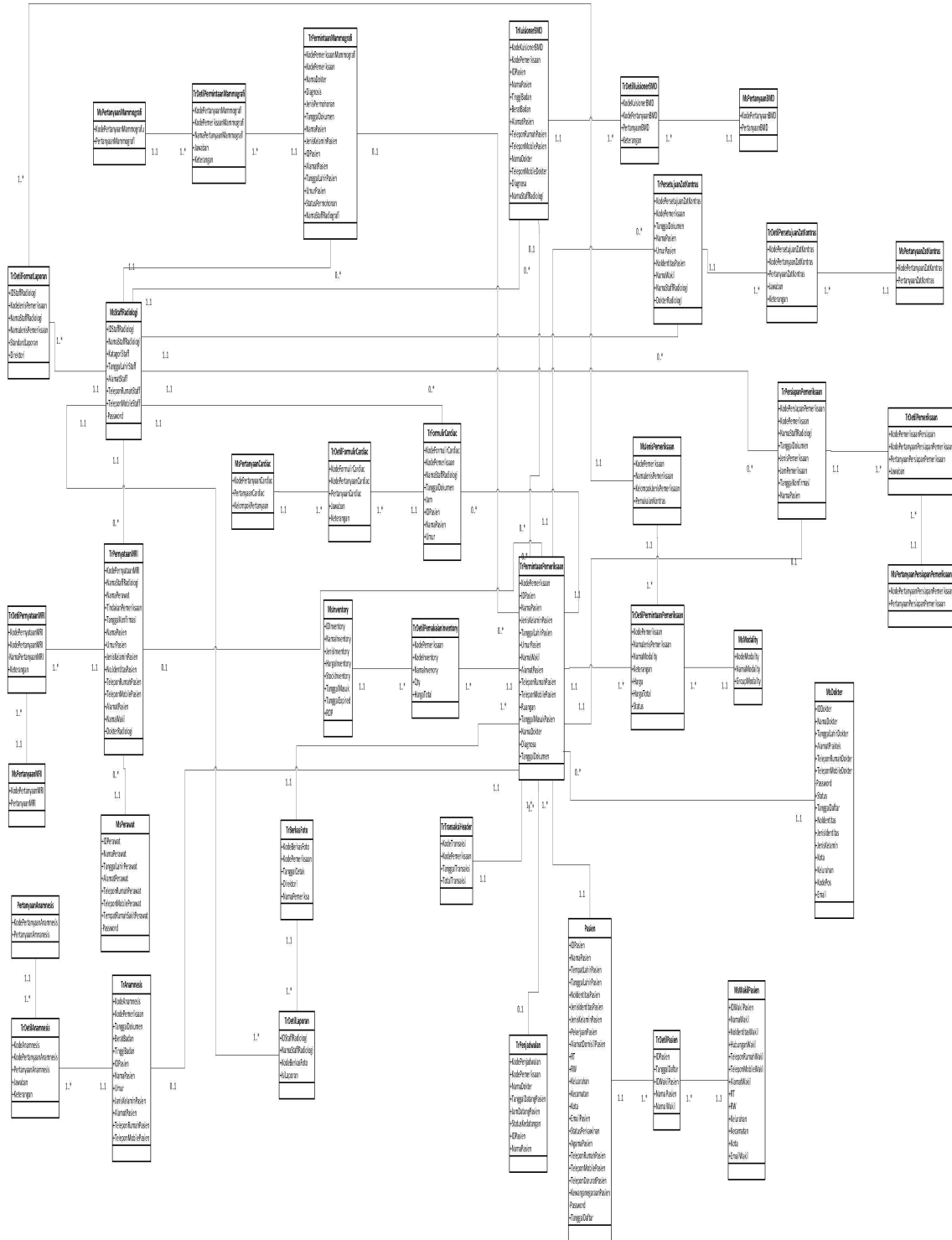
Figure 2. Class Diagram.

5.1.3   Patient Medical Record Access

Current situation

The third step is accessing patient records. When doing the follow – up examinations, radiology assistant asks patient records from archives so the current examination can be compared to the previous examination. Radiologists verify the indication for the requested examination for deciding whether the asked modality is the most appropriate for problems and patients individually. This case is done by looking examination sequence together with patient medical record.

