How to assess the acceptance of an Electronic Health Record system?

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Abstract. Being able to access a patient's clinical data in due time is critical to any medical setting. Clinical data is very diverse both in content and in terms of which system produces it. The Electronic Health Record (EHR) aggregates a patient's clinical data and makes it available across different systems. Considering that user's resistance is a critical factor in system implementation failure, the understanding of user behavior remains a relevant object of investigation. The purpose of this paper is to outline how we can assess the technology acceptance of an EHR using the Technology Acceptance Model 3 (TAM3) and the Delphi methodology. An assessment model is proposed in which findings are based on the results of a questionnaire answered by health professionals whose activities are supported by the EHR technology. In the case study simulated in this paper, the results obtained showed an average of 3 points and modes of 4 and 5, which translates to a good level of acceptance.

Keywords: Technology Acceptance Model, Technology Assessment, Electronic Health Record, Intensive Medicine.

1 Introduction

Health information technologies, such as the Electronic Health Record (EHR), and information management are fundamental in transforming the health care industry [4]. The flow of information in any hospital environment can be characterized as highly complex and heterogeneous. Its availability across systems in due time is critical to the success of clinical processes. Thus, the implementation and use of information systems that aggregate patient data can facilitate the work of health professionals and maximize their productivity. However, this is only possible if the system is fully accepted by its users.

This paper aims to outline how the level of acceptance of an EHR can be assessed through the combination of the Technology Acceptance Model (TAM) and the Delphi methodology. A simulation was performed through the application of these methodologies in a case study that evaluates the level of acceptance of the EHR used in the Intensive Care Unit (ICU) of Centro Hospitalar do Porto (CHP). The assessment is based on the application of a questionnaire and subsequent statistical analysis of the results. The results were produced by an algorithm that generated responses to the questionnaire according to the characteristics of the questions. The simulation was designed

to represent various possible results and outline how its analysis can be performed. The use of a simulated environment also ensured data integrity and anonymity. The analysis process was optimized to facilitate its replication in a realistic scenario, where the questionnaire should be answered by health professionals whose activities are supported by the EHR technology. The replication of the assessment model proposed will allow to evaluate the level of user acceptance, to identify the factors that influence health professionals' resistance to the EHR and to put forward a set of improvements which will increase user acceptance.

This paper is composed of five sections. The first section introduces the study. The second section defines relevant concepts. The third section presents the assessment model proposed. The fourth section describes the application of the model in a case study. Finally, the conclusions are presented in the fifth section.

2 Background

2.1 Intensive Medicine

Intensive Medicine is a multidisciplinary field in health care with focus on the prevention, diagnostic and treatment of patients with dysfunction or failure of one or more organs, particularly respiratory and cardiovascular systems [1, 9]. These patients are admitted to Intensive Care Units (ICU), which are specially prepared to continuously monitor vital functions and offer mechanical or pharmacological support [1, 3]. Due to the high complexity and severity of the cases handled in the ICU, it is essential that health professionals make the right decisions in a timely manner. However, the decision-making process can be hindered by the extensive amount of data generated across different systems and hospital services.

2.2 Electronic Health Record

The documentation of clinical information regarding a patient is one the of the major day-to-day activities performed by a health professional. This information can include biometrical data, prescriptions, imaging and lab test results, among others [7]. The health record of a patient includes records of all their encounters with all caregivers across all health providers linked to the health records system. When this data is gathered electronically, it is designated as Electronic Health Record (EHR) [14]. The EHR is commonly used in health care to aggregate all clinical information and make it available across different services and units [7]. Furthermore, the EHR directly impacts the work performance of health professionals as it is the main tool used by them in the decision-making process.

2.3 Technology Acceptance Model and Delphi

The Technology Acceptance Model (TAM) is frequently used to assess the user's acceptance of a specific technology. The model aims to explain the impact of external

factors in the user's behaviors and intentions by demonstrating the relationship between two constructs: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) [5]. PU is "the degree to which a person believes that using a particular system would enhance his or her job performance", while PEOU can be defined as "the degree to which a person believes that using a particular system would be free of effort" [5]. A second version of this model was proposed to further specify the external variables that determine the PU. These can be categorized in terms of social influence (subjective norms) and cognitive instrumental processes (image, job relevance, output quality and results demonstrability) [17]. Another version was proposed in the same year that defines the variables that determine the PEOU. These can be divided in anchors (computer self-efficacy, perceptions of external control, computer anxiety and computer playfulness) and adjustments (perceived enjoyment and objective usability) [15]. More recently, the Technology Acceptance Model 3 (TAM 3) combines all the variables that determine both constructs (PU and PEOU) and presents new relationships regarding user experience [16]. TAM 3 is comprised of four constructs: PU, PEOU, Behavioral Intention (BI) and Use Behavior (UB).

