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RADIOLOGY DATA WAREHOUSE DEVELOPMENT AS A MEANS OF EDUCATION, RESEARCH, AND QUALITY ASSURANCE

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ABSTRACT

Today almost all of the data in the radiology department is already in digital form because it is one of the hospital departments that use many computerized systems. The data contains information that is essential for the development of health care. Data warehouse (DW) development has been widely used in business, but it also can be used in health care. The objective of this study is design a model of data warehouse that can be implemented in radiology department so it can be a source of knowledge of radiology science. The research method used on this study are 1) data collection through literature review, forum group discussion with radiologist, and observations; 2) design method of data warehouse using the fourth stages of data warehouse design methodology Kimball and Ross (2013). Through this research we will design a radiology data warehouse so the radiologist or researcher can analyze report requirement from case study of patient historical record and assess the accuracy of diagnosis by comparing the results of radiological diagnosis with laboratory test results and other medical record from anamneses, medical procedure, medical treatment, or patient questionnaire.

Keywords: *Radiology Data Warehouse*

1. INTRODUCTION

Radiology operational data at the hospital is one of the largest data because the data contains either in text (alphanumeric) or images. Accordance in the laws and regulations (PERMENKES No. 269/MENKES/PER/III/2008 on Medical Record), the operational data must be stored at least in a period of 5 years. Therefore the implementation of data warehouse (DW) is very necessary to support radiology department.

Medical record is a file containing the records and documents about the identity of the patient, examination, treatment, and other services has been given to the patient. This information is a valuable data for the hospital. The data will be transferred to the long-term storage media after that time period. Therefore it can have problems if necessary to access the data that has been entered into the long-term storage medium, for example if there is a sudden need for ad hoc reports with historical data then it will take a long time. In addition, there is a need to conduct an analysis of historical data based on time series, patient, disease, doctors, age, gender, and other information for the purposes of radiological science development and service improvement. The following overarching research question will guide the research: How is the model of data warehouse in clinical and administrative aspects of the hospital's radiology department? Therefore it is necessary to develop a data warehouse system to utilize such data for the purposes of education, research, and quality assurance of radiology services.

2. THE RESEARCH PURPOSE AND BENEFIT

The objective of this study is to design radiology data warehouse that can be used to by radiologist and to improve the quality of radiology services.

The specific purposes of this study are as follows:

a. Education: to generate a report or inquiry of the case study of patient historical data as study materials for radiologist to improve patient

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disease diagnosis skills based on radiological images.

b. Research: through the database system will facilitate the collection of data and easy to access the data in the research of radiology field.

c. Quality assurance: Allows the comparison of diagnostic results with laboratory test or other medical treatment report to assess the accuracy of the diagnosis.

This research will give benefit to the radiologist, doctors, and the researcher in health care.

3. RESEARCH METHOD

In carrying out this research, it is used data collection method as well as design of data warehouse that will be explained as follow.

3.1 Data Collection Method

The data collection method that is used in this research is:

a. Literature review

To obtain information on the preliminary study that has been conducted in this research field and get the results that have been achieved in previous study. This information is necessary to formulate a research gap by previous study.

b. Forum Group Discussion

In this method, the discussion is executed directly to a radiologist to get the requirement of the information that can be used from the development of radiology data warehouse.

c. Observation

In this method, writer does an observation against radiology process in some hospital in Jakarta, Indonesia. Radiology process that is observed is a workflow in radiology department of hospital.

3.2 Data Warehouse Design Method

Data warehouse design method to be used is in accordance with the methodology recommended by Kimball and Ross (2013), namely the fourth stages of data warehouse design methodology as follows:

a. Choosing the process

b. Choosing the grain

c. Identifying and Conforming the dimensions

d. Choosing the facts

4. LITERATURE REVIEW

4.1 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.

4.1.1 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 [1]. This service is supported by 4 functions which are:

- Patient admission: Patients are visiting administrations to do registration.
- Scheduling and examination: Examination of the patient will be scheduled and will be conducted as scheduled.
- Radiology examination reporting: radiology expertise report will be reported by radiologist..
- Distribution of Radiology result and archiving: 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, obtaining the radiology images, 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.

4.1.2 RIS Module

Here are a number of important features that is in RIS according to the recommendation from The Royal College of Radiologists [2]. 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.

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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.

