A conceptual design of modified **Human Factor Analysis and Classification System** mobile application

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**Abstract.** This article aims to provide a conceptual design of the medication error identification based on a mobile application using the modified HFACS approach. The conceptual design in this study discusses the user and functional requirements based on the organizational structure and business process of medication prescription. This study used DFD that aims to describe the relationship among the user. Interface and prototype of the application is developed based on a focused group discussion of ergonomics expert. The user involved in the prescription process are the doctors, hospital workers from the pharmaceutical department, and hospital workers from the Hospital Patient Health department. The role of HFACS investigation is played by the patient-health department. The developed interface of HFACS focuses on the evaluation and documentation of medication error cases. This present study is the first study focus on the development of HFACS mobile application in evaluating and documenting medication error.

**1. Introduction**

Medication errors are defined as failures in the patient care process that can endanger patients [1]. A study also mentions about 246 medication errors reported in the United States are related to human factors. In addition, [2] state that human factor is not only the medication errors cause; working conditions and the environment, as well as the organizational factors also the cause of the medication errors.

To reduce and prevent medication errors, several approaches were applied to analyze errors. Reason [3] proposed the Swiss Cheese Model that became a prime basis of the Human Factors Analysis and Classification System (HFACS). Although HFACS starts with the word ”human factors”, in fact, not only human factors but also other factors related to human factors are considered [3].

HFACS is one of the human error identification techniques that was first developed for Naval flights [4, 5]. HFACS has been used and adapted in several industrial sectors, as has been done by [6] who used this approach in the healthcare sector. What makes this model useful in accident investigations is because this model will require the investigators to analyze latent failures in an accident. Latent failure might be undetected for days, weeks, or even longer, until the latent failure affects the actual accident [7]. The HFACS approach has been proven to be a reliable, diagnostic, comprehensive, and valid in several industries [8]. HFACS has four primary parts...
In Indonesia, research that addresses medication errors with the HFACS approach has been conducted by [9]. In this study, the result is the causes of medication errors for the main layer were unsafe actions (performance-based errors), precondition (mental awareness), and organizational influences (organizational instructions or policies create unsafe situations). In addition, for the sublayers, the highest causes of medication errors found in this study were the information overload and fatigue.

In relation to the HFACS adaptation for medication error analysis, [10] developed the modified HFACS (from now on called med-HFACS) in which 90 categories of factors are included. In addition, there are 19 sub-categories that are excluded because irrelevant to the pharmaceutical field and the professional pharmacists’ work.

Considering the high number of medication error happen in the hospital, unfortunately, the hospital does not yet have a standardized tool in evaluating the case of medication error that occurred. In fact, these tools are needed to analyze the root causes and error patterns of a medication error case, so that it can provide valuable information for the effort of quality improvement [11].

Information and communication technologies, including mobile technologies, have made significant progress in its development in recent years. The technology has become an integral part of people’s daily lives [12]. Thus, a great interest in the use of mobile technology can be utilized for the development of the medication error identification based on mobile application in particular for evaluating, recommending improvements, and documenting medication error cases. This study aims to provide a conceptual design of the medication error identification based on a mobile application. The approach used in evaluating medication error is the modified HFACS.

2. Method
This research includes identifying the organizational structures and business processes and developing the conceptual designs for mobile application. Identification of organizational structure and business process of medication prescription aims to describe the whole stakeholders and processes involved in the medication prescription. The conceptual design of mobile application (mobile app of med-HFACS) is the first step of the multiphase process involved in creating new products. The design phase is followed by the preliminary design and detail design phases. The conceptual design in this study discusses the user, functional requirements, define CD and DFD, and display design.

This study uses the modification of HFACS approach for medication error analysis. Med-HFACS developed by [12] is used in this study as a basis.

| Table 1: Subcategories of Modified HFACS |
|------------------------------------------|
| Level | Number of Subcategories 2 HFACS by Department of Defense 7.0 | Number of Subcategories 2 HFACS for Recent Study |
| Act | 13 | 12 |
| Preconditions | 61 | 45 |
| Supervision | 17 | 17 |
| Organizational influence | 18 | 16 |
3. Result

3.1. Organizational structure and business process
In general, the organizational structure in relation to medication prescription in the hospital (i.e. pharmaceutical installations) is shown in Figure 1.

