Designing Medical Checkup Information System for the Navy Hospitals

Bens Pardamean, Shirley Louis, Leli Setyaningrum

Abstract: This research investigated the implementation of medical checkup conducted within the military health departments and Navy hospitals in the western region of Indonesia. Medical checkups conducted within the health departments and Navy hospitals still uses manual processes, resulting in various errors, such as assessment inaccuracies, difficulty in data search, and so on. Therefore, this study aimed to provide information system solutions in the form of a computerized medical checkup system design and integration, as well as health monitoring functions of personnel. The design of these systems produced a computerized medical checkup process and utilized an integrated database; the latter is network-supported by Internet, both in the health departments and Navy hospitals.

Keywords: Computerized Physician Order Entry, CPOE, EHR, Electronic Health Record, Information system design, Medical checkup

I. INTRODUCTION

An example of a navy medical checkup system is that of the Indonesian Navy, in which two parties are interconnected, the Department of Health and Naval Hospital. Routine medical checkup is performed each year or as needed by the personnel. Health status is one of many important requirements for military personnel. Thus, this military medical checkup is different from other medical checkup, which is performed by private hospitals. The differences lie within the standardization of health status assessment and procedures that are more comprehensive. For military personnel, not only general medical checkup, but there are another comprehensive checkups need to be complied. Higher standards are required for military personnel, especially for those in the operational and special forces.

However, the current process of medical checkup still utilizes a manual process, which involves a lot of complicated bureaucratic processes. This in turn increases cost as well as various problems due to inaccuracies in the medical records. With traditional solution, paper-based patient files have to be carried by the medical doctor or staff, which in turn increases the amount of dossiers, as well as the difficulty in searching medical data for further examinations [1].

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The administration of health services in hospitals begins with a medical appointment, during which the physician documents the patient's physical record on paper forms. The data from these forms are then entered into a computer system to establish the patient's medical record. These records could then be distributed to various parties that request them and utilized for documentation by the Department of Health or the hospital. Based on the health examination result, the physicians can then determine whether or not a navy personnel requires treatment. However, the absence of an integrated system between the Department of Health and hospitals results in an inefficient coordination of monitoring the health of the navy personnel. Additionally, the determination of a health condition is often done subjectively by the physicians rather than based on previously established medical standards.

Hence, there needs to be an information system that could meet the necessity for linking the database of the Department of Health and hospitals, and provide computerized process to reduce paperwork and manual documentation. Achieving a high level of efficiency is crucial in order to have quick access to a whole range of information about the current patient, such as medical history, results of previous medical investigations, opinions of other specialists on the case, and so on [1].

II. RELATED WORKS

There are three main aspects considered in this study, which are database, application, and network. Storage and standardized data from different units can be achieved using a data warehouse that can store, call, and analyze the information that is integrated from various sources [2], [3].

Computer network is required to obtain information on time in order to reduce diagnosis and treatment errors [4]. Patients can be reminded about examination or treatment schedule via mobile phones or smartphones [4, 5]. Medical record systems require a database and network support. Network can be a stand-alone system, a local area network system, or a wide area network system [6].

A portal is also needed as a mean of integration, enabling the concerned parties to view the personnel's health information. Syed-Mohammed, Ali, and Mat-Husin [7] have utilized a web-based portal for the health section at the Hospital University Sains Malaysia (HUSM), namely the One Stop Crisis Centre (OSCC) portal. By using this OSCC, dispersed information can be integrated and accessed from different types of web browsers and all types of computers through the usage of an intranet network at HUSM.

The lack of standardization for reporting formats and redundancy of data collection calls for a design of the portal to be well-established in order to provide faster medical data input and to reduce unnecessary repetition of data input by different departments [7]. This can be done with radio

buttons, check boxes, and drop down lists. Additionally, when the staff from other departments input a set of data, previously entered data are also shown, enabling data updates on patient's medical information [7].

Few medical systems have been developed before, such as the District Health Information Software (DHIS) with open-source software in Tanzania, Zanibar [8], areas that also lack information technology resources. Hence, a low investment cost system is also required without sacrificing the efficiency and effectiveness of health services [8].

CHCS (Composite Health Care System) is a health care system developed by the Department of Defense in the United States. CHCS includes EHR (Electronic Health Record) and CPOE (Computerized Physician Order Entry), in which patient data is stored in a data repository that can be accessed by patients with authorization [9]. CHCS II also brings together all CPOE capabilities with a user-friendly interface.

