SClinico: Usability Study

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Abstract: The use of electronic health records (EHR) to support clinical practices is widespread worldwide, due to the need to optimize health care delivery. Therefore, the usability assessment of EHR systems is crucial. The objective of this study was to perform a qualitative and quantitative assessment of the usability of SClinico, the most used EHR system within the Portuguese National Health Service. This observational study to assess SClinico usability took place in several clinical services of the Centro Hospitalar de Trás-os-Montes e Alto Douro. The results show that SClinico has some usability issues that influence the clinical practice and, therefore, need to be improved.

1 INTRODUCTION

In 1998, the International Organization for Standardization (ISO) defined usability as being the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (International Organization for Standardization, 1998).

The present paper reports an observational study to assess the usability of SClinico, the most used electronic health records (EHR) system within the Portuguese National Health Service. This study was performed in several clinical services of the Centro Hospitalar de Trás-os-Montes e Alto Douro (Trás-os-Montes and Alto Douro Hospital Centre), known as CHTMAD, composed by three hospitals of the Portuguese Serviço Nacional de Saúde (National Health Service).

In addition to this introductory section, the paper comprises five more sections: Related Work,

Methods, Results, Discussion, and Conclusion.

2 RELATED WORK

An EHR, in its simplest form, consists of an electronic file containing clinical information about the individuals and can help to personalize care, prevent medical errors, promote the consistency of care, support the referral of the care receivers to the correct services, control costs or support clinical research. In terms of health care delivery, EHR systems represent a benefit to both the patient and organizations, since they enable secure, accessible and efficient clinical information reporting and retrieving and, therefore, contribute to the quality of the health care delivery.

EHR systems allow the clinical report, as well as the access, exchange and share of the required clinical information (Rouleau et al., 2015). Therefore, EHR systems support highly collaborative and demanding

processes, involving large number of clinicians with distinct profiles (e.g. physicians, nurses or therapists), social workers, managers and administrative personnel (Marin, 2010; Mair et al., 2012).

Adequate and efficient mechanisms must be made available to allow the visualization of the required information to prevent and treat the disease, whenever and wherever required (Zahabi et al., 2015). In fact, the use of clinical information is often carried out in different contexts, such as, for example, an emergency service of any hospital, where the rapid access to comprehensive patient's clinical information is essential. The adaptability of health care applications to different situations might influence the way the clinical information is reported and retrieved, which, necessarily, has impact on the health care delivery.

According to Zahabi and colleagues (Zahabi et al., 2015), some of the problems with the implementation of EHR systems may be related to the usability of the respective user interfaces, such as poor readability, poor alarm identification or insufficient feedback on the actions being taken. Considering that EHR systems are fundamental tools for the health care delivery, it is therefore important to assess their usability (Bhutkar et al., 2013).

Internationally there are many usability studies of EHR systems, targeting different clinical domains (American Medical Association, 2014; Feng, Chang, 2015; Villa, Cabezas, 2014; Choi et al., 2015; Czaja et al., 2015; Clarke et al., 2014). There are also efforts to standardize the usability assessment methods attempting to find a common ground, which is fundamental to perform comparative studies (Johnson et al., 2011; Zhang and Walji, 2014).

According to Saitwal and colleagues (Saitwal et al., 2010), some EHR systems do not have user-friendly interfaces, as they often do not take in consideration the user centric development. The referred authors (Saitwal et al., 2010) applied a cognitive analysis method to assess the usability of EHR systems, which made possible the identification of issues that could be improved, namely the reduction of the number of steps to perform certain tasks, together with the minimization of the cognitive effort required to execute them (Marquié et al., 2015).

Edward and colleagues (Edwards et al., 2008) argue that the usability of EHR systems is crucial to ensure safety and to enable clinicians to focus more on patients and less on technology. These authors used a heuristic assessment method to identify points of possible usability improvements of an EHR system supporting a paediatrics service. The results of this usability assessment allowed immediate improvements in the EHR system configuration and training materials.