4.2 Data and Information

According to Inmon (2005:493), the data is a record of the facts, concepts, or instructions on the storage medium for communication, acquisition, and processing by means of automatic and presentation as information that can be understood by humans. Meanwhile, according to McLeod and Schell (2007:9), the data is a collection of facts and figures that generally could not be used because of its huge size and unprocessed.

According to Inmon (2005: 498), the information is data that has been assimilated and evaluated by humans to solve a problem or make a decision.

According to McLeod and Schell (2007: 9), the information is data that has been processed and has a meaning, usually tells users something they do not know.

4.3 Data Warehouse

According Inmon (2005: 29), the data warehouse is a collection of the data subject oriented, integrated, time variation (time-variant), and not change (non-volatile) to support management decision-making process.

4.3.1 Characteristic of Data Warehouse

1. Subject-Oriented

Data warehouse is organized by the main subject of the company (such as customer, product, and sales) than on the basis of the main application areas (such as customer invoicing, inventory control and product sales). This illustrates the existing data in the data warehouse is the data for decision-making, not data-oriented applications.

2. Integrated

The data in the data warehouse is derived and different data sources from different application systems throughout the enterprise. Source data is usually used inconsistently, for example, different formats. Integrated data sources should be made consistent to display an integrated view of the data to the user.

3. Time-variant

The data in the data warehouse is accurate and valid only within a certain time or within a certain time interval.

4. Non-volatile

The data in the data warehouse is not updated in real-time, but updated periodically from the operating system. The new data are being added as an extra to the database rather than as a replacement

4.3.2 Structure Data Warehouse

According to Inmon (2005: 33), the data warehouse has some level of detail, namely: older level of detail (usually found in the alternate storage area), the current level of detail, lightly summarized the data (level data marts), and highly summarized data. The flow of data into the data warehouse from the operational environment. Usually the transformation of data from the operational level to the level of the data warehouse. If the data in the data warehouse of aging, then the data will be moved from the current older detail to detail. If the data has been compiled, the data will be moved from the current details to lightly summarized data and then from lightly summarized data to highly summarized data.

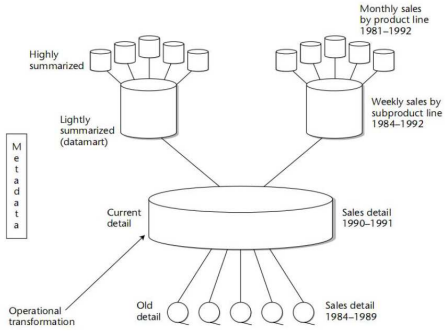

Figure 1. Structure Data Warehouse

4.4 Data Integration to Data Warehouse

According to Inmon (2005), ETL (Extract, Transform, Load) is a process in data warehouse that adding value to data through cleaning, changing, and improving data.

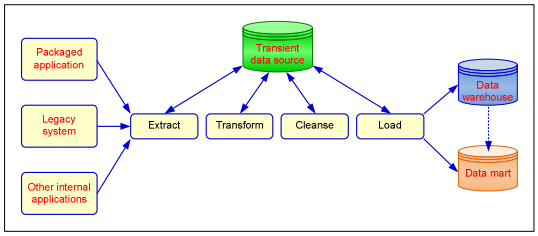

Figure 2. ETL (Extraction, Transformation, And Load) Process

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4.5 Dimension and Fact Table

According to Kimball, R., & Ross, M. (2013), A fact table is the primary table in a dimensional model where the numerical performance measurements of the business are stored.

We use the term fact to represent a business measure. We can imagine standing in the marketplace watching products being sold and writing down the quantity sold and dollar sales amount each day for each product in each store. A measurement is taken at the intersection of all the dimensions (day, product, and store). This list of dimensions defines the grain of the fact table and tells us what the scope of the measurement is.

4.6 Data Warehouse in Clinical Field

Some studies already conducted on implementation of data warehouse in clinical environment. A multimedia data warehouse in the medical field has been implemented on a therapeutic study on acute myocardial infarction based on ECG graphics [7]. This new approach integrates different computation modes of Functional Multiversion Multidimensional Model into the proposed model, in order to allow the user to select the best representation of data.