Optimized situation

Figures and reports from previous examinations are taken from long – term saving electronically, using the PACS. Because it was assumed that the needed previous examination, the current relevant pictures are mounted in the memory, even before the requests are made, this technique is called "prefetching". Prefetching can be programmed to be happened in certain times where it can be adjusted according to each organization. Radiologists verify the indication for the asked examination using HIS that allows the sequential observation CPOE together with patient records.
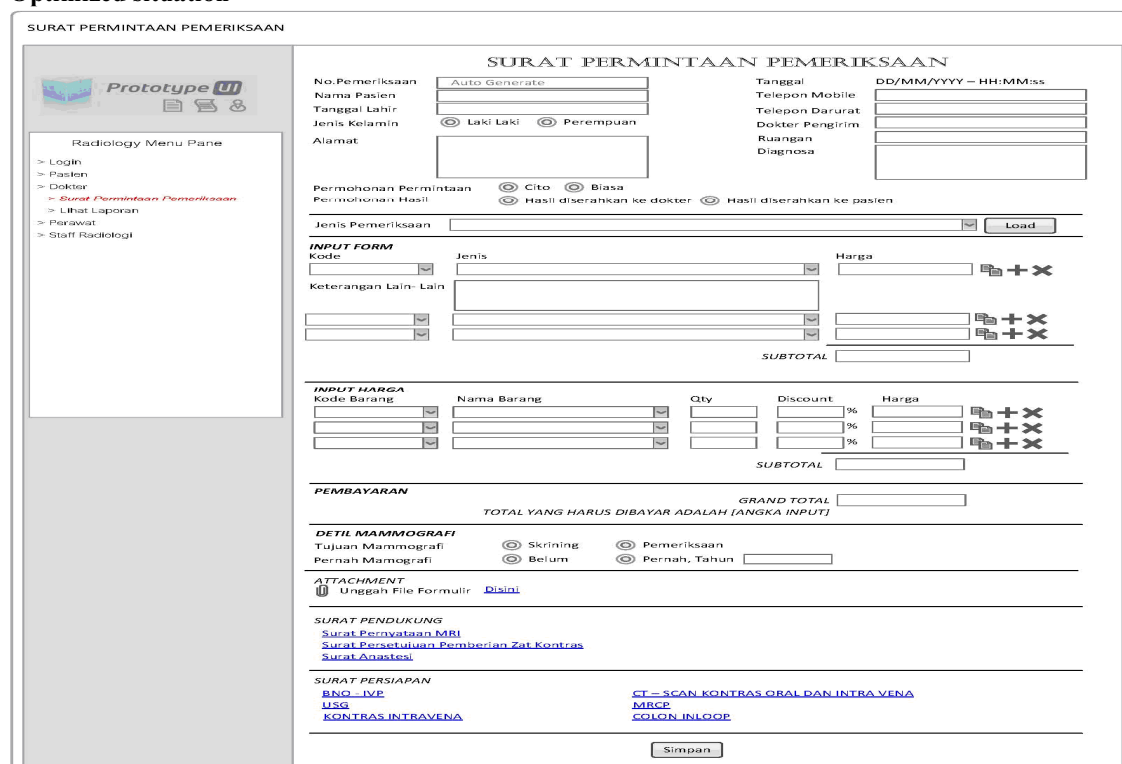

Figure 3. Radiology Cpoe User Interface.

5.1.4   Patient   Transportation/Mobilization
Current Situation

In this step, radiology assistant will call nursing wards before the scheduled examination to coordinate patient transportation to radiology department. The needed information about patient status is collected in terms of transportation coordination, including outpatients or otherwise. These factors are not just influential to the amount of time that is necessary for transportation, but also how long to prepare modalities, and the real

conducted experiments. The transportation service brings patients to the radiology departments and gives medical records to radiology assistant.

Optimized Situation

Radiology assistants call nursing wards in related fact with the scheduled radiology examination to request so that the patients come to the radiology department. Radiology assistant then can access patient transportation status through HIS or RIS. Just like the previous scenario, nursing wards direct the patients to the radiology department. However,

in this case, there is no need to call proper medical records and patient form to be brought together with the patients, because all of these are available in HIS as well.

5.1.5   Examination   Preparation   Current Situation

In this step, the radiographer checks patient's identity after it arrives in radiology to make sure that he is the scheduled man for the following examination. Because the patient documents that are needed for examinations are just available on papers and in the unstructured form, these documents are also checked for the completeness. After preparation, the patients are brought to the examination room and radiologists are assigned for examination implementation.