Since there is a worldwide trend to consider usability as one of the important factors of the implementation of EHR systems, the American Medical Informatics Association (AMIA) created a working group to propose relevant recommendations (Middleton et al., 2013). Moreover, the National Institute of Standards and Technology (NIST) describes a set of procedures for design evaluation and user performance testing of EHR systems by defining an EHR usability protocol (EUP) (Lowry et al., 2012). The purpose of this protocol is to provide methods to measure and validate user performance prior to deployment and it comprises a three-step process: application analysis, user interface expert review, and user interface validation testing (Lowry et al., 2012).

Thus, since there is no solid evidence on the usability assessment of SClinico, the most used EHR system within the Portuguese National Health Service, and given the growing interest of the international community in the usability of EHR systems, the authors considered important to assess the usability of SClinico (Pavão et al., 2016).

3 METHODS

3.1 SClinico

In the Portuguese public hospitals, clinical records have been carried out in electronic format since 1988, using a common information system, the Sistema Integrado de Informação Hospitalar (Integrated Hospital Information System) also known as SONHO, and two specific health care applications for physicians and nurses, respectively the Sistema de Apoio ao Médico (Medical Support Service), known as SAM, and the Sistema de Apoio à Prática de Enfermagem (Nursing Practice Support System), known as SAPE. These two applications were used until 2013. In 2014, the application known as SClinico replaced the previous two, by integrating in a single application the medical and nurse profiles. According to the organization responsible for the development of SClinico, the Serviços Partilhados do Ministério da Saúde (Shared Services of the Ministry of Health), known as SPMS, SClinico is present in more than 50 public hospitals, as well as in more than 300 primary care centres (Serviços Partilhados do Ministério da Saúde, 2017a; 2017b).

The SClinico is part of the strategy defined by the Portuguese Ministry of Health to introduce

information technologies in the Portuguese National Health Service. SClinico was born from the vast experience with two previous applications used by thousands of clinicians of the Portuguese National Health Service: the SAM and SAPE applications, which have evolved to be a single application for all clinicians and focused on the patient (Serviços Partilhados do Ministério da Saúde, 2017a; 2017b).

With SClinico, the Portuguese Ministry of Health foresees the provision of a standardized tool for reporting and retrieving clinical information to promote the homogenization of procedures at national level (Serviços Partilhados do Ministério da Saúde, 2017a; 2017b). This might contribute to the efficacy and efficiency of health care delivery, allowing the clinicians to perform better their role in multidisciplinary teams and to provide better support, assistance and follow-up to their patients (Serviços Partilhados do Ministério da Saúde, 2017a; 2017b).

The SClinico has two versions, SClinico Hospital and SClinico Primary Health Care. The first, SClinico Hospital, has more than sixty thousand registered clinicians. In turn, more than thirteen thousand clinicians are using the SClinico Primary Health Care (Serviços Partilhados do Ministério da Saúde, 2017a; 2017b). Particularly, in this study the SClinico version that was assessed was the SClinico Hospital version.

3.2 Usability Assessment

The usability of an application, decisive when dealing with health care application, is influenced by the efficiency and efficacy of the respective user interface, as well as the required cognitive effort and overall user's satisfaction (Nielsen, 1993). It is expected that the focus of clinicians will be the patients and, in this sense, the more intuitive user interface the more it will contribute to adequate and proficient care.

A user interface with adequate usability allows the reduction of memorization efforts, tasks fulfilment duration and errors, as well as the promotion of its user's satisfaction. As Nielsen (Nielsen, 1993) points out, these characteristics influence the acceptability of a system by their users.

Usability assessment is an important part of the overall design of the user interfaces, which consists of interactive prototyping, design and validation cycles (Ivory and Hearst, 2001). Usability assessment must be understood in a comprehensive way in the context of a given project and cannot be done without connection to the intended functions of the system.

There is a wide range of tools and methods to identify and assess system's usability and to contribute, directly or indirectly, to its improvements (Martins et al., 2013; Martins et al., 2014). In particular, user-centred development methods ensure that real systems can be used by real people to perform their tasks in the real world (Bevan, n.d.).

3.3 Objectives of the Study

The primary objective of the observational study reported in this paper was to assess the usability of the SClinico, particularly the SClinico Hospital version, as well as the level of satisfaction of its users. As a secondary objective, it was intended to identify, in terms of usability, improvements that should be implemented.

3.4 Research Plan

Data collection was performed in several clinical services of CHTMAD.

