Context Sensitive Health Informatics: Many Places, Many Users, Many Contexts, Many Uses
E.M. Borycki et al. (Eds.)

doi:10.3233/978-1-61499-574-6-100

Integrating Methods to Evaluate Health Information Systems

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Abstract. There are different methods to evaluate Health Information Systems (HIS), such as Quality Evaluation of software products, human factors, and socio-technical approaches. This work aims to identify the main aspects used to evaluate HIS, and whether there are relationships between issues considered in assessment of software quality and the ones applied specific to the health domain. This was an exploratory study that included a literature search related to HIS evaluation and software quality analyses applying the norms of the International Organization for Standardization (ISO/IEC), to identify aspects and features applied during the assessment process. The result is a proposal of an evaluation method based on the integration of these two evaluative approaches, combining or complementing the considered aspects. The method was applied to an evaluation of a natural language processing system to identify continuity of care in discharge summaries.

Keywords. Technology assessment, health information system, evaluation methodologies, evaluation studies, quality software validation.

1. Introduction

Improving a patient's treatment and health management using a Health Information System (HIS) is a priority for health services and professionals. In this context, a strict evaluation of HIS is needed to assure the quality of information, effectiveness, and a full understanding of the effects, and impacts of its application [1,2].

One of the main methods to evaluate the quality of Information Systems has been the International Standard Organization's Software product Quality Requirements and Evaluation (SQuaRE) – Guide to SQuaRE, last reviewed in 2014 (ISO/IEC 25000) [3,4]. The focus is particularly on software quality [5]. To evaluate specifically the use of HIS, approaches related to human factors and socio-technical theories are often applied. These methods consider aspects such as efficiency, effectiveness, information quality, usability, and context. However, there is no tradition for HIS evaluations that integrate software quality and human factors approaches [6].

In an article that addresses the problems and challenges of evaluation of HIS, Ammenwerth [7] states that there is a need to understand information technologies as part of the information system of an organization. It is clear that an assessment will not only focus on hardware and software, but on the processing of information, namely on the interaction between IT and users in a given environment (human factors and socio-

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technical). This means that often more than one aspect of an HIS is evaluated in a single product. The evaluation requires not only an understanding of computer technology, but also social and behavioral processes that affect and are affected by technology. To compensate for this flaw, this paper aims to identify the main features used to evaluate HIS, and to analyze its relation to software quality to specify a possible integration of the two approaches. This was applied in a case study to evaluate "IRDischarge" [8], a natural language processing system to support the identification of continuity of care in discharge summary narratives.

2. Method

The study started with a search of the PubMed database to identify publications from the last ten years (until May 2015) related to HIS evaluation, applying the terms: "evaluation" OR "assessment" AND "electronic health record". The search found 4835 articles, but only 105 articles were related to HIS evaluation considering human factors or sociotechnical issues. Reading the articles revealed 17 different features used to evaluate HIS. Usability, effectiveness (precision and recall), sensitivity and specificity were the most frequently found.

Hereafter, a new search was performed using the terms "Evaluation of quality in health information systems". As this search did not provide any relevant information, the search was redone using the terms "Evaluation of software quality". Sixteen articles were identified, although only two applied a regulatory norm in the evaluation. In these cases the ISO/IEC 9126 was used. An additional search using the terms ISO/IEC 9126, 14598 and 25000 was carried out. The analysis of this led to the conclusion that even the most recent publications are not related to the use of the norms ISO/IEC in the software evaluation, since the new series SQuaRe that was published in 2005, reviewed in 2008 and 2014 is not used in any paper [3].

The analysis of the methods that applied a socio-technical approach revealed few aspects that can be integrated to complement the ISO approach. From that, the authors attempted to integrate the methods that were carried out by composing a completely new approach that ensured the system's quality certification, was complemented by human factors and socio-technical evaluation, and was specific to HIS. This was performed by: combining similar aspects into one item, joining the ones that are complementary in a new item, and incorporating the specific aspects, involved in each approach, to reach the final proposal. To demonstrate the strength of the new proposed method, it was applied in the IRDischarge evaluation.

3. Results and Discussion

The decision to integrate different kinds of evaluation approaches has the aim to improve the process, whereas there are features that are repeated, others are complemented, and a few are indispensable for the system to work and to assure benefits. It does not mean that these features are insufficient if they are done separately. Each feature fulfills exceptionally well its role to evaluate, however, together they complement each other and are able to guarantee that a system has quality while it brings benefits when utilized.

Figure 1 shows features considered by the human factors approach in the left column and the right column presents the aspects evaluated by ISO. By analyzing both approaches it is possible to see that the aspects of usability and efficiency are the same. These aspects can guarantee a user-friendly system, in other words, a system that is easy to use by any professional, and will reach its goal without great efforts.