The organizational structure directly related to the patient is the pharmacist at Clinical Pharmacy who is responsible for the Head of Sub-Installation Services. Furthermore, the Head of Sub-Installation Services is responsible for the Head of Pharmaceutical Installation. The Head of Pharmacy Installation coordinates with the Hospital Patient Safety in conducting medication error investigations.

Based on the organizational structure, the business process of medication prescription consists of five processes as can be seen in Figure 2. Prescribing is the process of writing a prescription done by a doctor. Transcribing is the process of reading a prescription by a pharmaceutical employee. Dispensing is the process of preparing drugs. Delivering is the process of giving medication to patients. Meanwhile, the administration is the process of using drugs by patients. According to [13–15], the five processes allow medication errors to occur.

The conceptual Design

3.2. User Identification
The user of this mobile application is a medication-error investigator which includes the selected doctors and hospital workers from the pharmaceutical department (Widyanti & Reyhanisa, accepted), and especially hospital workers from the Hospital Patient Health department. Based on the organizational structure, hospital workers from the pharmaceutical department can include pharmacists in the clinical pharmacy section, the Head of Sub-Installation Service, and the Head of the Pharmacy Installation.

3.3. Identification of Functional Needs
Based on the structural organizational structure, business process, and user identification, the functional needs for the med-HFACS mobile application is identified. Focused group discussion
Figure 2: Business Process of Medication prescription
Figure 3: Context Diagram

involving two ergonomics experts resulting in the needs of investigator and evaluator, which can be described as follows:

(i) Input for investigator
- Investigators input their data into the system
- The system will store data
- The system creates user management lists

(ii) Input case data
- Investigators input case data into the system
- The system will store case data

(iii) Evaluation
- Investigators fill out questionnaires
- The system stores data
- The system processes data

(iv) Display Result and Recommendation.
The system displays the results of the evaluation and provides recommendations

(v) Documentation
- Hospital Patient Health department will get evaluation results and recommendations
- Hospital Patient Health department can see documentation of evaluation results for one case or several cases at a time.

3.4. Context Diagram (CD) and Data Flow Diagram (DFD)
CD illustrates the association between all stakeholders involved in the system. The CD defines as the DFD highest level which represents all inputs into the system or the output of the system that gives an overview of the whole system [16]. Figure 3 shows the CD of a medication error investigation application.

DFD are defined as a diagram that represents the data flow through the process [17]. DFD is displayed based on 5 processes that have been described in functional need, such as input of
investigator data (Figure 4a), input of case data (Figure 4b), evaluation (Figure 4c), display results and recommendations (Figure 4d), and see documentation (Figure 4e).

3.5. Process Identification
The developed application has two main functions that are evaluating and documenting medication errors that occur. In the beginning, the investigator will be given a choice whether they will evaluate the new medication error case or want to see the documentation of the medication error that has been evaluated previously.

(i) Evaluating Medication Error This function has three main menus that are input data, evaluation, and results. The input data facilitates the input process for both the user data and the case of medication errors. Evaluation menu is a facility to evaluate medication errors that occur using modified HFACS by investigators. Meanwhile, the results menu is a facility to show the results of the evaluation consisting of information on the number selected at each level or level, the conclusion of what factors influence, as well as recommendations for preventing and reducing medication errors.

(a) Input Data Medication error data contains narrative information about medication errors that occur, such as case number, date, type of error, patient name, type of drug, type of disease, and actions taken. The type of error is the part where the treatment phase of an error occurs, which consists of prescribing/ordering, transcribing, dispensing, delivering, and administration process. The investigator inputs the investigator’s data, such as id, name, and role. In the next section, the investigator enters medication error data into the application. Figure 5 (a) shows an example of the investigator’s input data display.