The protocol of the observational study comprised two stages. In each of them, a specific usability assessment method was used: in the first stage, a qualitative assessment was carried out; while in the second stage, a quantitative assessment was performed using a validated usability assessment scale.

The first stage of SClinico's assessment took place few weeks after it has being introduced in the clinical services of CHTMAD (i.e. May and June 2014). In turn, the second step was performed eighteen months after the first assessment, when all potential users were already familiar with SClinico.

The qualitative assessment for the first stage was performed by a specially prepared questionnaire (Covêlo, 2015). In turn, the second stage consisted in a quantitative self-reported assessment of the SClinico usability (user opinion) using the Post-Study System Usability Questionnaire (PSSUQ) (Lewis, 2002). Specifically, after using SClinico the clinicians were invited to participate in the study and to complete the PSSUQ.

3.5 Instruments

The development of the questionnaire used on the qualitative assessment was based on a literature research related to relevant questions that should be considered when assessing the usability of EHR systems (Covêlo, 2015; Pavão et al., 2016). It is composed of two sections, the first one dealing with demographic aspects and the second with the

interaction with SClinico. This second section has 45 questions, and if a particular inquired clinician was allocated to the emergency service, he/she would have to answer four more questions. Most of the questions are closed answer questions, being seven of them open answer questions aimed to detail some of the closed answer questions.

The questions that constitute the second section were grouped in the following classes, accordingly to the recommendations of other studies (Covêlo, 2015):

- System performance (10 questions).
- Clarity of information (12 questions).
- Quality of the graphical interface (12 questions).
- Adequacy of the system's functions to the tasks performed (11 generic questions plus four questions specifically related to the emergency service).

In turn, the PSSUQ, used for the quantitative usability assessment, was developed by International Business Machines (IBM) and consists of 19 items rated on a 7-point scale (from 'strongly agree' - 1, to 'strongly disagree' - 7) (Lewis, 2002). The PSSUQ addresses five usability characteristics of a system: rapid completion of the task; ease of learning; high quality documentation; online information; and functional adequacy (Lewis, 2002).

According to the authors of the original version, the score of the PSSUQ can be specified by three sub-scores, system utility (SysUse), information quality (InfoQual), and interface quality (IntQual), that can be obtained as follows (Lewis, 2002):

- The mean value related to the system utility (SysUse) - items 1 to 8;
- The mean value related to the quality of information (InfoQual) - items 9 to 15;
- The mean value related to the quality of the interface (IntQual) - items 16 to 18.

The final score of PSSUQ is the average of the scores of its items. If a participant fails to respond to an item or classify it as N/A (not applicable), then that item should be scored with the average score of the remaining items. Finally, higher scores indicate lower usability and vice-versa.

The PSSUQ was translated and adapted from the cultural and linguistic point of view to the European Portuguese (Rosa et al., 2015). This instrument was completed by the participants considering their opinions about the interaction with SClinico.

3.6 Sample Selection

All physicians and nurses of CHTMAD using SClinico in their clinical practice were eligible to

participate if they previously gave a written informed consent accepting to participate in the study, whereby the available population covered by the questionnaire was composed of 1253 elements, out of which 426 were physicians and 827 were nurses. As the SClinico interface is different for physicians and nurses, the data analysis was performed separately.

3.7 Regulatory, Ethical and Data Protection Aspects

To address the ethical issues, a request of approval was directed to the administration and ethical committee of the CHTMAD.

Additionally, all the involved subjects received all the information regarding the study and their participation before completing the informed consent. This study considered all ethical principles underlying the Helsinki Declaration (World Medical Association, 2013), the Good Epidemiological Practice Guidelines (International Epidemiological Association, 2007), and the applicable legislation and regulations.

All necessary steps were taken to protect the participant's privacy and all relevant guidelines on data privacy were followed: information that may allow the identification of participants was not stored in the study database; participants were identified in all study documents by a unique identification number; and the only document linking the identification number to personal information (e.g. names, addresses or telephone numbers) was stored in a safe that could only be accessed by the principal investigator. Moreover, professional secrecy was mandatory for all investigators involved in conducting the study and doing reports. The investigators were told not to disclose personal information, obtained by having access to research data, to someone outside the research team. In accordance with Good Epidemiological Practice (International Epidemiological Association, 2007), all study investigators agreed to respect the legislation and regulations applicable to data processing resulting from research on humans. The principal investigator was in charge to ensure that all team members were aware of these rules.