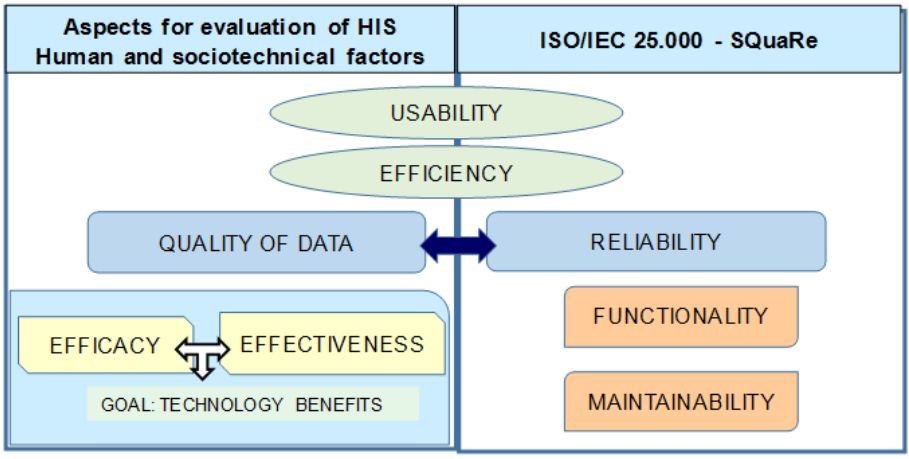

Figure 1. Relation between the evaluation methods based in human factors and in the ISO.

Also, in observing what is common between the two evaluations, Oleto [9] asserts that when we analyze the information quality of the product, it emphasizes the information as an object, giving the information quality some dimensions or attributes, such as reliability. Therefore, we understand that with this view, reliability is an aspect to be evaluated inside the big group of information quality.

Efficacy and effectiveness are essential during evaluation to show whether the new technology will bring the requested benefits or not. These features are not included in the ISO/IEC 25000 approach. On the other hand, the aspects of functionality and maintainability, which guarantee the system to be liable to execute tasks, and that it can be sustained, are not covered sufficiently by the human factors and socio-technical approaches.

To use the socio-technical and human factors approach to evaluate the HIS and aggregate it to the series SQuaRe, would be a way to complement the evaluation.

Items to be evaluated	Evaluation's goal
Literature	What are the methods used until this moment for this kind of HIS?
Evaluation design	Define the goals and how they are going to be reached.
Functionality	Will the system be reliable to use?
Maintainability	Can the system be kept up or changed if necessary?
Information quality	Are the results, data generated or entered trustworthy?
Efficacy	Will this system bring benefits in ideal situations?
Effectiveness	Will this system bring benefits in real situations?
Usability	Will this system be easy to use?
Availability	Will this system be able to reach the goal of minimizing loss of resources?

Figure 2. Presentation and description of the evaluation items.

However, before launching any evaluation study it is required to determine the type of evaluation, the aspects of a particular type of system, as well as the results aimed for. A literature review is the best way to identify this information. This step helps to start the characterization of the study design, in other words, to choose what suits the system evaluation best, based in what has previously been studied and used.

Based in these surveys, the proposed method is composed by nine items that associate aspects from both approaches, also including an initial analysis performed by a literature review. Figure 2 shows these items with their description.

Figure 3 shows what has to be done in each of the items of the proposed method to evaluate the natural language processing system, IRDischarge.

Evaluation item	Example in *IRDischarge* Evaluation
Literature	Information retrieval systems are mainly evaluated regarding precision and recall.
Evaluation design	Is IRDischarge able to support physicians during discharge summaries elaboration, advising them on the absence of continuity of care description?
Functionality	Can IRDischarge be used in health institutions? Can it be incorporated into Electronic Health Records?
Maintainability	If there is any modification in continuity of care description, could the *IRDischarge* make these modification? If there is a necessity to recover any other information inside the discharge summary, is it possible to insert this new functionality in a simple way?
Information quality	Is the presence or absence of continuity of care indicated correctly?
Efficacy	Precision and recall evaluation.
Effectiveness	When used in health institutions, will the system bring benefits for the society? For example, facilitating health treatment continuing after a hospital discharge?
Usability	Is the system interface clear and user-friendly to the health professionals when elaborating the discharge summary?
Availability	Will the system indicate the presence or absence of continuity of care, with the best quality and using the minimum resource as possible?

Figure 3. Example of the proposed method to evaluate the IRDischarge.

4. Conclusion

HIS have to be developed with the aim to facilitate a health professional's work. To reach this goal, systems have to be evaluated properly. This paper presents an improved method, including pre-evaluation steps and features to be analyzed that assure the quality of the product and the benefits of the new technology for society.

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