Optimized Situation

The radiographer starts examinations by transferring data to the equipments and taking working lists from HIS or Image Workflow Management System. The benefits are the basic patient data is not really filled manually again, which reduces the mistakes that often causes the loss context or the photo itself. Clinical symptoms are also prepared in the system, so that the correct examination can be done. In these steps, workflow from MRI imaging with the administration of contrast media that will be used as examples for many types of diagnostic examinations that can be done in radiology.

5.1.6   Examination   Implementation   Current Situation

The radiographers principally are responsible for technical aspects to do examination as well as documentation. Contrast media are used for visualize specific anatomy structure with a certain degree of precision or differentiate inter – networks. Radiographers can do post processing anything that is needed from picture sequence, even during the examination is on work. This case can be done in examination console or workstation post processing. Every relevant picture is archived on modalities or in workstation processing and the patient repatriated. Without PACS, there are two possible ways for archiving the finding / examination result:

- By producing laser film with laser camera.
- By archiving picture data on external media such as CD – ROM, DVD, or MOD (Magnetic Optical Disc).

Optimized Situation

If the integrated circuit of radiology application is applicable, the pictures that are got during the examination are automatically continued to the appropriate PACS console or to post processing workstation. Post processing aims on modification with computer aid from original data that are received from every imaging modality. This includes Multi Planar Reconstruction (MPR), Maximum Intensity Projection (MIP), 3D and volume rendering. This concludes that data can be archived in PACS for long terms without delaying storage room.

5.1.7   Follow – up Examination Current Situation

During this step, the information can be printed on the label or put on the needed shape and then for accurate billing. Moreover, the consumed materials during the examination, just like the amount of contrast media and other used medical material, facilitate additional supplies.

Optimized Situation

The work that is done are no longer documented on label, but written on imaging management workflow system. On the last examination, the modality reports the number of series and pictures, as well as the number of consumption items that will   be   billed.   An   electronic   warehouse management system makes sure that the necessary materials are always available in an appropriate amount. The benefit of this system is it does automatic order procedure matched with the programmed parameter and the consumed materials can be correlated with the specific patients.

5.1.8   Reporting Current Situation

In this step, there is no standard procedure because it depends on the hospital infrastructure and each individual radiologist preference. The assistant usually will hang the film on the light box to light the films so that the pictures can be compared. This is the first step for a few supportive procedures. The previous examination is always got asked during this step for a comparative reason. The radiologists add necessary corrections by hand and usually it is recorded in an audio cassette. The radiologists then send back the reports to the typist for further correction and give it back to the radiologists for final correction.

Optimized Situation

In this situation, the report will be made in the integrated workplace. All relevant data from two systems: RIS and PACS are available for everyone

that has authority to operate the equipments. Individual authorities can be calculated automatic work procedure sequences for each radiologist who starts to make a report. After that, post processing can directly be done in this stage with IT supports. The last report can be legalized in RIS by using electronic signatures. This digital identifier is similar to the signatures by law, especially become essential for specific sensitive patients.   The security infrastructure that fulfills the conditions that are agreed by law allows writer's identity and data integrity in the exchange of electronic data to be reliable.

5.1.9   Archiving

Current Situation

The main criteria that needs to be fulfilled for image data archiving on electronic storage data:

- Report writer, place, and issued place need to be identified.
- Original images need to be kept in post processing data.
- Personal data needs to be related to the reported finding.
- Data compression until certain degrees is permitted.
- The images that are sent need to be matched with the report.

Optimized Situation

When the report is done, radiologists archived the relevant radiology imaging data on radiology application circuit (RIS and PACS), that allows pictures and examination reports can be available for the requested department through the web – based distributed system. The lost image level can be reduced to zero. In this time, manual survey system states that the image lost in a radiology archive reach 30 %.

6.   CONCLUSIONS

6.1   The Advantages of a series of integrated radiology application

The big enhancement in efficiency can be achieved with the usage of a series of an integrated radiology application that offers full functions of RIS and PACS. For radiology, the most significant benefit covers:

- Mitigating the hospitalization time: international study has shown that PACS can diminish the overall of living hospital in the amount of 2, 4-8 hours.