The Delphi methodology is an iterative process of application of questionnaires used to obtain a consensus regarding a specific matter [11]. This method consists in collecting and analyzing the results of each questionnaire and, subsequently, creating a new round of questionnaires based on those results. The process ends once all parties come to a satisfactory agreement. The participant pool should include field experts with similar cultural and cognitive levels while also representing different points of view within the study area [18]. By using this methodology, we can determine and predict a group's behaviors, needs and priorities [11].

The assessment of TAM 3 constructs can be achieved through the application of questionnaires. The combination of this model (quantitative method) with the Delphi methodology (qualitative method) allows to evaluate the acceptance of a certain technology while reducing the level of uncertainty and ensuring the presence of complementary views, which will increase the quality of the results [11].

2.4 Related Work

TAM has been widely used to assess the acceptance of information systems and to understand and explain user behavior [13]. Some of the most relevant works in the health care field are presented next.

An assessment of the INTCare system, used in the ICU of CHP, was performed using the constructs proposed by TAM and a questionnaire-based approach guided by the Delphi methodology [10]. Through the best (PEOU) and worst (UB) acceptance results, the study showed that health professionals were satisfied with the technology implemented in terms of innovation and functionality but complained about the real-time performance and responsiveness of equipment. Thus, the successful combination of TAM constructs and Delphi methodology allowed to identify positive and negative aspects of the system and suggest future improvements.

TAM was also applied on the assessment of the AIDA system in the Pathologic Anatomy Service of Centro Hospitalar Alto Ave [8]. The results showed that the lower

level of user satisfaction regarding some aspects of the system also lowered their intention to use it. The study contributed to a better understating of user perception about using a specific system and suggests that this type of analysis should be performed in other health care systems.

3 Assessment Model

To assess the level of acceptance of an EHR through the combination of TAM and Delphi, a questionnaire must be designed based on both methodologies. The first step is to structure the questionnaire in sections. Table 1 shows how sections should be structured, the motivation behind each group of items and how these should be evaluated.

Table 1. Questionnaire structure.

Section	Goal	Evaluation
Level of Technological Experience	Understand system user types and assess their level of experience regarding computer use in day-to-day activities.	Answer options are dependent on the type of question.
Overall System Functioning	Provide an overall view of the system by assessing global characteristics and functionalities.	Likert scale.
Technical and Functional Characteristics	Evaluate technical and functional characteristics of specific system panels/sections.	Likert scale.
Additional Comments	Promote further comments from the participants.	Free text field.

A 5-point Likert scale [6] is applied for items designed to evaluate the TAM constructs PU, PEOU, BI and UB. This scale allows the participant to specify their level of agreement with a certain statement [12]. The use of a short 5-point scale, with two negative values (1, 2), two positive values (4, 5) and a neutral value (3), narrows the results, avoiding their dispersion and reducing inaccuracy [10].

Considering the structure proposed, a sample of items for each questionnaire section is offered in Table 2.

Table 2. Example of items per section.

Section	Item	Answer Options

Level of Technological Experience	How often do you require technical support while using a computer?	1 – Always 2 – Often 3 – Sometimes 4 – Rarely 5 – Never
Overall System Functioning	Meets your needs with speed and quality?	1 – Strongly disagree 2 – Disagree 3 – Neither agree nor disagree 4 – Agree 5 – Strongly agree
Technical and Functional Characteristics	Does the image enhance the registration/consultation of procedures?	1 – Strongly disagree 2 – Disagree 3 – Neither agree nor disagree 4 – Agree 5 – Strongly agree
Additional Comments	In your opinion, what are the major issues in the system?	Free text field.

To ensure that each TAM construct is evaluated by at least one item, it is necessary to show the relationship between questions and constructs. Table 3 shows an example of how these relations can be represented through a matrix. Each table row should be read as "Item A evaluates constructs PU and PEOU".

