Pervasive Information Systems to Intensive Care Medicine
Technology Acceptance Model

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Keywords: Information Systems, Technology Acceptance Model, Delphi, Intensive Care.

Abstract: The usability of information systems in critical environments like Intensive Care Units (ICU) is far than the expected and desirable. Typically, ICUs have a set of not integrated information silos and a high number of data recorded in paper. Whenever ICU professionals need to make a decision they have to deal with a high number of data sources containing useful information. Unfortunately, they can't use those sources due to the difficulty of evaluating them in a correct time. Pervasive Intelligent Decision Support Systems (PIDSS), operating automatically and in real-time, can be used to improve the decision making if they are suited to the requirements of the ICU. In this work a PIDSS have been assessed in terms of quality and user acceptance making use of Technology Acceptance Model (TAM). TAM proved to be very useful when combined with Delphi method features to involve the professionals and to make the system usable.

1 INTRODUCTION

Nowadays, intensive care professionals face important obstacles to take decisions in a short time. Intensive Care Units (ICU) are recognized as a place where there are, a high number of electronic devices to collect the patient data, a high number of information silos and a high number of information in paper. This situation contributes to increase the number of data available in the moment of the decision. However, to a human it is very difficult access to all the information in a correct time without technology help. To give support to ICU professionals in the Decision Making process, a research project called INTCare was developed. The first goal of the project was to develop an Intelligent Decision Support System (IDSS) to predict organ failure and patient outcome for the next hour. Later, a Pervasive IDSS (PIDSS) has been deployed. This implied a set of modifications in the ICU information systems (IS). In this context, was developed an automatic and real-time data acquisition system and a platform to record / validate / consult the patient data in real-time. To assure the success of information systems and associated technologies it is very important to assess the system quality and the acceptance level by the users. In order to assess the technology acceptance by the users (nurses) was used the Technology Acceptance Model III combined with some features of Delphi methodology. This paper provides an overview of the system, presents the methodologies used and the results achieved. The present work allows a better comprehension of the importance that a PIDSS has to the ICU needs and the respective technology acceptance by the professionals.

This paper is divided in six sections. The first one makes an introduction to the subject. The second section presents some background and related work. Then the third section presents the questionnaire elaborated and the relationship with TAM. Fourth section presents the results at level of TAM III. Finally, in section five the results are discussed and in section six some conclusions are done.

Aguiar J., Portela F., Santos M., Machado J., Abelha A., Silva Á., Rua F. and Pinto F..
Pervasive Information Systems to Intensive Care Medicine - Technology Acceptance Model.
DOI: 10.5220/0004441001770184
In *Proceedings of the 15th International Conference on Enterprise Information Systems* (ICEIS-2013), pages 177-184
ISBN: 978-989-8565-59-4

2 BACKGROUND

2.1 Pervasive Information System

Over the last three years, some important changes were made in the ICU Information System (IS): gathering and processing the data in real-time and introduction of intelligent agents in order to perform some tasks automatically, replacing some manual operations. During the development of the project the environment also was changed. This system meets some of pervasive health care (Varshney, 2009) and pervasive computing (Orwat et al., 2008); (Saha and Mukherjee, 2003) features, namely: health care for anyone anywhere and anytime, remove restraints of time and location, increase both the coverage and the quality of healthcare; scalability, heterogeneity, integration, invisibility and context awareness. Now, the IS interoperates with the data acquisition system to automatically and in real-time provide a set of data anywhere and anytime. Currently, the INTCare system performs all tasks automatically, online and in a real-time.

2.1.1 Architecture

The IS architecture of ICU is divided into two subsystems: one to collect the data and another to process and obtain the knowledge. To obtain the data there are two ways of acquisition: manually and automatically. To produce the knowledge, a set of intelligent agents are used in order to automatically execute some tasks according to the targets (e.g., predict organ failure, score ICU measures, and calculate Critical Events). Now, the data is acquired online, in real-time and in an electronic format using automatic or manual procedures. The data is provided from several data sources (eg. bedside monitors (vital signs), laboratory results, eletronic health record (EHR), pharmacy (drugs prescription)). Then, the data acquired are stored into the database and made available online through the Electronic Nursing Record (ENR).