Second study by Rubin & Desser (2008), described the design, methodology, and implementation of a data warehouse to integrate and make accessible the types of medical data pertinent to radiology research and teaching. A database schema was designed to link radiology and pathology reports and to enable users to retrieve cases using flexible queries. The system can be implemented in radiology departments within a reasonable budget to make their vast radiologic-pathologic case material accessible for education and research [8].

Another study by Demigha (2010) realized that a systematic screening can result in a volume of data which cannot be managed by present computer architecture, either in terms of storage capabilities or in terms of exploitation tools [9]. This study proposed the design and development methodology of data warehouse system in radiology-senology (DWRS). The DW used to support the important volume of information providing from multiple sources of data and images and for the other hand, to help assist breast cancer screening in diagnosis, education and research.

Based on the results of previous research about the application of data warehouse in the clinical field, it can be concluded that the data warehouse can be used as a tool for accessing and representing data for the purposes of research, teaching, and diagnosis. By applying the methodologies, which have been discussed in previous research, this study will develop a data warehouse that integrates radiology and pathology data together with clinical records and other administration record with the intent for education, research, and quality assurance.

5. RESULT AND DISCUSSION

5.1 Radiology Workflow

Based on previous study [5], the following is a summary of radiology workflow:

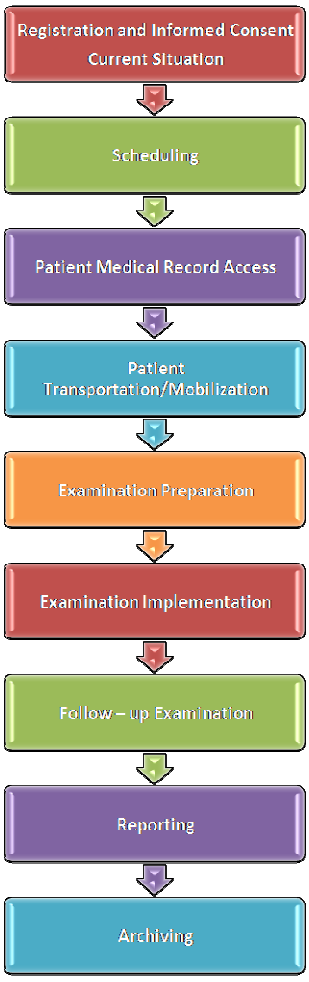

Figure 3. Radiology Workflow

5.2 Forum Group Discussion with Radiologist

Qualitative analysis is conducted through discussion with radiologist to get information about the source systems and the requirement of report or

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inquiry in radiology environment. The results are shown by the figure 4 below.

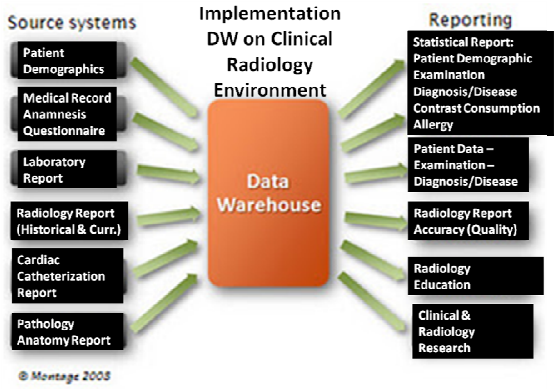

Figure 4. Implementation DW On Radiology Environment

Based on discussion, the benefit of radiology data warehouse (DW) only useful when the radiologist active as a speaker in a seminar or conference. The radiology data warehouse is only worthwhile for research, education, and public health policy for government.

The radiologist also state that RIS (Radiology Information System) must contribute in radiology data warehouse, as follows:

- Keywords about image impression should be recorded on the RIS systems.
- Integration of ICD-10 on RIS Report
- Scanning of 3rd party data/information in to the RIS (eg. pathology laboratory result or operation report).
- Query of radiology historical case using disease keyword

5.3 Design of Radiology Data Warehouse

5.3.1 Choosing the process

Referring to radiology workflow on the previous study, we will choose business process of radiology department that are focused on: 1) Patient Registration, 2) Radiology & Laboratory Examination

5.3.2 Choosing the grain

Grain determines the representation of fact table row.

In radiology and laboratory examination we analyze: total examination based on the type of examination; total patient based on age and disease; total patient based on gender and the type of disease; total patient based on region and the type of disease; total patient based on type of disease and type of examination; total patient based on examination parameter and type of disease.

