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Example of a Human Factors Engineering approach to a medication administration work system: Potential impact on patient safety

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ABSTRACT

Objective: The objectives of this paper are:

1. To describe a Human Factors Engineering (HFE) approach to a medication administration work system, in the context of a hospital medication Computerized Provider Order Entry (CPOE) project.
2. To identify the determinants of this work system potentially impacting both the efficiency and the safety of the medication use process.

In this approach, the implementation of such a complex IT solution is considered a major redesign of the work system. The paper describes the Human Factor (HF) tasks embedded in the project lifecycle: (1) analysis and modelling of the current work system and usability assessment of the medication CPOE solution; (2) HF recommendations for work re-design and usability recommendations for IT system re-engineering both aiming at a safer and more efficient work situation.

Methods: Standard ethnographic methods were used to support the analysis of the current work system and work situations, coupled with cognitive task analysis methods and documents review. Usability inspection (heuristic evaluation) and both in-lab (simulated tasks) and on-site (real tasks) usability tests were performed for the evaluation of the CPOE candidate. Adapted software engineering models were used in combination with usual textual descriptions, tasks models and mock-ups to support the recommendations for work and product re-design.

Results: The analysis of the work situations identified different work organisations and procedures across the hospital's departments. The most important differences concerned the doctor–nurse communications and cooperation modes and the procedures for preparing and administering the medications. The assessment of the medication CPOE functions uncovered a number of usability problems including severe ones leading to impossible to detect or to catch errors.

Models of the actual and possible distribution of tasks and roles were used to support decision making in the work design process. The results of the usability assessment were translated into requirements to support the necessary re-engineering of the IT application.

Conclusion: The HFE approach to medication CPOE efficiently identifies and distinguishes currently unsafe or uncomfortable work situations that could obviously benefit from an

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IT solution from other work situations incorporating efficient work procedures that might be impaired by the implementation of the CPOE. In this context, a careful redesign of the work situation and of the entire work system is necessary to actually benefit from the installation of the product in terms of patient safety and human performances. In parallel, a usability assessment of the product to be implemented is mandatory to identify potentially dangerous usability flaws and to fix them before the installation.

1. Introduction

In the healthcare domain, the last decade has been characterized by a growing concern over patient safety [1,2]. In an era where investigative techniques and treatments are becoming ever more powerful, adverse events and medical errors are increasingly threatening to the patients' welfare. Unfortunately, it is also clear that a significant number of adverse effects actually reach patients, with possible deadly consequences [3]. We also know that most of these adverse events are preventable [4,5]. This has led to considerable effort to render the health care process more secure [6] and to improve its quality and efficiency.

In this context, the Human Factors Engineering (HFE) approach to analysis, evaluation and redesign of the healthcare work systems has proven efficient [7]. This approach allows identifying the determinants of the work system that make the situation potentially dangerous. It also provides recommendations to optimize this work system, on organisational, cognitive and technical levels.

This paper presents a case study of a Human Factors Engineering approach to a medication administration process in a large academic hospital, in the context of a medication Computerized Provider Order Entry (CPOE) project. The study focuses on the nurses' tasks of preparing and administering oral route drugs to the patients, with a particular attention to the nurses' needs in terms of information necessary to efficiently and safely support their tasks.

2. Rationale and theoretical background

2.1. *Rationale: the HFE approach*

The Human Factors Engineering framework (Fig. 1) provides structured methods and tasks to achieve the optimisation of the work system and to inform its re-design: human well-being, usability of the products or work devices, overall work performance and safety of the care process [8].

The first task of the HFE approach is the *analysis of the work system*. It requires the understanding, description, analysis and if possible modelling of the work situation. The description of the work situation identifies *who* (people, user) does *what* (tasks), *how* (technology), in which *context* (environment, care process) and under which *constraints* (regulations). This analysis issues a description of the work situations along with a list of diagnosed problems from the Human Factors point of view, and proposes recommendations to fix these problems or at least mitigate their potential negative impact.

When a new IT system is envisioned, the second step of the HFE approach is the *usability evaluation* of this system. This evaluation identifies general usability problems as well as specific ones, i.e. problems that would affect the work system under consideration. The usability evaluation results in recommendations for fixing the problems.

The recommendations must be reconciled with the institution/designers/developers capabilities, leading to the third step, the *cooperative design or re-design* of the expected, re-engineered work situation featuring the new product/IT application. This design phase should generate a model of the re-engineered work situation, incorporating organisational and usability goals that can be translated, as far as possible, into detailed requirements for the future product/work situation.

As soon as early prototypes or advanced mock-ups are available, or as soon as pilot sites start functioning, the last phase of *iterative evaluation* starts, that aims at identifying discrepancies between the expected work system or product and the observed ones. Human Factors or usability problems are identified and reported, along with suggestions for fixing the problems. When the new work system meets all the HF and usability requirements, the product may be released and/or the new organisation implemented throughout the institution.

2.2. *Theoretical background: cognitive models*

Within the HFE framework, the theoretical background supporting the analysis and modelling of the work system is a key point. Where patient safety is concerned, the analysis of the work situation also aims at identifying error prone factors and should therefore incorporate cognitive models of information processing, decision making and human errors as well as taxonomies of errors [9].

In the healthcare domain, the work situation presents some remarkable features, the most important ones being the importance of cognitive factors and the continuous evolution of this situation.

- *Importance of cognitive factors*. A great deal of healthcare professionals' activities comes down to {medical, clinical, physiological, biological, psycho-sociological} information management, i.e. information gathering, processing, selection, interpretation, documentation, and transmission. This information management in turn is the foundation for decision making and for the planning and execution of the care process. Those cognitive activities are therefore of particular importance when tracking error prone factors in the healthcare work situation. Mishaps, flaws and problems in the information accessibility and display may lead to medical errors both in the form of *slips* (application of correct procedures or reasoning on incomplete or false informa-