2.1.2 Electronic Nursing Record

Electronic Nursing Record (ENR) is a platform that was developed with the objective to collect all the clinical data and make it available to the doctors and nurses in an hourly-based mode. Now, using ENR, the ICU professionals can have more information about the patient, essential to make their decisions. ENR is a touch and web-based platform. ENR is the main technology of the ICU and was assessed in terms of user acceptance. A set of questionnaires were made having in consideration each component of the platform. All system features were evaluated.

2.1.3 Decision Making Process

The Decision Making Process (DMP) in ICU is a crucial process, because the professionals are dealing with patients in critical condition. The decision needs to be performed quickly and assertively. Due to the high number of data sources present in the ICU it is difficult to have a correct decision in the right moment. In order to avoid this problem, INTCare changed the way the data is presented to the decision makers. Now, taking advantage from the environment changes and using an inference engine, new knowledge is provided in the moment of the decision is made. The utility and importance of this new knowledge was assessed by TAM 3. INTCare delivers knowledge essential to the DMP anywhere and anytime. INTCare can provide:

- ✓ Patient Clinical data;
- ✓ Critical Events tracking;
- ✓ ICU Medical Scores;
- ✓ Probability associated to organ failure or death.

2.1.4 Intcare

INTCare (Gago et al., 2006); (Santos et al., 2011) is an Intelligent Decision Support System (IDSS) to predict organ failure and patient outcome in real-time using online-learning. The work deployed allows for obtaining new types of data electronically and in real-time (Portela et al., 2010). New knowledge fundamental to the decision process is now available automatically and in real-time (Portela et al., 2011). INTCare uses ENR to acquire data and present some new knowledge generated in a pervasive way, i.e., anywhere and anytime. Intelligent agents are used for processing and transforming the data automatically, without human intervention in order to prepare the input variables for the models.

2.2 Technology Acceptance Model

The evaluation of a certain technology is crucial to understand its suitability in a specific environment and also to measure the users' satisfactoriness level. One of the most used models in this area is the Technology Acceptance Method (TAM). The main purpose of TAM is to present an approach to study the effects of external variables towards people's internal beliefs, attitudes, and intentions

(Chooprayoon and Fung, 2010). This model is also important because gives an understanding about the acceptance of modifications made in the decision support, and how they can be useful in the course of ICU professionals' daily work. More recently, Venkatesh and Bala set the TAM 2 (Venkatesh and Bala, 2008) to a model using determinants of the perceived ease of use(Venkatesh and Davis, 2000) and developed an integrated model nominated TAM 3. TAM 3 is composed by four constructs: Perceived Ease of USE (PEOU), Perceived Usefulness (PU), Behaviour Intention (BI) and Use Behaviour (UB) that are derived from other type of analysis as can be seen in Figure 2.

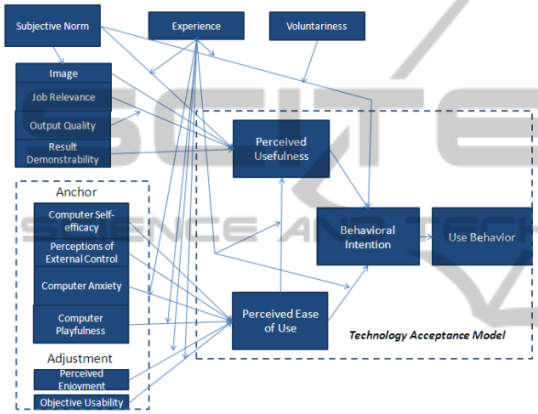

Figure 1: Technology Acceptance Model 3 (TAM 3) (Venkatesh and Bala, 2008).

In order to obtain plausible results in the analysis of the questionnaires, a program called statistical data analysis by PAleontological STatistics (PAST) was used (Hammer et al., 2001). To evaluate the correlation results was used Kendall's tau technique. This technique is a non-parametric correlation coefficient that can be used to assess and test correlations between non-intervals scaled ordinal variables. Kendall's tau (Bolboaca and Jantschi, 2006) is used as a statistical test to determine if two variables can be considered as statistically dependent. The correlation coefficient should deliver a range of [-1, 1]. If the agreement between the two evaluations is perfect, the coefficient has a value (1). If the divergence between the two evaluations is perfect (inverse of the other), the coefficient has a value (-1), but if the two evaluations are independent, the coefficient is nearly zero (Bolboaca and Jantschi, 2006).