- Lessening filming cost: The utilization of PACS drastically is cutting filming cost and filming processing cost. It has a potential to create a saving in a significant amount of money. However, the amount of film remainders, that are related with the examination type, are keep on used even with PACS application; so that the correct saving estimation needs an examination type of analysis that is conducted.

PACS offers an extra advantage, including:

- The reduction of archiving cost: If the conventional working method is continued, the archives may need to be expanded. Depends on how far the conventional film residues are used, radiology pictures slightly need to be archived when using PACS. As a result, the archive growth rate is decreased to the bigger level than the alternative choice to reduce the size of the archive that is available for conventional working method.

- Reducing the conventional film processing price: When PACS is used, maintenance cost to film processing equipments and reporting technology, just like light box and film alternator, are removed practically or reduced significantly, depend on the film residual usage. Other than that, investment planning to modernization and expansion of conventional building and reporting technology can be saved.

- Decrease personnel cost: The usage of PACS mitigates the needs of old and new film submission to take the previous examination from the archives, so that the amount of archives and radiology personnel, which are needed for patient administration, can be diminished. Besides, PACS utilization increases the workflow efficiency in radiology department as well as all hospitals.

- The improvement in overall quality: digital radiology also gives a quality that is better from reporting with the possibility of comparison with all previous examinations from other modalities, along with 3D reconstruction, sequence of sine graph analysis, imaging fusion (image blending). Image data is rarely gone, just like x-ray film that often happens and is archived.

- Financial impact: quickening picture distributions, increasing accuracy and correctness of examination billing cost, decreasing the source of mistakes, reducing the involved person, and facilitating the readiness of the constant

information as well as influencing the financial performance fully from health service provision.

6.2 IT helps optimizing radiologist workflow

The benefits from IT:

• Examination Registration / Appointment: CPOE makes a scheduling easier, removes tiring communication on registration process and scheduling. With CPOE, the background information on the patient's clinical is kept in HIS and can be accessed anywhere from radiologist and others.

• Scheduling: Centralization scheduling through RIS that enables promises will be reallocated electronically, so that it will reducing the amount of involved people in a process and effort that is needed for communication.

• Accessing Patient Records: The previous examination can be loaded automatically through PACS, so that it will minimize the amount of data search requests.

• Patient Transportation: The status of patient transportation and all patients' data that are relevant can be accessed every time through HIS or RIS.

• Examination Preparation: Patients' data that are need for examinations always available and can be transferred directly from HIS to modalities, so that it decreases the possibility of errors.

It should be cleared that the radiology workflow efficiency can be increased with modern IT. Radiology department is positioned uniquely in a crossroad in clinical workflow, because it operates exclusively as the service provider for other departments in hospitals. In conclusion, let us look at the most important benefits to integrate IT inside radiology workflow.

Examination implementation:

• The graphs that are acquired during the checking can be diverted directly to PACS console that is appropriate or to post-processing workstation, so the report becomes easier and faster.

• Follow-up work examination. The examination that has just been conducted will be listed immediately from imaging workflow management system. Besides, electronic warehouse management system guarantees automatic reordering material.

• Reporting: Working on workstation that is integrated and used voice recognition system accelerating reporting.

• Archiving: reports are archived through PACS can be accessed quickly from requesting department. Besides, the data lost risk, is compared to films that are processed in dark room, removed practically, and decreased archiving cost.

If we see it closely in the radiology workflow, you will be able to see how every useful step from IT support.

6.3 The comparison of today's situation and optimized situation with The Benefits of Radiology Information System – A process that is more slender.

The comparison of actual workflow and target workflow is expected to show that the radiology workflow process can be downsized. The left diagram shows the today's situation. In the right diagram, every step that are marked with red color can be erased, represents an optimized workflow. As you can see, the benefit of a series of an integrated radiology application has impacts on every step. Digital radiology technology is assured to have positive implication for financial performance in total from health service provider. Other than that, because it is more accurate in many cases, a series of an integrated radiology application increases the nursing quality. Overall, IT solution in radiology increases department efficiencies, and gives contribution to give faster recovery treatment.

7. RECOMMENDATIONS

For the next study, it is recommended that the implementation and testing have to be done against the system that has been built as well as continue to do data warehouse design that is used for patient database management and examination results.

Web-based radiology information system can be further developed as a basis for the development of e-business in radiology services.

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