



# Neurosurgery Reporting System (NeuroSyRS): Prototype of Innovative Information System Application in Neurosurgery Center, Bandung, Indonesia

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## Authors' contributions

This work was carried out in collaboration between all authors. Authors AF, MZA, ABS and SAY designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and managed literature searches. This study was supported by Grants-in-Aid, Internal Grant No. 1390/UN6.C/Kep/PN/2014(075), Faculty of Medicine, Universitas Padjadjaran for Research and Development on Medical Biotechnology. All authors read and approved the final manuscript.

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## ABSTRACT

**Objectives:** Neurosurgery Reporting System (NeuroSyRS), innovative information system application designed for healthcare with comprehensive scope. NeuroSyRS is a web-based with costum-made, modular-dynamic design; can be enhanced using cloud.

**Methods:** NeuroSyRS combines the open-source flexible system design that benefits for implementation and development needs as well as support for mobile devices to enable high quality patient care. The web-based network allows online access not only among departments but also between government and private installations. NeuroSyRS platform is designed to meet the

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needs of database management and its interphase with other services that are responsible for data acquisition and visualization. NeuroSyRS act as central-portal and -data base in the communication information system (ICT), designed to compile patient report paperless and equipped with tele-consultation.

**Results:** NeuroSyRS is a prototype that developed for a variety of administrative processes. This system will simplify the work process and can be integrated with hospital health care system, Health Department and the Ministry of Health. A good ICT will be useful in collecting clinical information than conventional paper-based reporting system and to minimize errors in the reporting chain.

**Conclusions:** Our system may bridging gap between the clinical needs and digital documentation, telemedicine-monitoring and improve the quality of patient care, facilitate communication within both the scope of the internal (hospital) and external (stakeholders and follow-up), increasing productivity and reduce overall expenses.

*Keywords: Neurosurgery Reporting System (NeuroSyRS); Medical IT; Information Communication System (ICT); eHealth Cloud Computing.*

## 1. INTRODUCTION

There has been an increase of 14.5% in the incidence of traumatic brain injury at the Dr. Hasan Sadikin Hospital (RSHS) in Bandung, in the 2010-2011 period. In the year 2011, there were 2,509 cases of head injury, divided into 1,856 mild head injury patients (74%), 348 moderate head injury patients (17%), and 215 severe head injury patients (9%). The mortality rate of patients with severe head injury had also increased, from 33% in 2010 to 43% in 2011. The number of patients presenting to the emergency department in 2011 were 9,608 patients, which is an average of 800 patients per month. Of these patients, an average of 384 patients per month were motorized vehicle accident cases, averaging 67 mortality per month, of which 14 patients were dead on arrival [1].

Results of a community survey of basic health research conducted by the Ministry of Health of the Republic of Indonesia in 2007, with a sample size of 987,2005 from 258 366 head of the family, in 33 province [2], it was found that stroke is the leading cause of death in the community over the age of 5 years including 4-15% of all causes of death in this country [3]. Survey in 2004 reported that stroke is the number one killer in government hospitals across Indonesia. There were an estimated 500,000 people per year affected by strokes that occurred in Indonesia [4]. Risk factors for stroke in Indonesia is hypertension (73.9%), smoking (20.4%), heart disease (19.9%), and diabetes mellitus (17.3%) [5]. Among those, one-third have complete remission, another third have mild to moderate functional impairment and the remaining third experience a severe functional impairment

requiring patients to be treated continuously in a special treatment room until death.

The role of medical information technology (IT) is expanding in the field of healthcare and medicine, especially in the development and use of computer programs. In the field of neurosurgery, such programs have seen much use, such as computer programs which monitor intracranial pressure, oxygen saturation, body temperature and blood glucose level in the head injured patients [6], the rendering of 3-dimensional images for volume calculation of intracranial masses [7], and the system of monitoring for head trauma patients at home [8]. Earlier studies of information technology programs in neurosurgery shows a trend to imaging software, such as magnetic resonance imaging, 3-D computed tomography scans, digital angiography, and the use of operating microscopes and robotic technology. Interest in the field of tele-neurosurgery is also increasing.