Karim and Muhammad [10] developed the Medical Data Acquisition System to safely and accurately acquire and store confidential medical reports. Patient's medical record is stored in a base-unit database, eliminating the need for paper medical records. With this system, the medical staff can easily monitor and update the patient's databases.

Darabant [1] has developed a medical system that uses mobile devices (PDAs) and wireless network to provide synchronization of data among medical staff, physicians, patients, and the hospital's database server.

However, due to limited infrastructure and capability of health department staff and hospital, the designed medical checkup system will require PCs for clinics and the Internet in the form of WAN/LAN, to provide data synchronization.

Based on literature review, the system can incorporate some previously used concepts; among them are EHR (Electronic Health Record), CPOE (Computerized Physician Order Entry), and health portals. EHR is a system that provides physicians and other staff with an online access to patient data and decision support. In order to rapidly formulate appropriate decisions, medical doctors need fast access to various pieces of information on their patients. The required information should be accurate, up-to-date, and available on the spot [1]. Electronic Healthcare Record (EHCR) is a record of medical data in the form of text, numeric, graphics, audio, and video. EHCR compliance requirements are influenced by the ability of a healthcare organization to build an integrated access [11].

CPOE is a part of the EHR, which requires the physicians, nurses, and other specialists to follow the procedure menus in order to run and perform a test, procedure, and treatment on patients [12]. Thus, the process can be standardized to reduce errors. Laflamme, Piotraszek, and Rajadhyex [12] also stated that with automated and standardized information in the healthcare field, organizations can provide efficient procedures, in which medical data can be managed transparently; clear guidelines for procedures and tests are also maintained. These improvements would then greatly reduce excess paperwork, redundant medical care, and treatment error, thereby improving health care quality [13].

In order to implement CPOE and EHR concepts, an integrated database is required, in which the Department of Health and hospitals could enter the personnel's medical records either as a single database in a data warehouse or as a data mart [2]; this would result in standard procedures to determine the health status of a patient. Additionally, the medical staff requires a health related portal that is user-friendly [9], which could be a stand-alone system, a local area network or a wide area network [6]. With the portal, the results can be entered directly and health status can be determined automatically, in accordance with the standards and procedures that have been established. Thus, an increase in medical procedure efficiency and accuracy, as well as a reduction in cost and bureaucratic work, is expected.

III. PROBLEM FORMULATION

Due to manual processing, various problems occur in the navy medical checkup [7], [8]. Some issues are in regards to the excessive and redundant documentation, along with the lack of standardization of the personnel's health status determination procedures. Other problems are related to inaccuracies of manually inputting medical records and the long delay in generating and maintaining manual medical records. Then, of course, there is the lack of integration between hospitals and the Department of Health, resulting in an ineffective monitoring of health personnel. Therefore, the core of the problem is the effort to implement a computerized and integrated information system for medical checkup between Navy hospitals and the Department of Health.

Hopefully, the computerized and integrated system can solve most of the existing problems and improve the efficiency of existing infrastructure.

IV. METHODOLOGY

To resolve the aforementioned problems, a step-by-step methodology was applied:

Fig. 1. Methodological Steps

The first step taken was conducting surveys on the Department of Health and hospitals in order to assess the current medical checkup procedure. Then, a literature review was performed in order to investigate medical checkup systems that have been designed by previous studies, which then served as the benchmark for subsequent system design. Interviews were also performed to gather the views and opinions of the medical staff and health officials on the current system.

Based on both data obtained and literature review, a system of computerized and integrated medical record database was designed. The final step was to evaluate the design based on its accordance with the literature review conducted and its ability to resolve the current system's setbacks.

V. PROPOSED SYSTEM OF MEDICAL CHECKUP

Based on the implemented methodology (Fig.1) and the identified problems, the following system was proposed. By using the existing portal, patient mobile phone information can be used with the supervision of the head section [4], [5]. Subsequently, the Department of Health staff and hospitals can easily generate and send notifications regarding

upcoming medical appointments (Fig.2), thereby reducing the frequency of missed appointments by the personnel. During examination, the officer or doctor can immediately update a patient's file with the recently collected medical results through the portal (Fig.7). A list of general symptoms and diagnoses were provided in the form of options, which could then be selected using the check box system. This would then accelerate data-entry process. However, a description box is also included if additional diagnosis is necessary.