4 RESULTS

4.1 Results of the Qualitative Assessment

The qualitative assessment involved a convenience sample of 22 physicians and 47 nurses from the following clinical services of CHTMAD: medicine, surgery, intensive care, oncology, gastroenterology, paediatrics and emergency (Pavão et al., 2016).

The age of the participants varied between 26 and 58 years. Considering the physicians group, the participant's age varied between 26 and 58 years, while in the nurses group, the participant's age varied between 27 and 55 years. The mean age was 43 years (SD = 11.8) for the physicians group and 38 years (SD = 8.3) for the nurses group. Most participants were female in both groups, being 75% female and 25% male.

Regarding the number of years with clinical experience, 15% of the clinicians had 5 or less years, 32% from 5 to 15 years, 34% from 16 to 25 years and 19% from 26 to 35 years of clinical experience.
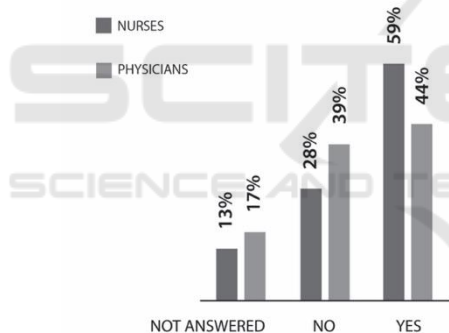

Figure 1: Percentage of answers to the question: do you consider the SClinico appropriate tool to report and retrieve clinical information?

Concerning the opinion of the participants about SClinico as a clinical information reporting and retrieving tool (Figure 1), only 44% of physicians think it is an appropriate system, while 17% did not respond. Regarding the nurses group, 59% of the participants answered positively when questioned whether SClinico is an appropriate EHR system, with only 13% who did not respond.

Regarding the assessment of whether SClinico facilitates the clinical practice (Figure 2), 22% of the physicians answered negatively and 35% did not respond, while 23% of the nurses answered negatively and 11% did not respond. The main concern, in the case of physicians, is related to the

organization of information that seems to be inadequate to the needs of these clinicians. In the case of the nurses, the ambiguity of some information fields together with the low contrast of the colours selected for the user interface (e.g. in the initial menu, the design of the icons is ambiguous with colours difficult to differentiate) do not facilitated the user interaction.

When questioned about whether the graphic environment is favourable after consecutive working hours (Figure 3), most physicians were satisfied (52%), while 31% of the physicians were dissatisfied. There is a great difference of opinion on this issue among physicians and nurses, since 66% of the nurses were dissatisfied, with only 34% satisfied.
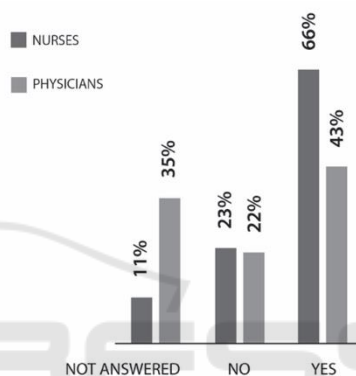

Figure 2: Percentage of answers to the question: do you consider that SClinico facilitates your clinical practice?
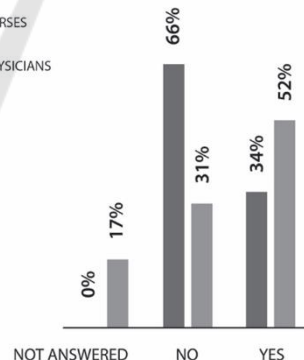

Figure 3: Percentage of answers to the question: do you consider that the SClinico's graphical environment facilitates your clinical practice, after hours of consecutive work?

Regarding the clinicians allocated to the emergency service, specifically when it is required to rapidly access to a comprehensive perspective of the clinical history of the patient (Figure 4), most of the

participants believe SClinico is not adequate, since 57% of physicians and 53% of nurses answered accordingly.