Neurosurgery Reporting System (NeuroSyRS) is designed to manage patient's data for the purpose of education and research. There are special requirements for acquisition and visualization. Central portal and data collection is required for this information system to facilitate better data retrieval compared to manual medical record book. In addition, the system is expected to be used for online consultation between resident and consultant, and, in the future, with patient. This server is equipped with cloud computing that allows users to access the system inside and outside the RSHS using an internet connection. This data includes history taking, physical examination, laboratory examination, imaging results and management.

This application is aimed to improve reporting systems and patient data retrieval in the Department of Neurosurgery, RSHS. Additionally, telemedicine for remote consultation also been made in this system. The purpose is to facilitate the understanding and use of software for prospective neurosurgeons, general surgeons, general practitioners, and nurses the first time they use the application. The display of the application is designed to support patient report for educational purposes and provide the transmission of information when referring a patient. This system is also intended to guide a surgeon during operation through audio-visual tele-consultation, tele-neurosurgery. This system is expected to help, because the number of neurosurgeons in Indonesia are still relatively small. This system is expected to be widely used not only for the Neurosurgery department but also for other departments within the Faculty of Medicine Padjadjaran University (FK UNPAD)-RSHS. This is possible because the core engine of the software application is based on web. If the system is integrated with other departments in the FK UNPAD-RSHS or even with other hospitals in Bandung or all over Indonesia, then this system may improve healthcare services. In

this study it's important to create web-based prototype of NeuroSyRS software.

## 2. METHODS

A trial been conducted in Neurosurgery laboratory in FK UNPAD-RSHS in collaboration with PT. TELKOM, Bandung. If the technical feasibility has been carried out in the Laboratory of Neurosurgery, this tool can also be used in another departments.

### 2.1 Network System and Engine

*NeuroSyRS* system network architecture consists of several sub-systems (Fig. 1):

- Engine management information system (*NeuroSyRS*)
- Multimodal data entry system that allows users to record data using a web browser, SMS and android application
- GIS-based user interface to retrieve *NeuroSyRS* data
- Broadband access for telemedicine and *NeuroSyRS* systems.