With this system, Department of Health can implement simple EHR, even with limited examination equipment. One such development in electronic medical data storage is the use of digital webcams and the analysis performance on the ECG graph before sending it through the Internet [14]. By using low-cost digital camera, Health Department also can electronically store personnel health examination result.

Through these portals, health status and its corresponding treatment can be immediately calculated by the system, based on the data entered by physicians. The results of medical checkups are also automatically saved in a database of medical records.
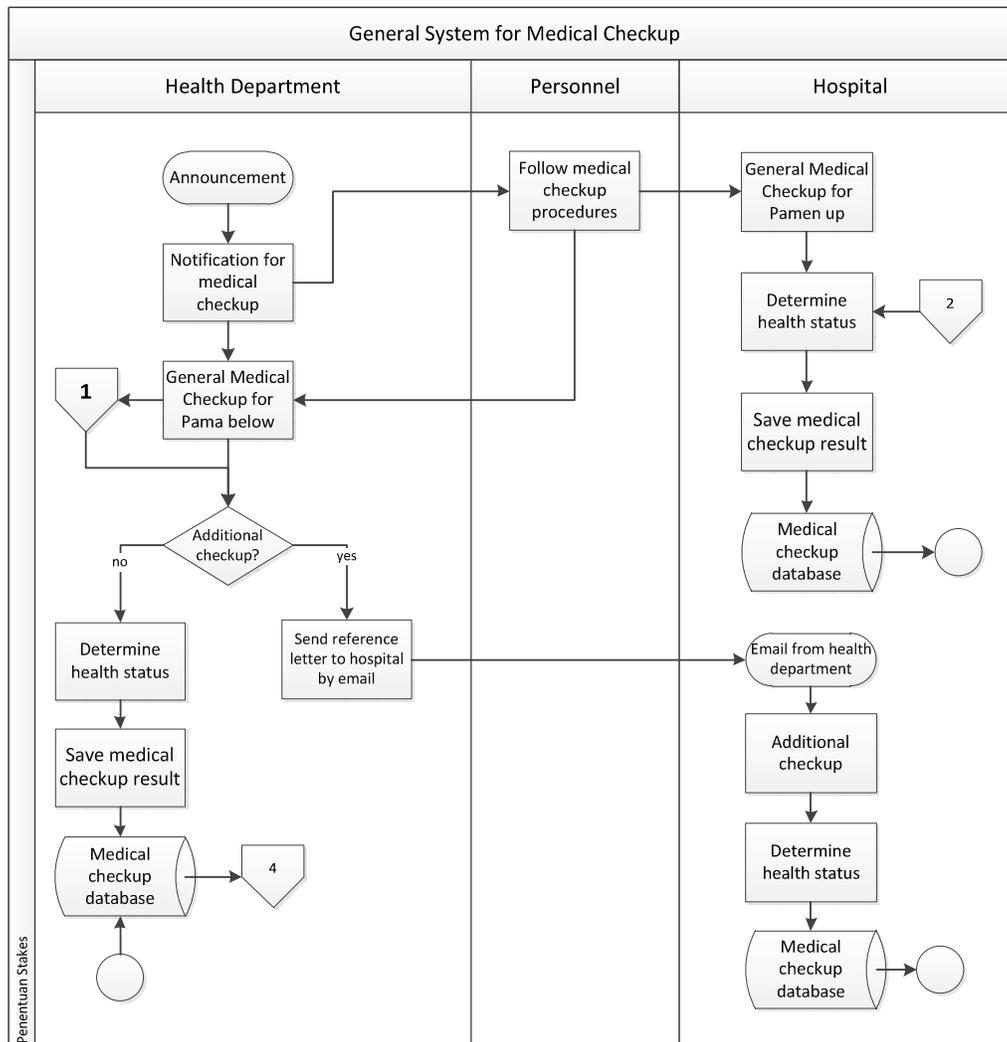
Fig. 2. General System for Medical Checkup

Furthermore, the health status result can be known if the person needs treatment (Fig. 3). If a necessary treatment is required, the person is notified, and details of treatments can be viewed in the portal.