(b) Evaluating Medication Error The evaluation uses a modified HFACS consisting of 4 levels (layers), 2 categories, 17 subcategories 1 (questions), and 89 subcategories 2 (statements). Questions (subcategory 1) consist of ‘yes’ and ‘no’ answers. Each ‘yes’ answer contains several statements (subcategory 2) that must be selected. Figure 5 (b) shows the design of one of the questions about culture or climate safety which is one of the categories of organization influence levels.

(c) Result Evaluation results can be seen based on the number chosen at each level or level, the conclusion of what factors influence, and recommendations for preventing and reducing medication errors. The number indicates the number of statements selected at each level. The influencing factors are obtained from the number of subcategories 1 which is the most chosen. Meanwhile, the recommendations given are recommendations that have been determined and compiled by researchers (application makers) by these factors. Figure 5 (c) shows the design of the evaluation results.

(ii) Medication Error Case Documentation

(a) Evaluation results for each case In this menu, the results of medication error evaluation in one case can be seen. First, enter the case number first. Then, the results of the evaluation of the case are displayed.

(b) Evaluation results for several cases In this menu, the results of medication error evaluation in certain cases can be displayed. First, choose the type of error that occurs, such as prescribing, transcribing, dispensing, delivering, and administration. Then, the results of the evaluation of several recorded cases will be displayed.

4. Discussion
This study aims to provide a conceptual design of the mobile medication error identification application using the modified HFACS approach. The steps include user identification, identification of functional requirements, define CD and DFD, and process identification.
Figure 4: DFD of 5 processes in functional need (continued to next page)
The conceptual design process gives attention to entities involved in medication errors, that are doctors and pharmacy. Doctors' activities involved medication errors in the prescribing process which is the process of writing a prescription. Meanwhile, pharmacists or pharmacists are involved in medication errors in the process of transcribing, dispensing, and delivering.

The users of this application are doctors that involved, hospital workers from the pharmaceutical department, and especially hospital workers from the Hospital Patient Health department. This is based on business processes where doctors and pharmacists are directly related to medication errors, whereas Hospital Patient Health department is related to monitoring and evaluating performance in improving patient safety.

The design of this application process has two main functions, that are evaluating and documenting medication error cases. In evaluating medication error cases, there are three processes, namely data input, evaluating cases, and displaying evaluation results. In looking at the documentation of the case of medication error, there are two facilities with functions of seeing the results of each case and seeing the conclusions of several cases.

This application is designed to facilitate the hospital in controlling and monitoring medication error cases that occur. In addition, it also analyzes latent failures that are the medication error root cause that occurs using the HFACS approach. This is the progress of an error reporting system with large-scale web-based that developed in the research of [17]. However, the existing reporting system developed, only records medication error cases without analyzing the root of
In evaluating medication errors, the HFACS approach is used. This approach was first used in the identification of accidents in the field of aviation [18]. Furthermore, [15] used this approach in the world of health. [16] used this approach to better understand medication errors in the setting of Emergency Medical Services (EMS). Furthermore, [5] used this approach to evaluate medication errors in the pharmaceutical field. This approach has several advantages. One of them is this model will require investigators to analyze latent failures in accidents that are hidden and difficult to identify.

This application is still in an initial concept form with the hope that production and expansion can be carried out in the future. Furthermore, this study will be proceeded by several research steps: (1) validating the design using more cases of medication error, (2) developing a prototype initial conceptual design system, and (3) testing the prototype in which an application design must consider the user or User-Centered Design [4]. The expected final result of this research is in the form of mobile application of medication HFACS.

5. Conclusion
This application is designed to facilitate the hospital in controlling and monitoring medication error cases that occur. The user involved in the prescription process are the doctors, hospital workers from the pharmaceutical department, and hospital workers from the Hospital Patient Health department. The role of HFACS investigation is played by the patient-health department. The developed interface of HFACS focuses on the evaluation and documentation of medication error cases. The next steps of developing this application is developing a prototype initial conceptual design system.

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