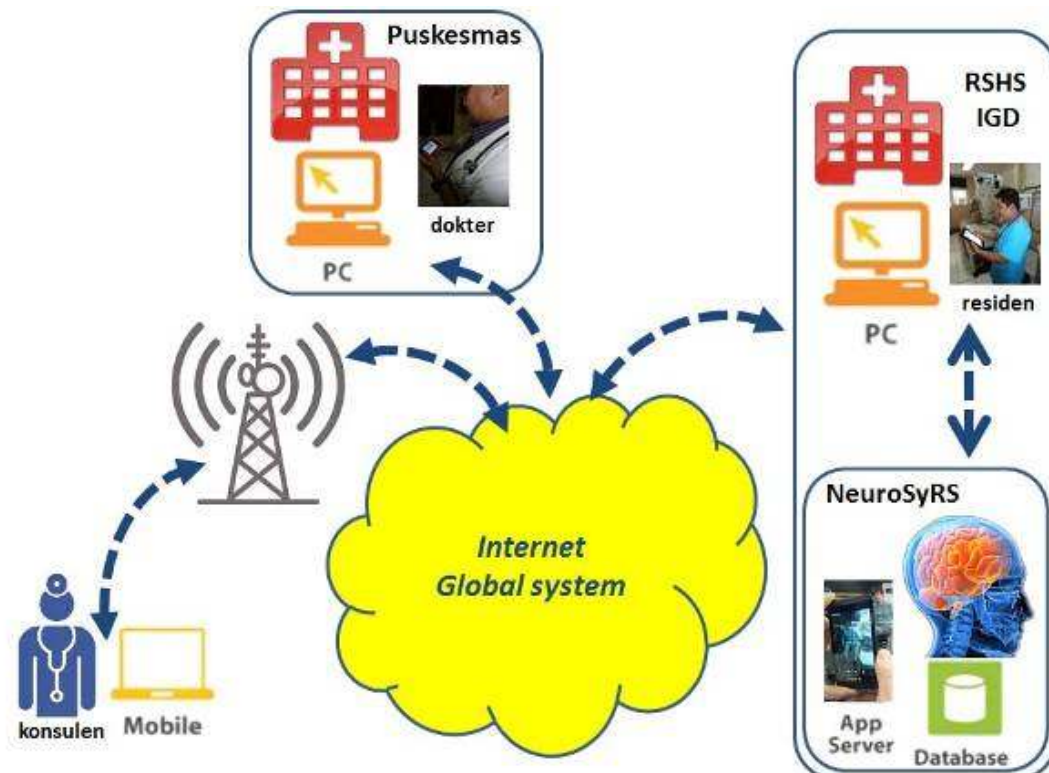


Fig. 1. NeuroSyRS system network architecture

NeurosyRS engine and multimodal data entry system lead users to maximize broadband communication systems usage available in the urban area and the surrounding area. The WiFi technology that been used in the emergency room; connected to surrounding areas and hospitals providing Neurosurgery services. In isolated or disastrous areas, the biggest challenge is not only due to broadband infrastructure but also the availability of electrical source. Based on earlier ideas, a communication package provided with solar system, WiFi receiver and NeurosyRS communication tools to support the system. Telemedicine system is included with a teleconferencing system that allows neurosurgeons to communicate with residents, paramedics, physicians and general surgeons. Full communication services been built in accordance with the needs of the user.

## 2.2 Coverage of Software Design

Coverage of NeuroSyRS system includes:

1. Service advancement of new patient data capture and ICU, reduce bias due to missing data or written data is converted into digital data, reducing the time to rewrite the data and transform into a report view.
2. Making better display than health care system within the FK UNPAD-RSHS. Some of the better sense is, the better the performance compared to the time before using the system faster data transfer, display better data format, organized presentation of information management, etc.
3. The efficiency of the user interface. The main goal in building this system is to provide software that is very easy to be use by users, enables users simply by pressing a button or touching the screen, or transfer data to a variety of communication tools available.
4. Provide a variety of information to be able to immediately make a clinical decision or action of the received data and their application in the field response.

## 2.3 Entity Relationship Diagram

Entity Relationship (ER) is a system built describes the relationship between the stored data into tables that appear. Physical appearance of the table data is usually processed computer to be initiated the structure

of meta-data into a database management system as an object relationship data base in the form of tables, views, stored procedures, and constraint data. ER diagrams are usually used to modify the design into a rational system of database objects; to maintain the structure of meta-data from database.

## 2.4 Graphic User Interface (GUI) Dan Multimodal Data Entry

Other development, when no smartphone, can be sought with text-based mobile phone based services (TBC). TB can be either short message service (SMS) and Unstructured Supplementary Service Data (USSD).

## 2.5 Geographic Information System (GIS)-Based Statistic Reports

The use of geographic information systems based on the display can be of much help health authorities to monitor patterns of disease and predict certain region, so that this information can assist policy makers in health issues in area earlier.

## 2.6 Technology Acceptance Model (TAM)

In the information systems required profile data to be used in the reporting system in the Department of Neurosurgery RSHS.

## 2.7 Cloud Computing

Cloud computing is the combined use of computer technology and internet-based development. The latest development in computer systems technology that allows users to only pay the appropriate use of that offer high-quality technology solutions in a timely, cost-effective and fast response. Advantages of cloud computing:

1. Cost savings, without the need of spending in the establishment of IT infrastructure both software and hardware.
2. Increased storage capacity. It saves data storage media because the data lies in the application and database servers.
3. Automation. Applications are updated at any time.
4. Flexibility. Can be optimized according to business needs.
5. Mobility. Users can access the applications and information anywhere and anytime using mobile devices.

Simultaneously, in the above process also gather information about equipment needed throughout FK UNPAD-RSHS, Bandung and other hospitals in Indonesia, which has emergency care facilities, out- and in-patient clinic. Coordination needs to be carried out by the Ministry of Health and Social Security Agency (BPJS) to establish policies that is correlated with research results along with industry-counterpart that will be potentially used and utilized by the people of Indonesia.

### 3. RESULTS AND DISCUSSION

#### 3.1 Network System and Engine

NeuroSyRS system and engine used is created to accommodate new data design and protocols have been implemented in the field. Training will also be conducted by authorities and neurosurgeons to record all medical needs and accommodate it into the system. Basic needs of the system are derived from the needs of users in order to facilitate consumer in completing tasks in the field. NeuroSyRS software system is designed to interact with the consumer anytime anywhere.

