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Improving Pervasive Decision Support System in Critical Care by using Technology Acceptance Model

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Abstract

The increase in the use of technologies in the health area and the evolution of their characteristics became an essential aspect for increasing knowledge in this area, especially in intensive medicine. This aspect is critical for the treatment of high-risk patients, so it became necessary to study the factors that influence the acceptance of the technologies. The INTCare is one technologic healthcare platform that is used in intensive medicine at the Hospital Centre of Porto. This article analyses the INTCare system, the technology acceptance model (TAM) methodology and its application in the preferred system. This analysis is the third already done to this platform, and it comes with the purpose of verifying if the improvements detected in the previous evaluation were carried out successfully and of finding new enhancements. As a result, a questionnaire was developed, with a total of 49 questions, where each one corresponds to at least one TAM construct. This paper allows understanding how systems features can be mapped to the TAM model and how the questionnaires can be used to support it.

Keywords: Technology Acceptance Model; INTCare; Intensive Medicine

1. Introduction

Technologies are suffering from significant changes that are sometimes not well accepted by those who need them in their daily lives. Thus, it became necessary to study why technology is or is not well received (level of acceptance) by its users. In the intensive care unit (ICU), of the Hospital Centre of Porto (CHP), there are intelligent environments

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that help the clinical decision making and hospital processes [1]. These intelligent environments emerged in the CHP with the objective of streamlining intensive care (IC) processes and tasks [2]. This happened due to the appearance of several obstacles that existed in this field, such as a significant amount of non-computerized data, which led to more time-consuming and ineffective decision-making [3]. The intelligent environments have knowledge-based decision support systems (DSS) able analyse large sets of variables to be able to answer a strategic question. Clinical decision support systems (CDSS) are created to support and complement clinical practice in different medical specialities. Through these systems it is easier to provide answers, to indicate suggestions and to trace ways to solve a problem, reducing the uncertainty in the clinical decision making [4]. The CDSS analysed in this article is the INTCare's platform of CHP. The INTCare platform works as intelligent decision support that aims to give new information, in real time, to physician and nurses helping them, thus, in possible decision making [5]. The INTCare platform allows obtaining valid data and making decisions of the almost immediate form [6]. The goal of the platform is the monitoring of patients' clinical condition [3]. The methodology used to evaluate the INTCare was the Technology Acceptance Model (TAM). This methodology uses questionnaires, made for the users of the platform, to help understand the determinants of the acceptance of a technology. The focus of this article is the health area, more specifically the ICUs, where the use of the technologies is of added value because it supports the decision of clinicians in health care. This paper presents the third evaluation of the INTCare's platform, considering the last two evaluations and defining improvements to it and show of the results can be delivered to developers' team. The content of this article presents INTCare and represents a theoretical basis for evaluating the platform, describing the essential concepts for the project, and is divided into four chapters. First, an introduction is made on the subject (chapter 1). In the second chapter are described four essential concepts of the article (chapter 2). The third chapter concerns the relationship of the TAM methodology with the INTCare platform. The fourth chapter presents a graphical analysis of the results. Finally, the fifth chapter appears with the intention of reflecting on the work done so far, and a list of guidelines is made for it.

2. Background

2.1. Intensive Care Units (ICUs) and INTCare

ICUs are responsible for treating high-risk patients, which means, patients with poor conditions where the percentage of organ failure is extremely high. The environment of the intensive care unit is recognised as critical as a result of complex health situations [8]. Thus, the INTCare platform has been taken care of, bypassing the data collected offline, where the analysis of them was complex and time-consuming [7], for quick and easy reading. The INTCare system was developed in partnership between the University of Minho and the CHP, in order to assist physicians and nurses in specific gaps in the CHP intensive care unit [7]. The INTCare system supports the management of patients' condition by consulting their real-time data, with tasks such as prediction of organ failure, treatments, outcome, among others.

It should be noted that the users in question are high risk, so it is necessary for an efficient platform promoting the effectiveness of those who use it. To achieve INTCare's platform goals, it is necessary to manage large amounts of data and obtain knowledge from them. Therefore, the main obstacles to overturn by this system were the amount of data acquired manually and the quality of the data acquired automatically [8]. INTCare features are divided by access form that can be through bedside monitors and ICU computers. INTCare has several features: Timeline, Business Intelligence, Patients Data, Drugs, Laboratory Results, Daily records, Clinical Scores and Events.

2.2. Technology Acceptance Model and Delphi

TAM is based on the Theory of Reasoned Action (TRA) and is used to explain the acceptance of technology by an individual through questionnaires and subsequent analysis of them [9]. The TAM's model emerged with two basic constructs: perceived usefulness (PU) and perceived ease of use (PEOU). For Davis [10] perceived usefulness happens when an individual uses technology with the goal of increasing their performance, and the perceived ease of use happens when one thinks that the technology is easy to use. This last construct is influenced by aspects such as formations, user manuals, technical support, among others. The basic constructs, PU and PEOU, are both influenced by external variables (social, cultural and political factors) [9]. TAM3 is based on two models: TAM 2 and the model

of the determinants of the perceived ease of use of Venkatesh [11]. The variables that influence the perceived ease of use are divided into two types [12]: foundation or base (anchors) and systematisation (adjustments). In the type of foundation or base are the following variables: computer self-efficacy, perceptions of external control, computational anxiety and computer playfulness. Systematization or adjustments are the perceptions of enjoyment and real usability.