2.3 TAM III and Delphi

The goals of TAM can be achieved by using methodologies based on questionnaires. As a support tool it is important to use some aspects/characteristic of the Delphi method. The basis of the Delphi method involves the use of questionnaires being one of its key features (Zackiewicz and Salles Filho, 2010), the preservation of anonymity of the participants. The questionnaire was prepared by a coordination team, composed by ICU and IS professionals, and sent to participants: a group of experts from the ICU professional team. The questionnaire was prepared having in account the constructs of TAM (Venkatesh and Bala, 2008); (Venkatesh and Davis, 2000) and has as support tool the Delphi method.

Table 1: TAM advantages and Delphi disadvantages.

Advantages TAM	Disadvantages Delphi
- Important not just a technical view, must also direct attention to the requirements offered by technology in order to understand user behaviour.	- Identification of specialist to respond to the questionnaires
- Strand/Slope Quantitative: aims to understand the social or human problems from tests of existing theory, using variables measured with numbers and analysed with static procedures	- In many times, the projections that do, are wrong or influenced
- It is useful to identify the reason for non-acceptance of a particular technology or system by users and subsequently implement the appropriate corrections	- Sometimes, they are ambiguous and divergent specialists in the same area

Table 2: Delphi advantages and TAM disadvantages.

Advantages Delphi	Disadvantages TAM
- Important that all related viewpoints are represented and pay attention to cultural differences and cognitive character	- Not evaluated the organizational context in which the system is involved, does not evaluated the situations of centralization, conflict, hierarchy, stability, uncertainty of the company
- Defined as an iterative process designed to combine opinions of a group of specialists to achieve a consensus	- Difficulties in researching the technology acceptance by the user with all the variables involved in its real-time environment
- necessary to ensure diversity in the composition of the group of participants, so that they cancel each other	- Many studies use self-report response type for the verification of system use

Several authors point to the importance of combining more than one method or technique on the methodological framework of an exercise prospective, to reduce the levels of uncertainty inherent to type of activity, integrating more approaches and results. When quantitative methods (TAM) are combined with qualitative methods

(Delphi Method), the explicit knowledge adds up to tacit knowledge, in seeking complementary or different views (Santos and Amaral, 2004).

Therefore, the union of the two methods may involve an improvement in quality and greater certainty of the results of the evaluation system to IDSS – INTCare, since the advantages of one method may mitigate the disadvantages of the other method. Table 1 and 2 present these points.

3 QUESTIONNAIRES

For this study it was elaborated a questionnaire based on four constructs of TAM 3: PEOU, PU, BI, UB. It means that the questionnaire was aggregated in several groups to represent all the aspects of TAM. The questionnaire is composed by 96 questions. In this questionnaire was applied the Likert Scale (Johns, 2010) to evaluate the results. As a consequence, the chosen scale will follow a range from one to five, because it gives two values for each side and at the same time finds a neutrality point (Johns, 2010). The considered levels were:

1) Not satisfies/in complete disagreement;
2) Satisfies a bit/in some level of disagreement;
3) Satisfies/under some level of agreement;
4) Satisfies a lot/strongly agreement;
5) Satisfies completely/full agreement.

The responses always depend on the goodwill of each participant by answering in a balanced way to the questions of a certain group. To avoid wrong answers it was added three screening questions to understand the level of the user's consciousness (ex: 3+2). The nurses scored the questions from 1 (worst) to 5 (best) points.

4 RESULTS

A preliminary analysis was made after collecting 14 answers (35% of total number of nurses in ICU). After this, a deeper analysis was done to exclude invalid or inconsistent answers given by the participants. Only one participant out of the 14 nurses answered the questionnaire in an inconsistent way. This situation leads us to consider as valid the other 13 questionnaires. Table 3 presents the technology experience of the respondents.

Table 3: Level of experience in information technology

Question	Answer	%
How much time do you spend at the computer?	Less than 2 hours/day	0%
	Between 2 to 4 hours/day	57%
	More 4 hours/day	36%
Type of User?	Full Autonomy	62%
	Rarely need technical support	38%
	Need regular technical support	0%
Uses computer preferably for? (multiple)	Application of production staff (email, text processing, spread sheet)	62%
	Handling/Consult administrative info	31%
	Handling/Consult clinical info	77%
	Handling/Consult management Info	8%

4.1 Analysis

In order to obtain plausible results in the analysis of the questionnaires, it was necessary to use a program called statistical data analysis by Paleontological Statistics (PAST) (Hammer et al., 2001). A comprehensive analysis has been performed on all the responses, excepting the text and dispersion questions (Ex: one + one), as well as an analysis of the four constructs of TAM 3 by calculating:

- Mean, standard deviation (univariate);
- Correlation Coefficient (correlation);
- Bar Chart (histogram).