#### 3.2 Logic Representation of NeuroSyRS Software System

New patients and patients in the intensive care unit (ICU) reporting system software will be elaborated into the relationship between actor-system; was shown in Fig. 2. Actor in this system is expressed in Table 1.

Actor represents people, system, external users or stakeholders who provide input or abstract output of the system. Diagram of this system, both will interact between actors and the system that is built to describe what the system is doing and obtained role based on task. Elaboration will be accommodated into the system as shown in Table 2.

The use of the above diagram aims to transform into a layer of information that states the general method of interaction. The next step is to arrange diagrams such as: interface diagram, library object programmers, and interface collaboration diagrams. Software system framework code is arranged based on these diagrams.

#### 3.3 Entity Relationship Diagram

ER diagram of NeuroSyRS can be seen in Fig. 4. The first phase of the design of the information system and sub-system that is used in it during the data analysis process needed to describe the information needs or the type of information that will be stored in a database format. Data modeling techniques can be used to describe various forms of ontology (such as an overview, calcification terminology and relationships among them) to display the data as the user desires.

#### 3.4 Graphic User Interface (GUI) Dan Multimodal Data Entry

In order to operated under no-internet conditions, we were to design a data entry that can be matched with the data of the SMS or USSD (Fig. 4).

#### 3.5 Geographic Information System (GIS)-Based Statistic Reports

NeuroSyRS system also equipped by GIS-based statistic reports

#### 3.6 Technology Acceptance Model (TAM)

The interface and the application display shown in Figs. 5 and 6, respectively. For the database, we use the SQL server to store pasien data [9]. The results will be evaluated to be eased user using TAM. From the data entry results of the software developed self-calculating statistic, as shown in Fig. 7.

#### 3.7 Cloud Computing

Cloud computing (Fig. 8) is the future of this technology is not only intended for the analysis and examination of neurosurgical disorders alone, but also can be developed into other fields. Its because Cloud Computing based on three parts: software, infrastructure, and platform as a service (SAAS, IAAS, PAAS) [10]. Thus local content can fill the three aspects mentioned above, such as for example, the development of software for applications in hospital, should not mass produced, but can be saved in the computing facilities and mobile devices (laptops, mobile phones, tablet PCs) (Fig. 9) which could be used by many people and can be adapted to the needs of its users (customize).