The Delphi aims to collect and synthesise the opinions of a group of experts [14] to obtain a consensus [15]. The collection is done through anonymous questionnaires that align different opinions/scenarios of the respondents in a coherent and unified perspective [16]. This qualitative, perspective and consensus-based trend assessment [17] is used when there is no data, lack of a multidisciplinary approach or lack of consensus.

3. Technology Acceptance Model application in INTCare

As previously mentioned, TAM is used in information technology, and it is known to be very strong theoretically and very useful for the identification of the reason for the acceptance, or not, of technology by the users [13]. The analysis that this article describes is the third one made to this platform, making this project an incremental project, that is, evaluating the new improvements resulting from other analyses, over time. The previous evaluation was made [3] in 2012 and was based on the Delphi methodology based on TAM 3. The primary objective of the project is the evaluation of the platform, being this evaluation made through the methodology TAM 3, with the help of the Delphi methodology, together with a Business Intelligence analysis. In the TAM methodology, it is necessary to respond to the four fundamental constructs, and Delphi is used to gather and synthesise the knowledge of the users of the INTCare platform, through questionnaires [14]. Delphi has the advantage of obtaining a consensus among the participants, coming from a diverse group [3] and mainly promotes the time of reflection. The Business Intelligence component comes with the objective of assisting in the analysis of the data resulting from the application of the TAM 3 model through graphic visualisation of the results, making it easier to draw useful conclusions from them. The steps necessary to perform an analysis of a platform, in this case, the INTCare, based on the technology acceptance model, TAM 3 was 1) Analysis of TAM's Model, 2) Analysis of INTCare platform, 3) Elaboration and Application of the Surveys and 4) Business Intelligence Analytics. This relationship is made through questionnaire rounds where strategic questions are asked, depending on the four constructs of the model, producing results that can be analysed in the next phase. The questionnaire developed has a total of 49 questions, which are divided by the constructs they analyse. Table 1 shows the number of questions per construct and an example of each. It is important to note that one question could be applied to more than one construct.

Table 1 - Number of questions per construct

Construct	Number of questions	Example of question
Perceived Usefulness	34	What is your purpose to use a computer?
Perceived Ease of Use	27	Does the system allow efficient registration of information?
Behavioural Intention	17	Does using the system allow you to lower the heavy workload?
Use Behavior	31	What is the perspective of my colleagues regarding my use of the system?

The areas analysed by these questions are technology experience, functional and technical characteristics, user perspective, ease of learning and individual evaluation of the essential parameters of the system. The Likert scale rules this questionnaire. The Likert scale is usually used in questionnaires where there is an opinion survey, in order to obtain agreement through a statement [13]. The questionnaire is managed from one to five, not limiting the respondents in the choice of answer, nor leaving room for several types of response [3].

In the fourth, and last step, a Business Intelligence section appears where the data acquired by the questionnaires for dashboards will be transformed, helping in the critical conclusions of the acceptance, or not, of the platform.

In conclusion, TAM's methodology can help improve the INTCare's platform in the following aspects: a) Continuous evaluation of the platform and sequential improvement; b) User's participation in the application development; c) Detecting errors and operational failures; and d) Allow collection of users' feedbacks.

4. Data Analysis

In the health area, the possibility of combining clinical data with analytical tools brings benefits to institutions. It allows extracting useful data stored in databases. In this area, institutions are pressured to improve the services to their users by presenting better quality and speed. Therefore, data management makes health information useful promptly, improving the decision-making process, that is, improving the performance of the business and increasing its transparency. In addition to the analysis of the clinical data and considering the methodology is chosen, TAM 3, an analysis of the obtained responses, about the four TAM 3 constructs, was carried out to conclude them. The clinical data used in this analysis are simulated, since this questionnaire is still ongoing, with a total of fifteen nurses and five physicians. The idea is to show how the results will be delivered to INTCare developer team. The following examples are related to the responses of nurses' who use the platform, represented by orange colour. These examples were created to support the analysis of TAM. The sections chosen were: analysis of the functional features and techniques of the platform, which are represented in figure 1. It should be noted that 1 means “disagree strongly” and 5 means “agree strongly”[18]. Figure (a) refers to the functional characteristics of the platform. The questions with the lowest mean of evaluation were 2.1.1. and, 2.1.7. which relate to the efficient recording of information and to the evaluation of communication between the professionals about a patient in question, respectively. The question with the highest mean was 2.1.12. - evaluation of the system as an improvement in patient care.

Figure (b), in outline form, represents the technical characteristics of the platform. It should be noted that all questions have a similar mean value. The speed with which the system has met the needs of users was the highly rated (2.2.1.), and the least rated was the data security (2.2.2.).