Finally, an analysis was performed on the results by participant, by question, calculating the mean (bars) and mode values (line).

4.1.1 Global Analysis

A Global Analysis of the all responses is presented in tables 4 and 5. The nurses who participated in the response to the questionnaires are represented by A to M. As can be seen in Table 4 the mean of responses/evaluations corresponds to level 3. Standard Deviation (STD) shows a small dispersion, i.e. the variability in the responses is minimal. The standard deviation is close to zero, what means that the respondent maintained a consistency of response (e.g. nurse (A) showed a deviation of 0, 05858516).

Table 4: Results of univariate analysis global.

	A	B	C	D	E	F	G	H	I	J	K	L	M
N	91	91	91	91	91	91	91	91	91	91	91	91	91
Min	2	1	2	1	1	2	3	2	1	1	1	2	2
Max	4	5	4	5	5	4	5	4	5	5	5	4	4
Sum	303	325	228	304	339	292	324	317	327	316	270	331	347
Mean	3,32967	3,571429	2,505495	3,340659	3,725275	3,208791	3,56044	3,483516	3,593407	3,472527	2,967033	3,637363	3,813187
Std. error	0,05858516	0,1532257	0,05496947	0,05606819	0,09513942	0,0635085	0,07528341	0,06494505	0,1259669	0,1162586	0,08036934	0,05745197	0,04918993
Variance	0,3123321	2,136508	0,2749695	0,7362173	0,8236874	0,367033	0,5157509	0,2747253	1,443956	1,229792	0,58779	0,3003663	0,2202686
Stand. dev	0,5588668	1,46168	0,5243753	0,8581958	0,9075723	0,6056325	0,718158	0,5241424	1,201647	1,10896	0,7666746	0,5480568	0,4693278
Median	3	4	2	4	4	3	3	3	4	4	3	4	4
25 prcntil	3	2	2	3	3	3	3	3	3	3	3	3	4
75 prcntil	4	5	3	4	4	4	4	4	4	4	3	4	4
Skewness	-0,06908599	-0,6570513	0,2140829	-0,725368	-0,7904923	-0,1287136	0,8876165	-0,1697797	-0,8928575	-0,4793014	-0,3974322	-1,190534	-2,560176
Kurtosis	-0,6682557	-1,051244	-1,433855	-0,7338638	1,12947	-0,432014	-0,5274912	-1,449456	-1,05033	-0,2529606	0,6886321	0,4614477	6,035688
Geom. mean	3,281417	3,150109	2,451777	3,207727	3,577916	3,148624	3,494989	3,443254	3,299415	3,2425	2,846256	3,589766	3,775013
Coeff. var	16,78445	40,92704	20,92901	25,71935	24,36256	18,8804	20,17049	15,04636	33,44034	31,93524	25,83977	15,06742	12,30802

The results of the correlation coefficient

Kendall's tau are presented in Table 5.

Table 5: Results correlation coefficient Kendall's tau.