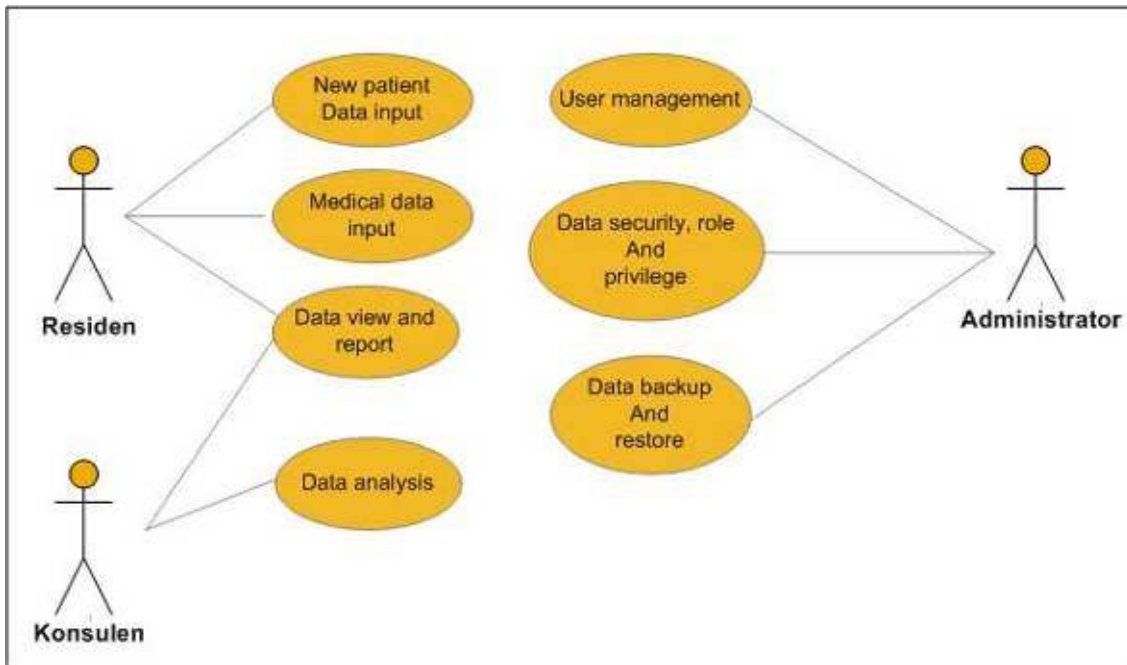


Fig. 2. NeuroSyRS software will elaborated into the relationship between actor-system