In health care, an efficient scheduling process is needed to improve the quality of services provided. Therefore, to ensure that the personnel received the right treatment at the right time, there ought to be a proper and efficient scheduling system [15]. In the provided treatment detail, a personnel can access the schedule, treatment order, and physician-related data. If a personnel were to miss a scheduled treatment, medical staff would then reschedule the appointment within a one-week period, unless the personnel had a legitimate excuse and had rescheduled the appointment on their own.
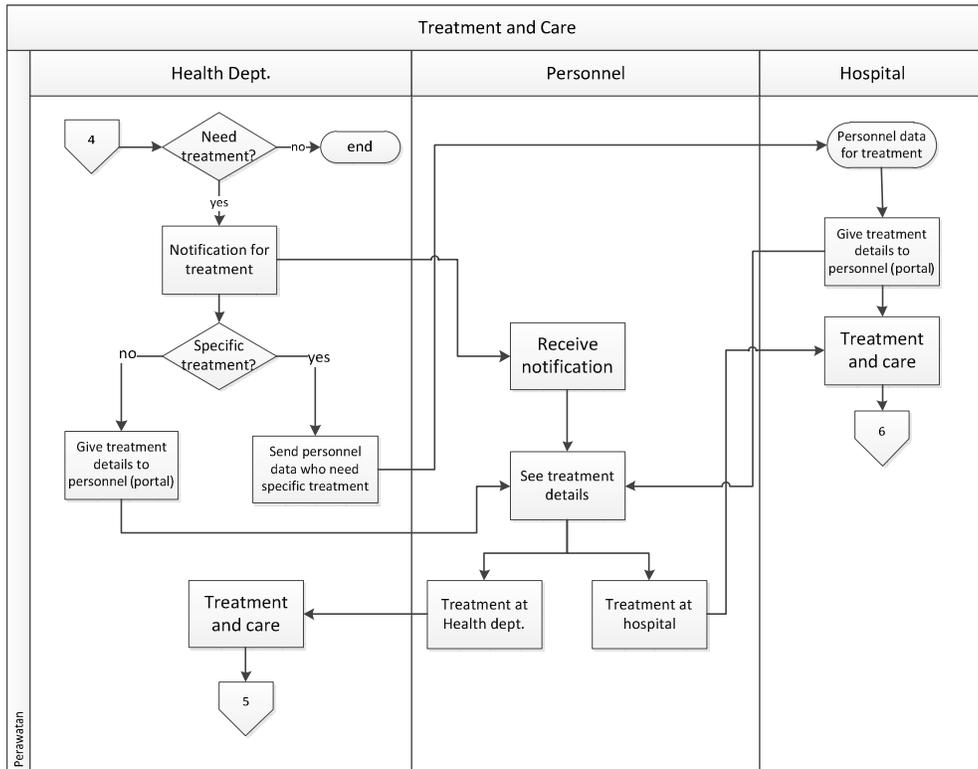
Fig. 3. Treatment and Care

The personnel's medical record would then be updated, according to the health status after treatment (Fig. 4). The necessity of a follow-up treatment would then be determined based on the new health status; if it is still needed, the patients would be notified again for further treatment until their health status no longer showed a need for further treatment. Thus, the health of the personnel can be monitored properly, leading to better performance of duties.
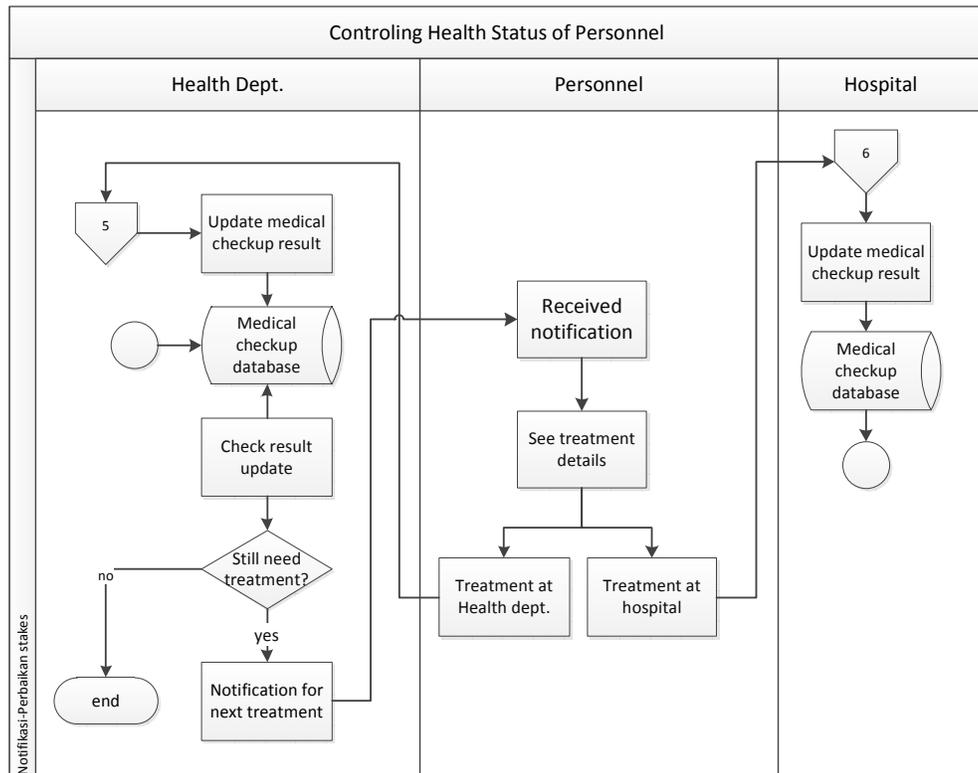
Fig. 4. Controlling Health Status of Personnel