Table 3. Example of matrix between items and TAM constructs.

Item	**PU**	**PEOU**	**BI**	**UB**
Item A	X	X	-	-
Item B	X	X	X	-
Item C	-	X	-	X
Number of items	2	3	1	1

After obtaining answers to the questionnaire, the results must be analyzed. The analysis process is divided into two phases: technological experience analysis and univariate statistical analysis. The first aims to better understand system user types regarding experience in technology. The second phase consists of several statistical analyses by participant, item, TAM construct and questionnaire section. Table 4 shows examples of indicators and metrics that can be used in the analysis.

Table 4. Indicators and metrics by analysis phase.

Phase	**Indicators**	**Metrics**
Technological Experience Analysis	Percentage of autonomous users (Never, rarely or sometimes require technical support while using a computer.)	Percentage
Univariate Statistical Analysis	Level of acceptance by participant, item, section and construct	Mean, mode
	Level of answer dispersion by participant and item	Standard deviation

Level of agreement level by participant and item	Correlation coefficient

The coefficient selected to analyze the level of agreement between answers was Kendall's tau [2]. This is a non-parametric correlation coefficient which evaluates the correlation between two ordinal variables. Negative values (closer to -1) represent a greater divergence between answers while positive values (closer to 1) mean a greater level of agreement.

The application of TAM to assess the EHR can also result in a SWOT analysis. This technique can be used to help identify strengths and weaknesses of the EHR system, factors/threats that influence user resistance and, subsequently, to put forward a set of improvements/opportunities which will increase acceptance.

4 Case Study

The evaluation model presented in the previous section was applied to a case study. The goal was to assess the level of acceptance of the EHR used in the ICU of CHP.

The questionnaire created is composed of 41 items divided into 12 sections. The first section assesses the level of technological experience of the participants. Section 2 evaluates global characteristics and functionalities of the system. Sections 3 through 11 assess functional and technical characteristics of different panels within the EHR system, such as: Header, Explorer, Discharge Notes, Problems, Daily Round Checklist, Procedures, Requests, Appointments and Clinical Research. These sections are evaluated by a 5-point Likert scale. Finally, a free text field was provided in the last section to accommodate additional comments. The relationships between items and TAM constructs are presented in Table 5.

Table 5. Relationship between items and TAM constructs.

Item	**PE**	**PEOU**	**BI**	**UB**
1. Level of Technological Experience				
1.1. What percentage of your daily work entails using a computer?	-	-	-	-
1.2. How often do you require technical support while using a computer?	-	-	-	-
1.3. Which activities require you to use a computer most often?	-	-	-	-
2. Overall System Functioning				
2.1. Allows to efficiently consult information?	X	X	-	X
2.2. Allows to efficiently register information?	X	X	-	X
2.3. Meets your needs with speed and quality?	X	-	-	X
2.4. Allows easy and fast access to other platforms (e.g. ALERT)?	X	X	-	X
2.5. Allows secure authentication in the system?	X	-	-	-

2.6. Is the interface appealing?	-	X	X	-
2.7. Is the information presented enough for decision-making?	X	-	-	-
2.8. Is the information adequately placed in the screen?	-	X	-	X
2.9. Easy to use?	-	X	X	X
2.10. Increases productivity?	X	X	X	X
2.11. Facilitates decision-making?	X	X	X	X
2.12. Are section / panel titles correct?	X	X	-	-
3. Header				
3.1. Is MCDT information (upper left corner) relevant?	X	-	-	-
3.2. Is patient data enough?	X	-	-	-
3.3. Are the hospitalization details (upper right corner) enough?	X	-	-	-
3.4. Does the information layout facilitate system use?	-	X	-	X
3.5. Is the position of the “Sair” and “Actualizar” buttons adequate?	-	X	-	-
3.6. Are all tabs (Alertas, Mensagens, etc.) necessary and relevant?	X	-	-	-
4. Explorer				
4.1. Allows to efficiently consult information?	X	X	-	X
4.2. Is all information necessary and relevant?	X	-	-	-
5. Discharge Notes				
5.1. Allows to efficiently register information?	X	X	-	X
5.2. Allows to efficiently consult information?	X	X	-	X
5.3. Is the number of fields adequate for decision-making?	X	-	-	-
5.4. Are all fields necessary and relevant?	X	-	-	-
6. Problems				
6.1. Allows to efficiently register information?	X	X	-	X
6.2. Is the number of fields adequate for decision-making?	X	-	-	-
6.3. Are all fields necessary and relevant?	X	-	-	-
7. Daily Round Checklist				
7.1. Allows to efficiently register information?	X	X	-	X
7.2. Is the number of fields adequate for decision-making?	X	-	-	-
7.3. Are all fields necessary and relevant?	X	-	-	-
8. Procedures				
8.1. Allows to efficiently consult information?	X	X	-	X
8.2. Allows to efficiently register information?	X	X	-	X
8.3. Does the image enhance the registration/consultation of procedures?	X	X	X	-
8.4. Does the information layout facilitate decision-making?	-	X	-	X
9. Requests				
9.1. Allows to efficiently register information?	X	X	-	X
10. Appointments				
10.1. Allows to efficiently register information?	X	X	-	X