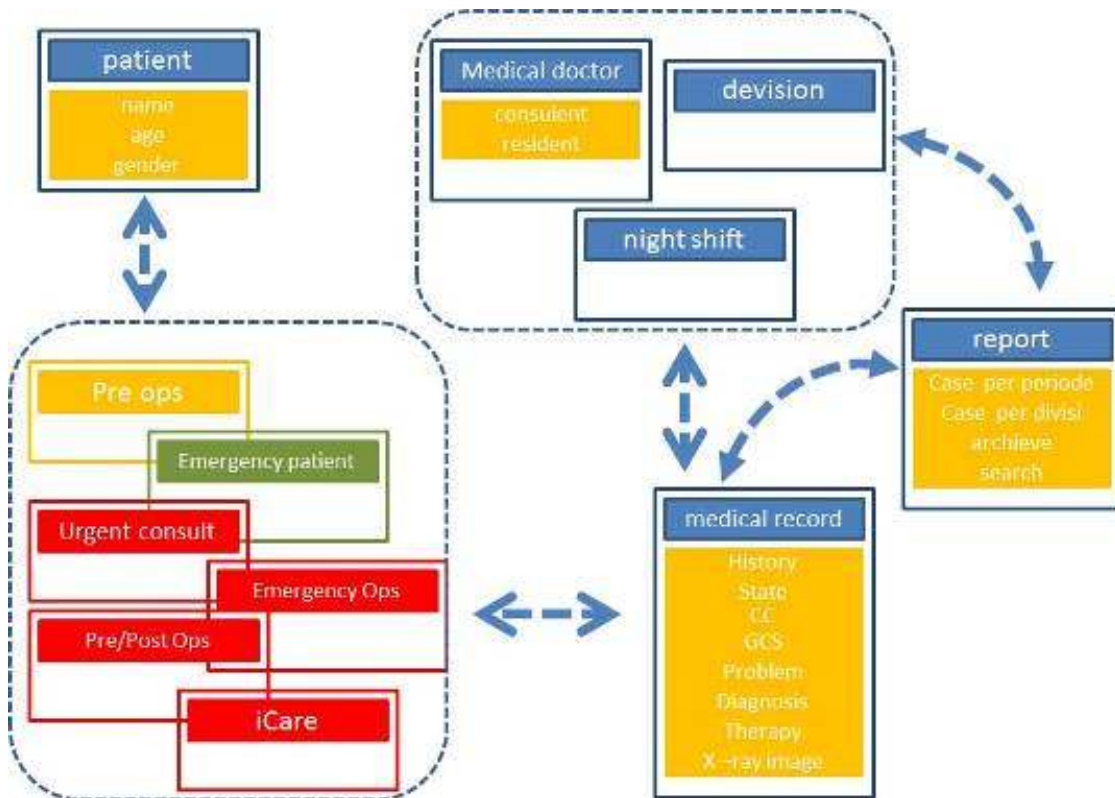


Fig. 3. Entity relationship (ER) diagram of NeuroSyRS system

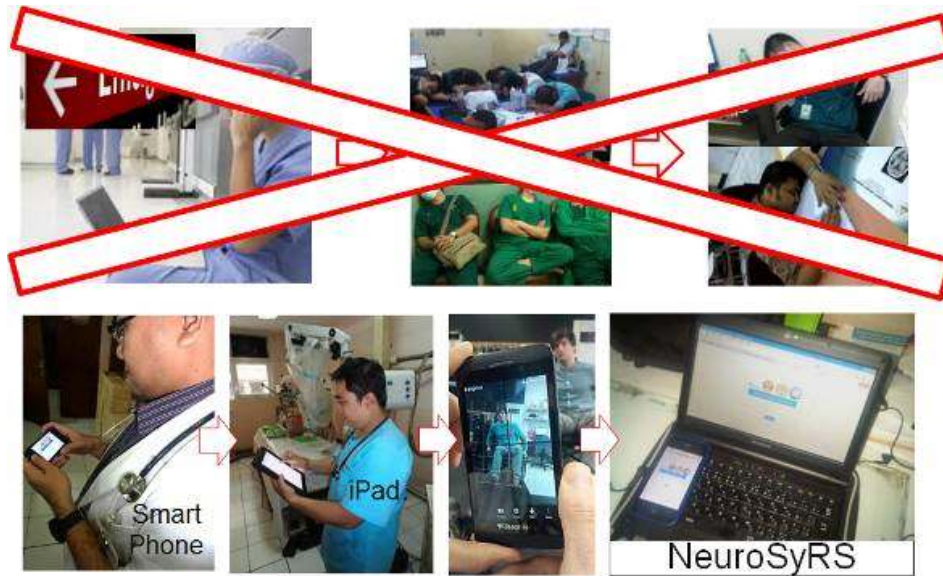


Fig. 4. Multimodal data entry for NeuroSyRS system



Fig. 5. NeuroSyRS Graphic user interface (GUI)

Tabel 1. Actor report in NeuroSyRS system of new patient and ICU patient

No	Actor	Descriptions
1	Administration	Users enable to activate access into the system. Responsible for operational, back up, security, maintenance the system
2	Resident	Users are responsible for data entry into the system
3	Consulent	Users who process incoming data, read and analyze

It is expected to stimulate the Indonesian people to be creative without having to worry about the needs of the place, maintenance, data security, licensing, infrastructure, high cost and can be accessed anywhere and anytime. Development of local content will be fast and useful if supported by government policy. Based institutionalization of research and development as well as collaborate with national industry will strengthen the use of the results of this research for the benefit of the institution, nation and state. Concretely this industrialization can be done also by opening an integrated institution funded by

government and private parties. Most departments in the Hasan Sadikin Hospital (RSHS) still rely on medical records (paper based) to support administrative activities. Currently focusing on the development of a web-based application (using PHP-MySQL platform) which will continue to be developed, research of NeuroSyRS is one of the top priorities in Neurosurgery Department - RSHS to facilitate continue medical education. The present modules are expected to support the administrative and clinical activities in the department. This application may also develop

into a portable electronic medical record application to support Neurosurgery residents learning activities.

NeuroSyRS is a data processing system in the Neurosurgery department that is aimed to support health care services and clinical-based education system in providing information for the consultants for remote consultation. NeuroSyRS can be regarded as a system that provides information to all levels of clinical neurosurgical patients whenever needed. This system can store, retrieve, change, process and communicate information recorded by using cloud computing information system. Recently, almost all medical services are competing to develop and improve the quality of health care management by implementing a computer-based information system to support the changes and improvements in all aspects and related fields, in terms of infrastructure, facilities, financial, medical devices and human resources. Another important factor is the human resources (HR) reliable to operate the information system. Information system technology play a major role

to resolve common problems in hospitals, such as unorganized data, error in outpatient clinic queue number, wrong drug prescription, and so forth. This information system is expected to overcome the problems which ultimately would have a significant impact in the quality of medical services, especially in Neurosurgery department, in this case the invention of NeuroSyRS.

Current medical technology is growing rapidly with amazing speed, so it is possible to create a system for reporting, data collection and services to patients faster and integrated could be developed in Indonesia. This system had been tested in our ER patients in RSHS, although we need more data to be entry in this system. Early research is primarily to assess how fast, effective programming system that we design and any interference that may interfere with the system NeuroSyRS earlier. This is important because the application will be made on a sample population of the wider community, realtime data entry of patient and or tele-consultations. Disadvantages of this system will be evaluated and repaired.