	A	B	C	D	E	F	G	H	I	J	K	L	M
A		0,0016085	0,85372	0,17192	1,1838E-08	0,0069348	0,043103	0,71237	0,046118	0,39071	0,38203	0,00088595	0,16186
B	0,22469		0,56504	1,6361E-06	3,9063E-09	3,998E-05	2,2345E-06	0,5356	0,00039413	0,068955	0,00069876	7,7841E-05	0,16719
C	-0,013134	-0,040984		0,59599	0,6657	0,00011844	0,10702	0,87863	0,22667	0,36599	4,5955E-07	0,61504	0,00072429
D	0,097306	0,34147	0,037776		2,4021E-06	0,062714	0,08931	0,29736	1,3798E-06	2,3973E-06	0,0011615	0,0017178	0,0001652
E	0,40617	0,39142	0,012047	0,33595		0,015065	0,54673	0,41433	8,6508E-09	5,2598E-08	0,083184	3,5579E-07	0,00018937
F	0,19232	0,2926	-0,27419	0,13258	0,17315		0,086374	0,012079	0,20983	0,092047	0,45149	2,698E-05	0,33758
G	-0,14408	-0,33699	0,11481	-0,12103	-0,042929	-0,12215		0,26523	0,024478	0,10742	0,0016641	0,27749	0,089926
H	-0,026261	0,044126	0,010877	-0,074232	0,059146	0,17878	0,07936		0,16129	0,21489	0,81961	0,0084737	0,00042197
I	0,14206	0,25244	0,086118	0,3439	0,40996	0,093226	-0,16024	0,099777		2,4164E-07	0,038793	0,0017047	5,746E-06
J	0,06114	0,13054	0,064407	0,33598	0,38766	0,12067	0,11468	0,088343	0,36784		0,03513	0,00027088	0,00040556
K	0,062268	0,24145	0,35921	0,23137	0,12341	0,053633	-0,22398	0,016244	0,14719	0,14984		0,63135	2,0398E-05
L	0,23681	0,26143	-0,035822	0,22332	0,36265	0,299	-0,077356	0,18752	0,22348	0,2594	0,034178		1,4534E-05
M	0,098642	0,098391	0,24078	0,26833	0,26589	0,068309	-0,11754	0,25116	0,32307	0,25191	0,30348	0,30883	

In Table 5 nurse G denoted a greater divergence in the responses (values near to -1). Nurses C and H showed a good correlation of responses, because they have a Kendall of 0, 87. This value represents that between them, the answers were very similar. Trough Histogram (Figure 3), it was found that the vast majority of respondents answered to 91 questions of the questionnaire with a rating between 3 and 4 points.

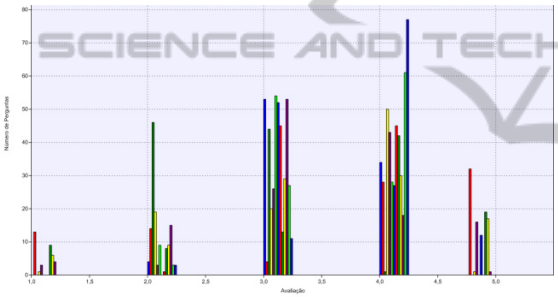

Figure 2: Global analysis histogram.

4.1.2 Analysis of the Perceived Usefulness

In order to understand which TAM 3 constructs achieved better results, an evaluation was made for each one of them. Table 6 presents the univariate analysis to perceived usefulness (PU).

Table 6: Results of univariate analysis (PU).

	A	B	C	D	E	F	G	H	I	J	K	L	M
N	49	49	49	49	49	49	49	49	49	49	49	49	49
Min	2	1	2	2	2	2	3	3	1	1	1	2	2
Max	4	5	3	4	5	4	5	4	5	5	5	4	4
Sum	163	169	129	158	177	155	168	170	168	156	153	172	187
Mean	3,326531	3,44898	2,632653	3,22449	3,612245	3,163265	3,428571	3,469388	3,428571	3,183673	3,122449	3,510204	3,816327
Std. error	0,07925973	0,0124149	0,069582656	0,1139329	0,1043946	0,07346466	0,08748178	0,0720334	0,1570346	0,1449476	0,1189261	0,08807488	0,07533073
Variance	0,3078231	2,210884	0,2372449	0,6360544	0,5340136	0,2644558	0,375	0,2542517	1,208333	1,028061	0,8930272	0,380102	0,2780612
Stand. dev	0,5548181	1,486904	0,4870779	0,7975302	0,7307623	0,5142525	0,6123724	0,5042336	1,099242	1,013934	0,9324826	0,6165242	0,5273151
Median	3	4	3	3	4	3	3	3	4	3	3	4	4
25 prcntil	3	2	2	3	3	3	3	3	3	2,5	3	3	4
75 prcntil	4	5	3	4	4	3	4	4	4	4	4	4	4
Skewness	-0,02288214	-0,4715803	-0,5678676	-0,4331269	-0,2407602	0,2506375	1,134988	0,1265877	-1,233425	-0,3853701	-0,463431	-0,8743446	-2,065144
Kurtosis	-0,6493054	-1,314164	-1,750749	-1,287218	-0,04621478	0,4658862	0,3182239	-2,07025	0,6631724	-0,3703929	0,3925447	-0,1844579	7,194461
Geom. mean	3,279667	3,028038	2,584846	3,116632	3,533414	3,121675	3,380262	3,433729	3,155272	2,985691	2,987206	3,449322	3,766867
Coeff. var	16,67858	43,11143	18,50141	24,73353	20,23014	16,25702	17,86086	14,5338	32,06123	31,84791	29,86121	17,56377	13,81735