11. Clinical Research				
11.1. Allows to efficiently register information?	X	X	-	X
12. Closing Remarks				
12.1. What are your main issues with the system? What improvements would you like to see implemented?	-	-	-	-
Number of items	**31**	**23**	**5**	**20**
Percentage of total (%)	**75,6**	**56,1**	**12,2**	**48,8**

5 Results

After generating 100 answers to the questionnaire through an algorithm that generated responses to the questionnaire according to the characteristics of the questions, the results were analyzed in two phases: technological experience analysis and univariate statistical analysis. The first aims to understand the level of experience of the participants regarding the use of a computer in daily activities. An example is presented in Table 6. The percentage of autonomous users in this case is 68%, which means the participants had an acceptable level of experience with the use of a computer. Thus, any issues with the system would not be the result of technological inexperience by its users.

Table 6. Example of level of technological experience results.

Item	Answer	Percentage
1.2. How often do you require technical support while using a computer?	Always	16%
	Often	16%
	Sometimes	23%
	Rarely	22%
	Never	23%

In the second phase of analysis, different statistical properties were used: mean, mode, standard deviation and correlation coefficient. A global analysis was performed by participant and by item. Both analyses showed similar results with an overall average of 3 points and standard deviation values close to 0. The correlation values in this analysis were mostly positive, which indicates a good level of agreement among the participants. Results were also analyzed by construct and section. The global results from both analyses are aggregated in Table 7. It can be observed that:

- Mean values are close to 3 points;
- Mode values are mostly of 4 and 5 points;
- All TAM constructs have similar results, but the best evaluated was BI with mean of 3,08 and mode of 5;
- Section 4 obtained the best results with mean of 3,98 and mode of 5;
- Section 5 had the lowest level of acceptance with mean of 2,93 and mode of 2.

Table 7. Overview of global analysis.

Construct/Section	Global Values	
	Mean	Mode
PU	3,03	5
PEOU	3,03	5
BI	3,08	5
UB	3,03	5
2. Overall System Functioning	3,01	5
3. Header	3,01	4
4. Explorer	3,18	5
5. Discharge Notes	2,93	2
6. Problems	2,97	4
7. Daily Round Checklist	3,09	4
8. Procedures	3,13	5
9. Requests	3,02	4
10. Appointments	3,05	5
11. Clinical Research	2,98	1

6 Conclusion

The assessment model presented in this paper successfully combines the constructs of TAM3 and the Delphi methodology to evaluate the acceptance of an EHR system. A structure for the questionnaires is proposed along with examples of possible items per section and the evaluation scale to be used.

This paper also suggests the type of results analysis that should performed with its indicators and metrics. The model is then applied to a case study to assess the EHR in the ICU of CHP. The results obtained by this simulation showed an average of 3 points and modes of 4 and 5, which translates to a good level of acceptance. The application of the model in a real-life scenario will help in identifying the factors that influence the user's resistance to the system and, then, to put forward a set of improvements which will increase acceptance.

In the future, the model proposed can be improved and extended as more acceptance assessments are performed.

Acknowledges

The work has been supported by FCT – Fundação para a Ciência e Tecnologia within the Project Scope: UID/CEC/00319/2019.The work has been supported by FCT – Fundação para a Ciência e Tecnologia within the Project Scope DSAIPA/DS/0084/2018.

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