Notifications are sent in the form of short messages on mobile devices and through the portal personnel (Fig. 5). If the personnel did not attend a medical appointment, a second notification via short messages and portal would be sent to the personnel. If the personnel was still absent for treatment and rescheduling, then a third notification would be sent to the personnel as well as the supervisor of the personnel's work unit.
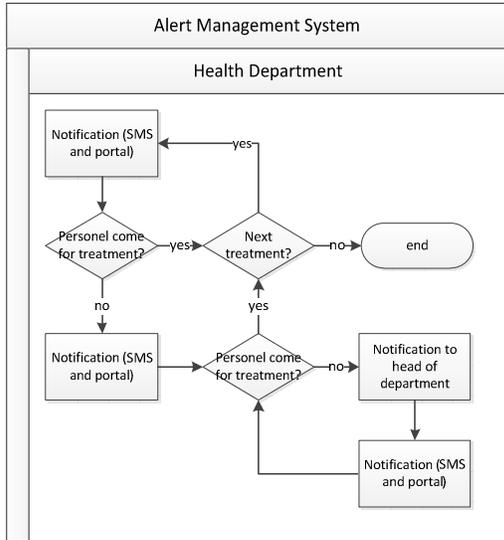
Fig. 5. Alert Management System

The implementation of the system for special forces personnel, i.e., warships members, divers, marines, and frogmen corps, must be carried out in more comprehensive medical checkups (Fig. 6). This applies to personnel with good health status in general medical checkups. It is necessary to determine the feasibility of their health condition in the execution of a military operation. Because in each execution of operation, there is always a chain of command function that is supported by troops with excellent level of health in order to carry out their duties optimally and always ready to face all conditions in the area of operation [16].
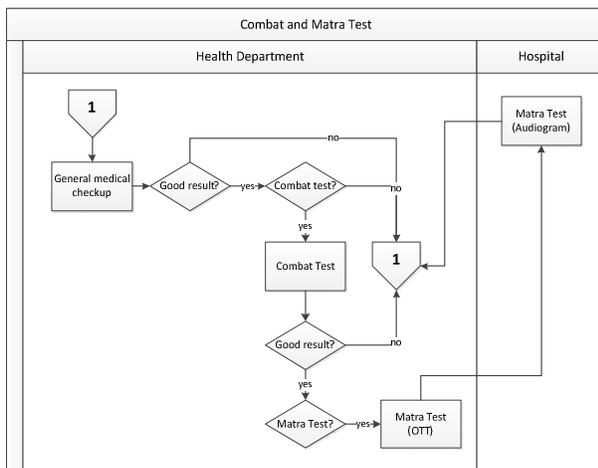
Fig. 6. Combat Test and Matra Capability

Health testing includes routine medical checkups that are coupled with a more intensive physical examination, i.e. body mass index (anthropometry), pulmonary (spirometry), cardio (ergometry), the strength of the hands and feet (dynamometry), aural (audiometric), and respiratory/oxygen tolerance test (OTT).