The mean of responses/evaluations was fixed around the three points. Standard deviation (STD) denotes a small dispersion. For example, nurse H maintained consistency of response, showing a deviation of 0, 0720334. In Table 7 nurse G has a bigger divergence response, since values were very close to - 1.While the nurse A showed a lowest variance with a correlation coefficient nearest to 1.

Based in the histogram of Figure 3 it can be seen that the most respondents answered 49 questions related to the construct Perceived Usefulness with an evaluation positioned between 3 and 4 points.

Table 7: Results correlation coefficient Kendall's tau (PU).

	A	B	C	D	E	F	G	H	I	J	K	L	M
A		0,0011352	0,72504	0,0033866	7,8233E-07	0,071709	0,34168	0,2892	0,27833	0,033314	0,27993	0,014943	0,57588
B	0,25821		0,95674	4,6626E-05	2,9711E-05	0,00015707	0,0032985	0,95035	0,0034553	0,092054	0,019686	0,00029811	0,67099
C	0,027905	0,0043038		0,39608	0,67593	1,2388E-06	0,03206	0,6764	0,83513	0,55091	4,9523E-06	0,2527	0,074271
D	0,23247	0,32304	-0,067327		2,8711E-06	0,11408	0,46055	0,666659	1,0442E-05	0,00051885	0,056641	0,011994	0,024417
E	0,39189	0,33127	0,012396	0,37127		0,025982	0,01307	0,90793	2,6589E-06	9,7246E-08	0,45875	0,00027465	0,021368
F	0,14288	0,29985	-0,38472	0,12536	0,17664		0,22012	0,080634	0,70587	0,031495	0,75323	0,00014802	0,37757
G	-0,075436	-0,23312	0,17007	-0,058544	0,1969	-0,097282		0,039932	0,70931	0,04831	0,051987	0,75943	0,69911
H	-0,084085	-0,0049404	0,033113	-0,1455	0,0091746	0,13846	0,16299		0,42518	0,21629	0,48807	0,30499	0,00037238
I	0,086005	0,23198	0,016511	0,34969	0,37252	0,029942	-0,029575	0,063266		3,6289E-08	0,22567	0,074798	0,011602
J	0,16685	0,1344	-0,047314	0,27536	0,423	0,17063	0,15668	0,098094	0,43698		0,089107	0,0013915	0,0026038
K	0,09572	0,18503	0,3623	0,15122	0,05878	-0,024941	-0,15417	0,055009	0,096121	0,13488		0,26032	0,01697
L	0,19308	0,28695	-0,090744	0,19931	0,28863	0,30102	0,024294	0,08138	0,14135	0,25359	0,089301		0,0056131
M	0,044381	0,033702	0,14161	0,17854	0,18258	-0,070003	0,030665	0,28235	0,20024	0,23888	0,1894	0,21972	

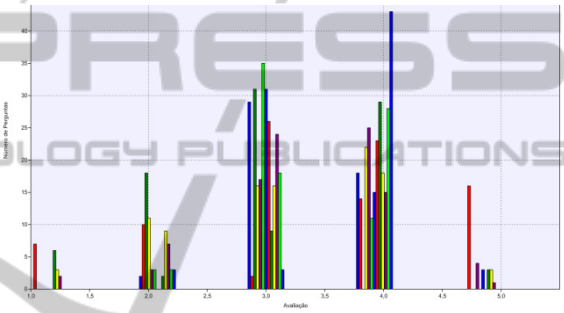

Figure 3: Histogram (PU).

4.1.3 Analysis of Perceived Ease of Use

Through a brief analysis of Table 8, it was found that the average of responses/evaluations in this construct was approximately around four points. Standard deviation (STD error) is not dispersed. It can be seen that responses are consistent (e.g. Nurse M had a deviation of 0, 05100626).

Table 8: Results of univariate analysis (PFU).