Most clinicians think that it is very important, or even decisive, to have a direct access to relevant patient information in cases of urgency, to speed up and facilitate the evaluation of the clinical history of the patients. Nevertheless, the participants have expressed disappointment with SClinico in this regard.

The main reason given is related to the slowness of the system, and it is unclear whether this is due to issues related to the communication network of the CHTMAD or related to usability issues of SClinico (e.g. the need for a large number of tasks using the pointing device or a deficient organization of the information).

One of the most desired features for all clinicians is the ability to view patient's information in a comprehensive way to cover the entire clinical situation in a glance. This form of visualization would allow a rapid assessment and correlation of different clinical aspects of a patient. This question was asked in the questionnaire and 100% of the participants of both groups considered important the existence of this type of function.
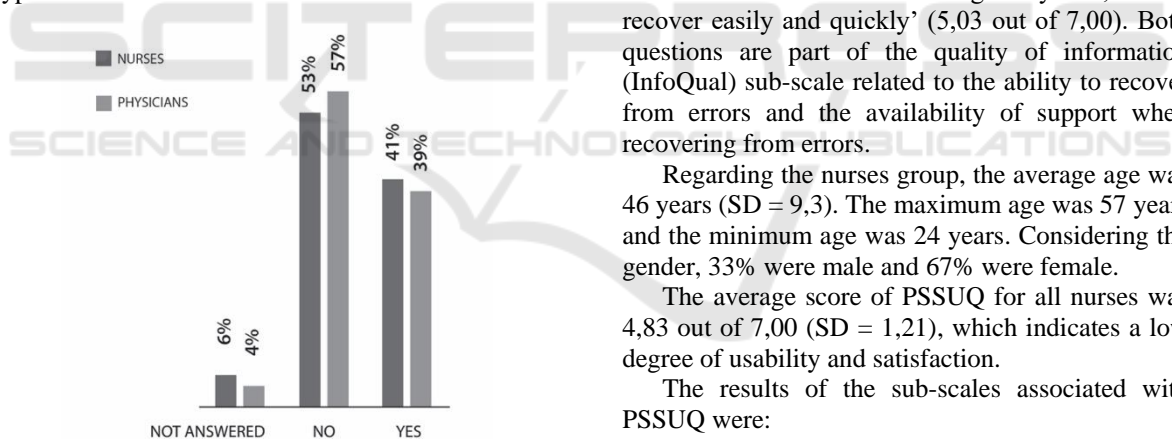

Figure 4: Percentage of responses to the question: in urgent cases, do you consider SClinico adequate for the clinical evaluation of the patient?

4.2 Results of Quantitative Assessment

For the quantitative assessment using the PSSUQ, the sample consisted of 33 physicians and 21 nurses of all the clinical services of one of the three hospitals that constitute the CHTMAD: the Hospital of Lamego.

Regarding the physicians group, the average age was 39 years (SD = 11,5). The maximum age was 66 years and the minimum age was 25 years. In terms of gender, 48% where males and 52% were females.

The average score of PSSUQ for all physicians was 4,10 out of 7,00 (SD = 1,35), which indicates a medium low degree of usability and satisfaction.

The results of the sub-scales associated with PSSUQ were:
- System Utility (SysUse): average of the responses from items 1 to 8 = 3,75 (SD = 1,48).
- Quality of information (InfoQual): average of the responses from items 9 to 15 = 4,47 (SD = 1,47).
- Interface Quality (IntQual): average of the responses from items 16 to 18 = 4,00 (SD = 1,60).

In a more detailed analysis, the questions that obtained better results were 'I felt comfortable using this system' (3,20 out of 7,00) and 'it was easy to learn to use this system' (3,30 out of 7,00). Both questions are related to the System Utility (SysUse) sub-scale.

The questions that obtained worse results were 'the system gave error messages that clearly told me how to fix problems' (5,20 out of 7,00) and 'whenever I made a mistake using the system, I could recover easily and quickly' (5,03 out of 7,00). Both questions are part of the quality of information (InfoQual) sub-scale related to the ability to recover from errors and the availability of support when recovering from errors.

Regarding the nurses group, the average age was 46 years (SD = 9,3). The maximum age was 57 years and the minimum age was 24 years. Considering the gender, 33% were male and 67% were female.