Matra test is an examination on the capabilities of personnel who joined the Special Forces but also has expertise in the navy. Through the same portal, data from the tested capabilities would be incorporated into the database of medical checkups, so it can be processed as a report.
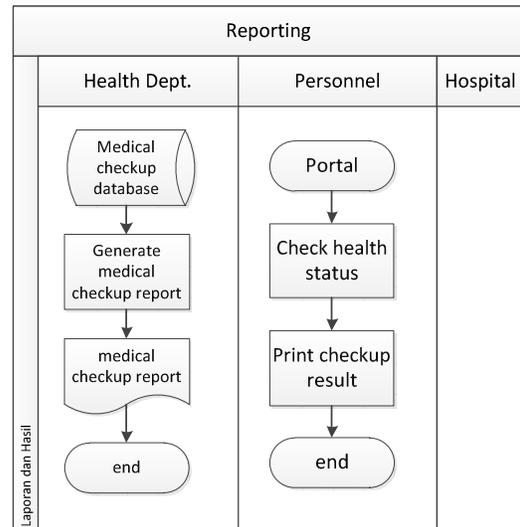
Fig. 7. Reporting

Medical staff can generate and print report from medical checkup database. Personnel can also check health status, checkup result, and print the result if needed for administration procedures (Fig. 7).

With the medical checkup system above, the Department of Health or hospital can also use available examination tools, which would lead to a maximally updated inventory on available medical checkup equipments. The database server also contains the data or information that can be processed directly into the system, including information from medical devices that can be linked with this information system [4]. This would offer a solution that would maximize the existing infrastructure while also avoiding the need to purchase new equipment with high cost.

Below are a few examples of medical checkup portal pages that would be used. With these portals (Fig. 9), personnel and health officers can create and print the reports related to a medical checkup in accordance with the access provided. By using existing systems and portals, health-monitoring staff can be more efficient. In addition, all modules are password-protected such that user access is limited only to predetermined modules [7]. Personnel also can view treatment details, schedule, and treatment order (Fig. 10). In one form of reports, the officer can identify the non complier of advanced health care, personnel who have schedule of further treatments, as well as personnel who do not perform medical checkups (Fig. 11).

Fig. 8. Login Page

On the login page, user access is limited and filtered by personnel identification number, password, and status (Fig. 8). Some modules are limited only to staff or physicians, which the personnel cannot access. If there is a need to update, add, edit, or delete personnel's medical checkup data or result, the department head must authorize the access to a personnel's medical data.

With the medical checkup system and portal, medical staff and physicians can directly input checkup results through a portal with the provided check boxes of diagnosis and description box for additional explanation. Then the system would automatically calculate the health status of a personnel and save the medical checkup information in the database.

The medical staff could also easily identify a personnel with poor health condition, then further categorize the group based on those are in the process of a treatment and those who are not receiving medical attention; this would allow for the creation of a list of people to be notified. Thus, the health conditions of personnel are expected to improve.

With this system, all procedures are standardized in order to accurately determine the health status of the personnel. The medical records would be integrated, leading to the reduction of unnecessary documents and the improvement of the medical checkup procedure efficiency.

Fig. 9. Medical Checkup Portal

As one attempt to control personnel health, treatment details can be accessed through the portal by personnel. With these treatment details, personnel can view the order and schedule of treatment that needs to perform, along with medical staff in charge (Fig. 9). Treatment categories correspond to checkup categories, which include vision, hearing, dental, laboratory, and so on. Treatment order according to categories, describe specific treatments which are needed to improve health status.

Health status is displayed to inform the personnel of any improvements in their health. If a personnel still requires treatment, the health status would be a "P" (treatment). After following all treatment schedules, the "P" status marker would disappear (Fig. 11).