In the statement of radiology examination, the analysis include: total patient based on group of questions; total patient based on type of application; total patient based on type of disease and statement; total patient based on group of question and age; total patient based on group of question and region.

5.3.3 Identifying and conforming the dimension

In this step, we determine the dimension as follow:

1. Time dimension

Contain details about the time that occurs when the examination took place. The details include: Year, Month, and Date

2. Patient dimension

Contain details about the patient personal data, such as Patient ID, Patient Name, Date of Birth, Gender, and Address.

3. Modality/Examination type dimension

Contain details about examination type that are available on radiology and laboratory department. The details include: Examination Type Number, Examination Type Name, and Examination Group Name.

4. Examination Parameter dimension

Contain details parameter are used in measuring the result of laboratory test. The details include: Examination Parameter Number, Examination Parameter Name, Examination Parameter Type Name.

5. Region dimension

Contain details about the address of patient or staff, include: City, District, Region

6. ICD10 dimension

Contain details about standard code used to diagnose the disease and recognized internationally. The details include: ICD10 Number, Disease Name

7. Question Group dimension

Contain details about the group of questions asked to the patient before radiology examination. The details include: Group of Question, Question

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5.3.4 Choosing the facts

Based on the dimension, we determine the important fact, as follow:

1. Fact Registration

Fact registration consists of examination statement that must be filled by patient.

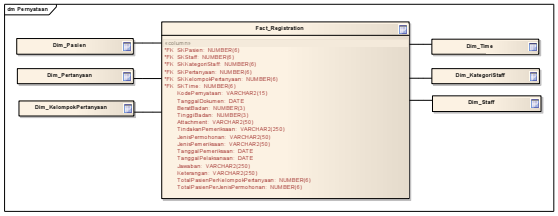

Figure 5. Fact Registration

2. Fact Examination

Fact examination is combining the details of radiology and laboratory examination.

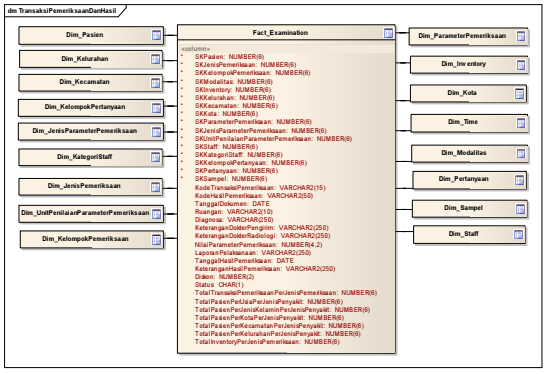

Figure 6. Fact Radiology & Laboratory Examination

Limitations in the development of a data warehouse is not performed data warehouse implementation on the image information radiology and pathology anatomy. In addition, the output data warehouse designed intended for clinical purposes only, not designed output required to support operational management of radiology and pathology departments in the hospital.

This study successfully implement methodologies that have been proposed in previous research to develop a system of DW in radiology. The advantages of this study compared with DW previous research is generated not only of integrating the data radiology and pathology and patient administration alone. The resulting output is not only used for accessing and presenting information for educational purposes, research, and diagnosis, but the output is also used to help perform assessment to the accuracy of the diagnosis (*Quality Assurance*). So that this system is useful for improving the quality of radiological diagnosis by the radiologist from time to time.

6. CONCLUSIONS

The following are the conclusions of this research:

1. A collection of data recorded in the RIS (Radiology Information System) has valuable information for the development of healthcare, specifically for the radiologist, doctors, and researchers in radiology field.
2. Development of Radiology Data warehouse can facilitate radiologist access to necessary information in radiology report. A report of patient historical data can be used as study materials for radiologist to improve diagnosis skills for determining patient disease.
3. Fact Examination can be used to integrate radiology examination results and laboratory test. This function will allow the comparison of the diagnostic results, so the doctors or radiologist can assess the accuracy of the diagnosis and improve the quality assurance of radiology services

7. RECOMMENDATIONS

For the next study, it is recommended that the design of data warehouse is continued with implementation and testing, and also to evaluate the benefit of the generated report. In the future, the radiology data warehouse can be used as a source of data for business intelligence that will help the visualization of data reports that can be analyzed well. Beside of that, the implementation of multimedia data warehouse on the radiology images data will give an additional advantage.

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