The average score of PSSUQ for all nurses was 4,83 out of 7,00 (SD = 1,21), which indicates a low degree of usability and satisfaction.

The results of the sub-scales associated with PSSUQ were:
- System Utility (SysUse): average of the responses from items 1 to 8 = 4,83 (SD = 1,38).
- Quality of information (InfoQual): average of the responses from items 9 to 15 = 4,84 (SD = 1,40).
- Interface Quality (IntQual): average of the responses from items 16 to 18 = 4,67 (SD = 1,32).

In a more detailed analysis, the questions that obtained better results were 'I felt comfortable using this system' (4,38 out of 7,00) and 'the interface of this system was pleasant' (4,43 out of 7,00).

The questions that obtained worse results were 'overall, I am satisfied with this system' (5,38 out of 7,00) and 'I believe I could become productive quickly using this system' (5,33 out of 7,00).

5 DISCUSSION

The analysis of the qualitative assessment results identifies several usability problems that need to be considered in more detail. One of these problems has to do with the cognitive load. According to Zahavi and colleagues (Zahabi et al., 2015) information overload appears when the ability to perceive and understand is exceeded by the amount of information presented by a user interface, to the point of facilitating information processing errors.

Moreover, an issue that all participants consider important, known and discussed in the area of information visualization (Hansen et al., 2011), was related to the user interface adaptability and flexibility to allow a comprehensive visualization of a patient's clinical information. Particularly, most participants allocated to the emergency service answered that it is difficult, in the context of emergency services, the rapid access to the clinical history of the patients, which they considered a fundamental requirement.

The quantitative results corroborate the discontent of the SClinico users patent in the qualitative analysis.

The physicians group considered that SClinico has low usability. The sub-scale that presented the best values refers to the utility of the system (SysUse) and the one that presented worse values is the one that refers to the quality of the information (InfoQual). This seems to indicate that there is a recognition of the utility of SClinico, however the clinicians were unsatisfied with the mode the information is presented and the general usability of the system.

The nurses group classified the usability of SClinico even lower than the physicians group. One of the reasons that may explain this result is the fact that nurses spend more time reporting and retrieving clinical information using SClinico than physicians. This fact may justify a greater frustration of the nurses group in terms of the SClinico usability. The overall functioning of the system and the ability to use it productively were the most critical aspects for the nurses group.

For both groups of participants, the best-performing score of PSSUQ was the system utility (SysUse), which suggests that clinicians consider that a system such as SClinico benefits their clinical practice. The second was the quality of interface (IntQual) and lastly the score of the information quality (InfoQual).

The values of InfoQual sub-scale (i.e. 4,47 for physicians and 4,84 for nurses) seem to suggest that the usability problems of SClinico are reflected in the perception that clinicians have of the information quality that SClinico provides. This must be deeply studied since the quality of the health care delivery relies on the quality of the information.

6 CONCLUSIONS

In terms of study limitation, the small sample size stands out. However, this is not significant, since the size of the sample does not preclude some conclusions from being drawn from the results, in particular as regards the need to improve the usability of the SClinico.

The results of the usability assessment questionnaire shows that the use of SClinico would clearly benefit from alternative forms of information visualization, as well as a better organization of the interfaces.

Moreover, the results of the application of the PSSUQ, which was applied 18 months after the introduction of SClinico (i.e. at a time when clinicians were already accustomed to its use) point clearly to usability problems: a general score of 4,10 (SD = 1,35) for physicians and of 4,83 (SD = 1,21) for nurses clearly indicates low degree of usability and satisfaction.

Given the widespread use of SClinico in the Portuguese National Health Service, the less positive points pointed out by the clinicians should be considered. Therefore, further developments are required to improve SClinico, namely in terms of visualization of the information and organization of the interfaces. These developments are required to facilitate a comprehensive visualization of the relevant information, as well as to facilitate correlations of possible past situations with the current episode. Furthermore, an improved version of the graphical design, too flat with poor colour contrast, should also be considered.

Therefore, based on the study reported in this paper, the authors are preparing a set of suggestions that may improve the usability of SClinico and are planning to evaluate these suggestions in another observational study to be conducted in the CHTMAD.

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