**Tabel 2. Detail elaboration in the sistem of NeuroSyRS**

Code	Name	Descriptions
UC_010	New patient data input	The basic capabilities of the system associated with the provision of data input by the actors through the classification process using display format/electronic devices. The main actor is the residents who will record the data of new patients and patients in ICU
UC_020	Medical data input	The basic capabilities of the system associated with the data collection, disease, other things that require confirmation from experts
UC_030	Data view and report	The basic capabilities of the system that includes the features of data presentation, generate reports, data indexes, data catalogs, etc.
UC_040	Data analysis	The basic capabilities of the system include: data inspection, data cleaing, transformation into another form, and data modeling aimed to underline the use of information for actors
UC_050	User management	Is an authentication feature that provides administrator with the ability to identify and control user status that will be recorded into the system
UC_060	Data security, role and privilage	Ensure data privacy and compliance with data loss or exploitation prevention methods. Protect data from intruders threats, data theft, malware and unauthorized users
UC_070	Data backup restore	The basic capabilities of the system associated with data copying or system database which can maintain its integrity if disruption or damage occur. Other capabilities are restoring data, basic capabilities associated with copying back up data from secondary storage into disk



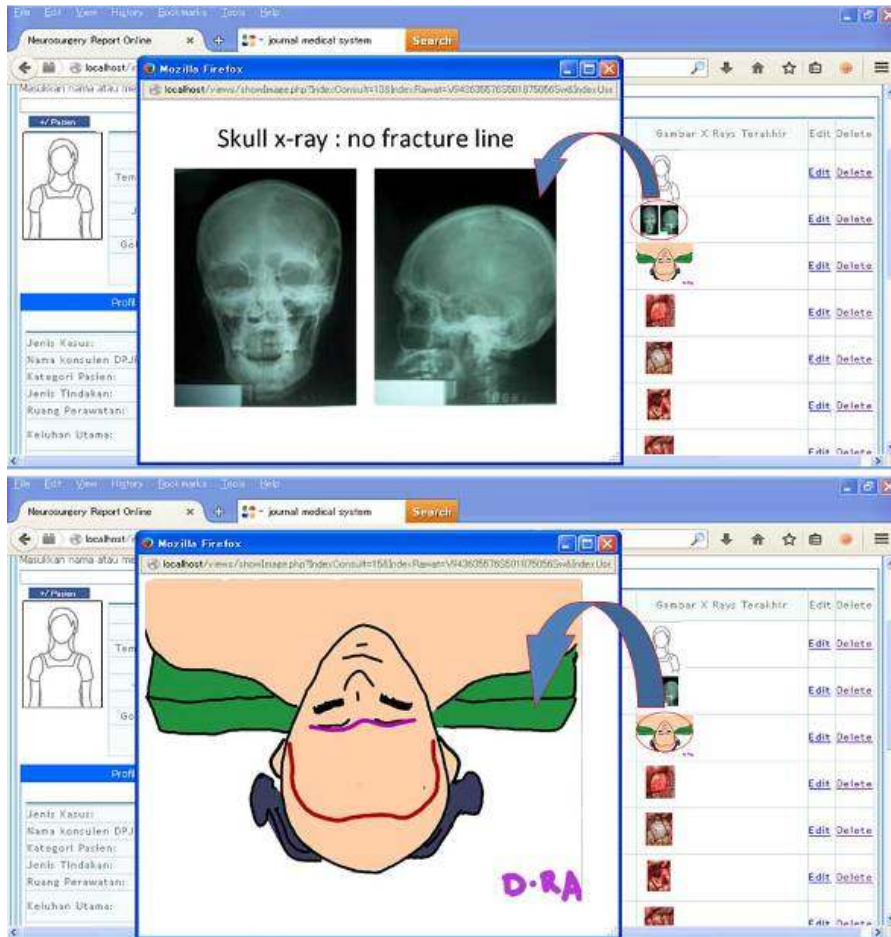