If a personnel misses a scheduled treatment, a notification for rescheduling would appear. An automatic rescheduling by the system could also occur (Fig. 10).
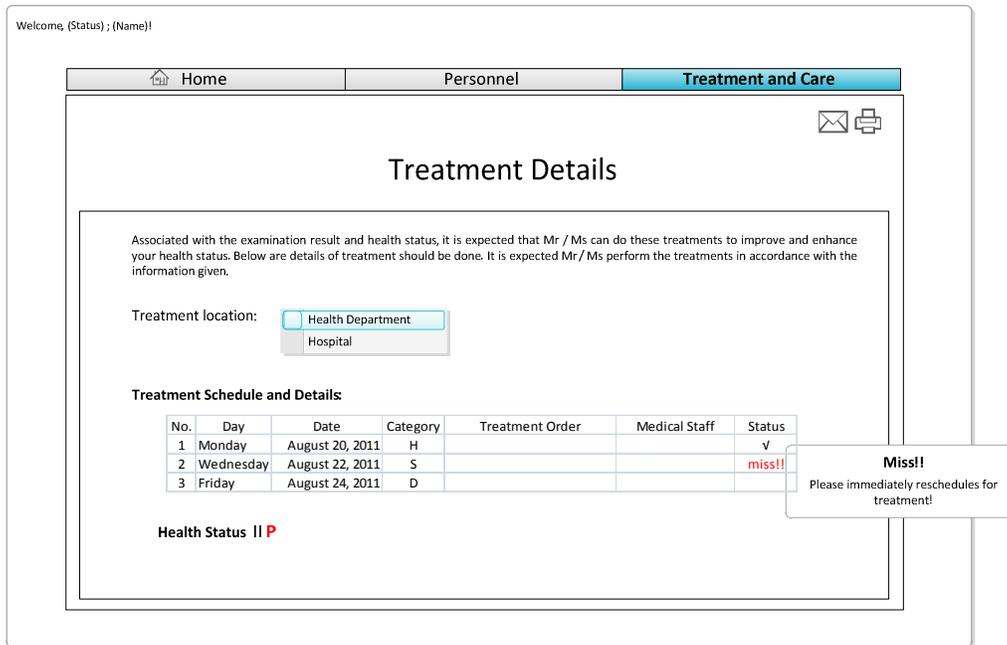
Fig. 10. Treatment Details Page
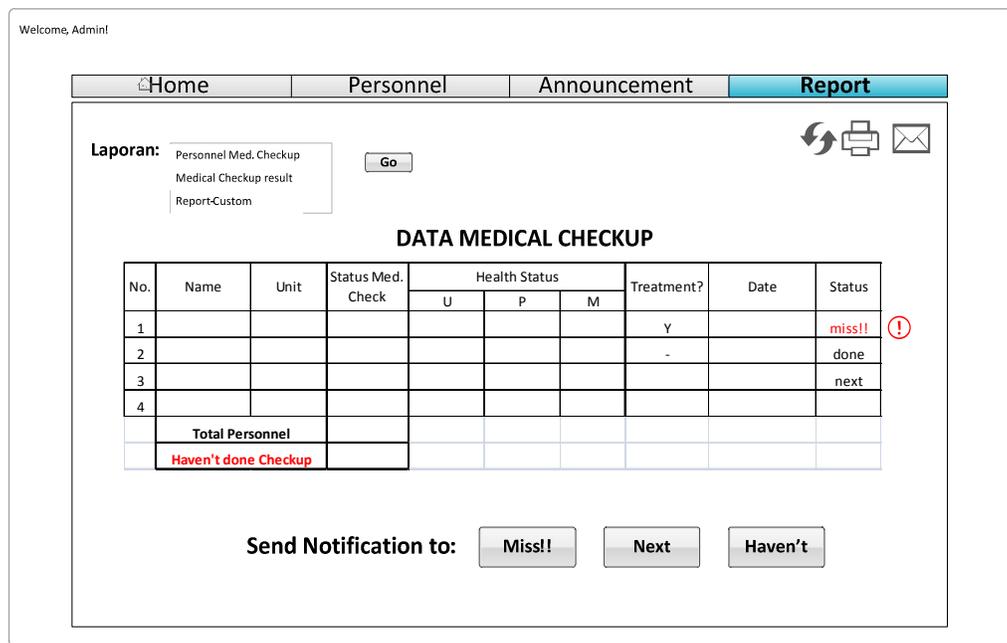
Fig. 11. Medical Checkup Portal-Report and Notification

VI. NETWORK ARCHITECTURE

Fig. 12 shows IT network architecture that describes the relationship among health department, hospitals, and personnel. The main server of the medical checkup system resides within the hospital, which can be accessed by the Department of Health using WAN/LAN. On the other hand, the personnel can also access medical checkup information via PCs, laptops, or smart phones with the ability to open web browser and access medical checkup information with modem connection, wireless or GSM/UMTS network.