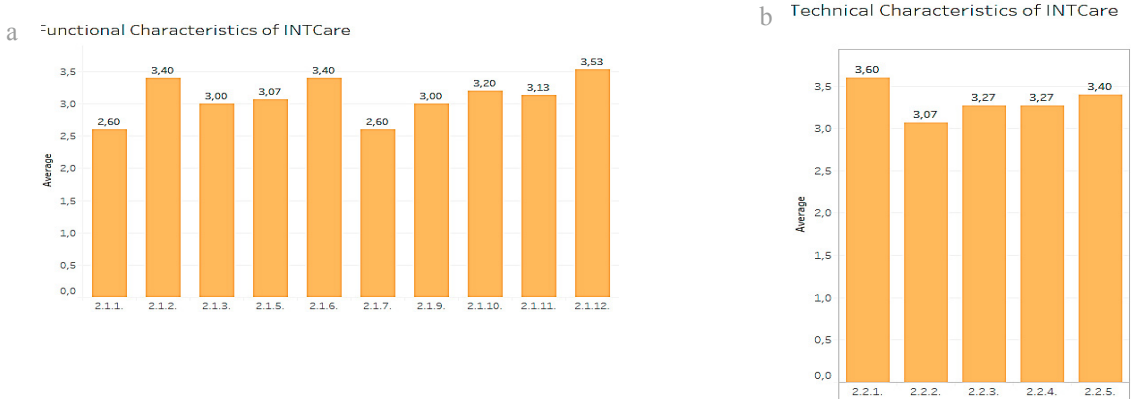

Fig 1. (a) Functional Characteristics of INTCare (b) Technical Characteristics of INTCare

Figure 2 is based on a TAM analysis. In each graph, the questions of the four constructs are evaluated: perceived usefulness, perceived ease of use, behavioural intention and use behaviour. The objective of this analysis is to reach the highest possible mean in the typical questions of each construct.

Graph (a), of figure 4, represents the construct perceived usefulness. We can conclude that the underrated question was 2.6.2.2. These questions are about the operation analysis of the Platform Diary. The questions with the best mean of evaluation were: 2.2.1., 2.6.2.1., 2.8.3., which concern the analysis of the efficient information recording in the platform, the evaluation of the effectiveness of the vital signs’ graphs and analyses clinics of a patient and the evaluation of the Events module, respectively. Figure (b) represents the perceived ease of use construct. The least rated questions were 2.1.1. and 2.1.7, referred previously, and the most highly rated question was 2.8.2. - concerns the analysis of the information record in the events module. Figure (c) represents the behavioural intention construct where the most highly rated question was 2.3. and the least rated was 2.4.3., which refers to the importance of access to external platforms and to the analysis of the benefits that the platform brings to the user. Finally, figure (d) represents the use behaviour construct, where the least rated question was 2.4.3, and the most highly rated question was 2.4.1.1. This last question concerns the acceptance of the use of the platform by other colleagues.

Fig 2 – (a) Analysis of Perceived Usefulness (b) Analysis of Perceived Ease of Use
(c) Analysis of Behavioural Intention (d) Analysis of Use Behaviour

Table 2 represents the calculation of the mean of each construct using the data of figure 2. According to Table 2, we can conclude that the best-evaluated construct was Behavioral Intention. However, the difference between the four constructs is minimal.

Table 2 - Average per construct

Construct	Average
Perceived Usefulness	3,11
Perceived Ease of Use	3,03
Behavioural Intention	3,20
Use Behavior	3,18

5. Conclusions and future work

The INTCare platform came up to manage large amounts of data and gain insight from them, however, data management had to be changed since most of them were acquired manually. Since this project was started, the INTCare platform has needed to enumerate reformulations to improve it. Initially, most of the information was recorded on paper and was later only placed in an offline database, used only for recording information [3]. Several conclusions were extracted through a previous analysis using TAM 3. Analysing this work and comparing it with the previous project, it is necessary to verify if the improvements proposed, in the previous evaluation (2nd round), were implemented and if the doctors and nurses like them. Previously proposed suggestions focus on the graphics aspect

of the system, the freedom to insert fields, the speed of the system, among others. With this questionnaire, it is necessary to know if these improvements, already made, are approved by those who use the platform and to enumerate new improvements to be made. To explain, how the analysis can be done, a simulated process was represented, and it is possible to observe that the highest construct was the behavioural intention, contrary to what it was in the previous analysis. The construct perceived ease of use had a significant decrease from 4 to 3.03 values.

The essential conclusion of this article is the impact TAM 3 will have on a platform such as INTCare. Thus, with this project will be perceived the impact that INTCare has in the day-to-day of the Hospital Centre of Porto more specifically in the intensive care unit, analysing its strengths and weaknesses and enumerating the improvements that must be made. It is essential to monitor the solutions regularly, and whenever there is a significant change, it is essential to do a new analysis to know the opinion of the users on the improvement. One of the primary motivating factors of this project is that it is involved in the medical field and can be of value to patients. One of the most significant challenges is the captivation of doctors and nurses for the project because, in the area of technologies, the resistance to change is always high. As a future work, the real questionnaire will be made available to physicians and nurses to understand their opinion about the platform. After that, a real Business Intelligence analysis will be done, so that conclusions can be drawn from the resulting data.

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