Fig. 6. The NeuroSyRS system application display

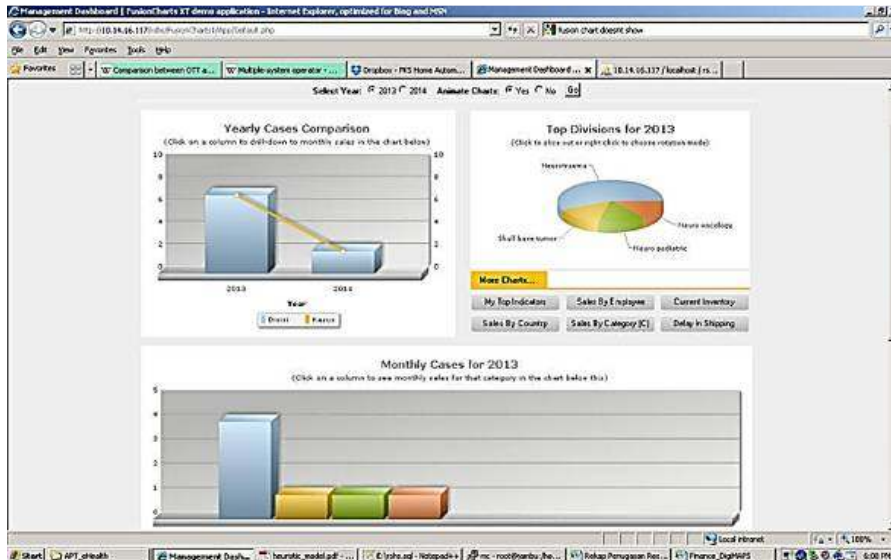


Fig. 7. The software developed self-calculating statistic

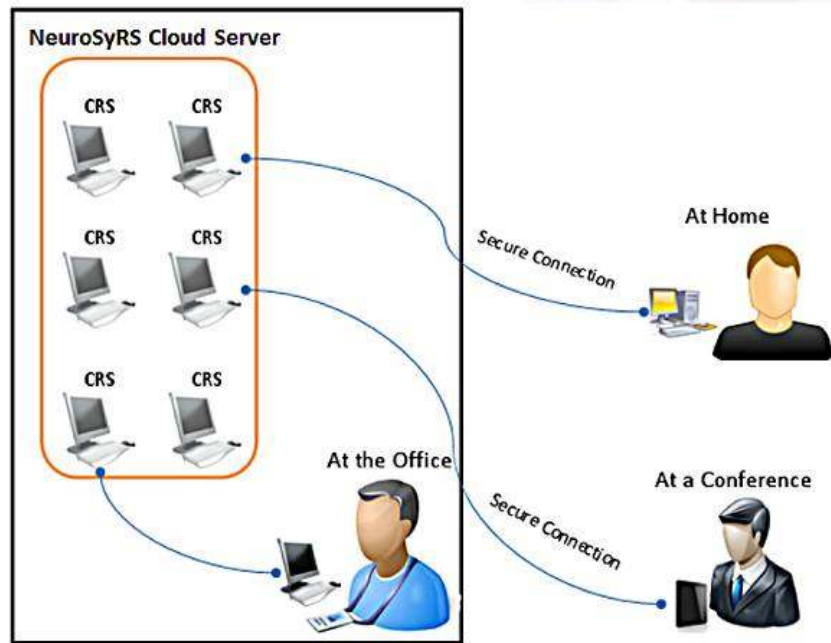


Fig. 8. NeuroSyRS cloud computing system



Fig. 9. Users can access the applications and information using mobile device

#### 4. CONCLUSION

Based on the results of the preliminary study we have implemented until this report is made, some tentative conclusions can be drawn from our progress report, as follows:

1. Department of Neurosurgery, FK UNPAD-RSHS, along with other departments requires reliable reporting system which can be upgraded according to the requirements of each department. The implementation of documenting and tele-

- consultation system or direct tele-conference will greatly improve the quality of service, reporting speed and data accuracy.
2. Based on literature studies and experiments that have been conducted, FK UNPAD-RSHS Health Technology working group has been able to develop an initial prototype of this system and an integrated reporting system to visualize consultation or conference between users.
  3. Algorithm optimization is required in order to upgrade the system, such as three-dimensional imaging visualization.
  4. Fully established software with integrated systems is priority in future research, so that this software will be ready to be implemented by other departments with the FK UNPAD-RSHS.
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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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