Department of Health can send notifications and upload details to the medical checkup server, which can be accessed by personnel through portals that are connected to the network. By using the network, the Department of Health can send emails, open and view medical checkup report to discern personnel health and treatment status, thus medical staff can give details for further treatment, and send notifications. In addition, by using GSM/UMTS network, the health department can send notifications to personnel's mobile device in the form of text messages.

In any system, security is an important issue. Therefore, it is recommended that the health department and hospitals use firewall and proxy, as well as a strong antivirus and internet security software to prevent external and internal attacks. Several methods of network security that can be used are encryption, strong passwords which must be changed periodically, selection and authorization of wireless connection, positioning network hardware in a safe place, and hosting web servers in DMZ with firewalls

VII. CONCLUSION AND RECOMMENDATIONS

From the discussions above, it can be theorized that the use of information systems technology can help improve the efficiency of the process by which the Department of Health and hospitals perform the personnel's medical checkups. Implementation of an information system should not require a high investment cost, as long as the information system can be aligned with the organizational needs.

Some performance improvement can be obtained by using medical checkup system, compared to the current process, which are in the use of forms, document storage, and data query. Using medical checkup portal to input checkup result will minimize the use of forms, which require a lot of cost and space. Printed document is only for reporting purposes and all medical data are stored in system database. Thus, data query will be faster and easier by calling personnel's ID as a key in data search. Additionally, this medical checkup system will improve the accuracy of personnel health status assessment, secure medical data, and provide monitoring and controlling function of personnel's health. Health status will be determined immediately by a standardized system according to the examination results. For access security, there will be different layers of access and authorization, in accordance to status and position. Other security measures will also be implemented, i.e., encryption, firewalls, proxy, and so on. For controlling and monitoring, notifications will be sent by the system until the personnel participates in either a medical checkup or a treatment scheduling.

For further research, treatment and care system can be developed as a continuation of this medical checkup system. In terms of using an integrated database, EHR, CPOE, and network technology, the medical checkup system can be the basis for next system development. Additionally, treatment and care system can be improved by using wireless technology and the Internet to monitor personnel's health in treatment procedures, especially patients with severe disease or illness [17].
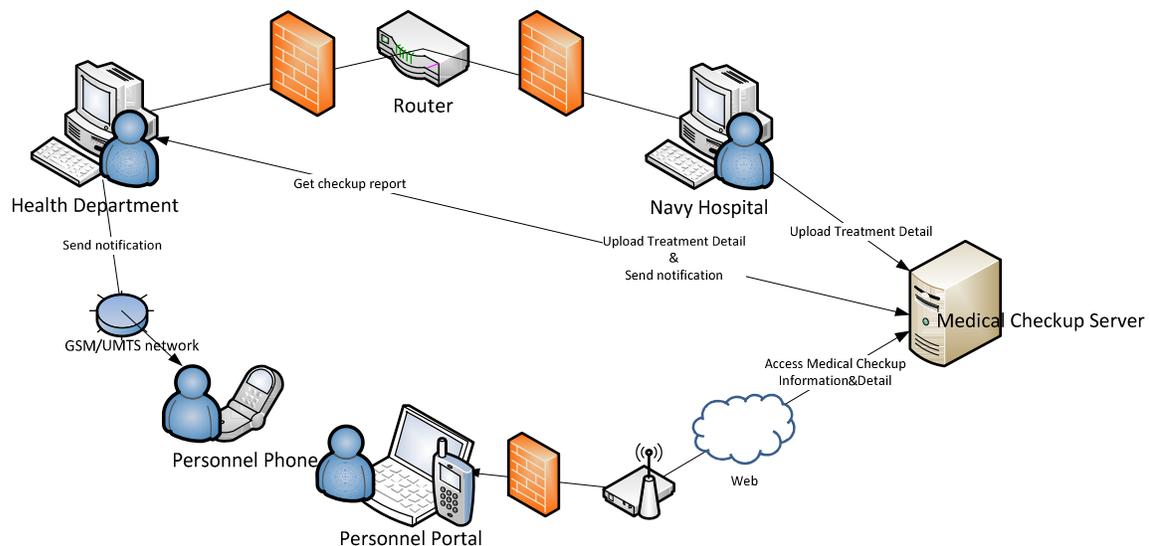
Fig. 12. E-Medical Checkup IT Network Architecture

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