	A	B	C	D	E	F	G	H	I	J	K	L	M
N	74	74	74	74	74	74	74	74	74	74	74	74	74
Min	2	1	2	1	2	2	3	3	1	1	1	2	2
Max	4	5	3	4	5	4	5	4	5	5	5	4	4
Sum	248	278	183	250	288	238	258	263	272	265	222	274	284
Mean	3,351351	3,756757	2,472973	3,378378	3,891892	3,216216	3,486486	3,554054	3,675676	3,581081	3	3,702703	3,837838
Std. error	0,06505895	0,1641859	0,05843502	0,09663346	0,08726281	0,07009348	0,07754862	0,05817759	0,1348386	0,1186228	0,08163454	0,06001891	0,05100626
Variance	0,3132173	1,994817	0,2526842	0,6767864	0,5634495	0,363569	0,4450204	0,2504628	1,345428	1,041281	0,4831507	0,2665679	0,1925213
Stand. dev	0,5596592	1,41238	0,502677	0,8226703	0,750663	0,6029669	0,6670985	0,5004626	1,159926	1,020432	0,7022469	0,5163022	0,4387725
Median	3	4	2	4	4	3	3	4	4	4	3	4	4
25 prcntil	3	2,75	2	3	3	3	3	3	3	3	3	3	4
75 prcntil	4	5	3	4	4	4	4	4	4,25	4	3	4	4
Skewness	-0,1052511	-0,9028388	0,1105194	-0,9632001	-0,2185249	-0,126102	1,046535	-0,2220168	-0,8472573	-0,3448939	-0,243926	-1,503749	-2,80795
Kurtosis	-0,7354211	-0,5924076	-2,043784	-0,3449199	-0,3045919	-0,4166805	-0,06474643	-2,0056577	-0,02696133	-0,3420008	1,275691	1,397965	7,627678
Geom. mean	3,303276	3,360837	2,422794	3,253406	3,814952	3,157158	3,429659	3,518391	3,418513	3,409964	2,904003	3,660442	3,805548
Coeff. var	16,69846	37,59572	20,32683	24,36104	19,28787	18,74771	19,13383	14,08146	31,5568	28,49508	23,40823	13,94393	11,4328

In Table 9 nurse G showed a bigger divergence of responses, since values were very close to -1. However, the nurse E already showed a lower divergence with a correlation coefficient near to 1.

Table 9: Results of the correlation coefficient Kendall's tau (PFU).

	A	B	C	D	E	F	G	H	I	J	K	L	M
A		0,0011352	0,72504	0,0033866	7,8233E-07	0,071709	0,34168	0,2892	0,27833	0,033314	0,27993	0,014943	0,57588
B	0,25821		0,95674	4,6826E-05	2,9711E-05	0,00015707	0,0032985	0,95035	0,0034553	0,090254	0,019686	0,00029811	0,67098
C	0,027905	0,0043038		0,39608	0,67583	1,2389E-06	0,03206	0,8764	0,83513	0,55091	4,9523E-06	0,2527	0,074271
D	0,23247	0,32304	-0,057327		2,8711E-05	0,11408	0,46055	0,066659	1,0442E-05	0,00051885	0,056641	0,011994	0,024417
E	0,39189	0,39127	0,012396	0,37127		0,025982	0,01307	0,90793	2,6589E-06	9,7246E-08	0,45875	0,00027465	0,021368
F	0,14288	0,29985	-0,35472	0,12536	0,17664		0,22012	0,089934	0,70557	0,031495	0,75323	0,00014802	0,37757
G	-0,075436	-0,23312	0,17007	-0,058544	0,1959	-0,097282		0,099932	0,70931	0,04631	0,051987	0,75943	0,69911
H	-0,084085	-0,0049404	0,033113	-0,1455	0,0091746	0,13846	0,16299		0,42518	0,21629	0,48807	0,30499	0,00037238
I	0,060005	0,23196	0,016511	0,24969	0,37252	0,029942	-0,029575	0,063266		3,6289E-08	0,22567	0,074798	0,011602
J	0,16885	0,1344	-0,047314	0,27536	0,423	0,17063	0,15666	0,098094	0,43698		0,089107	0,0013915	0,0026038
K	0,09572	0,18503	0,3623	0,15122	0,05878	-0,024941	-0,15417	0,059009	0,098121	0,13488		0,26032	0,01697
L	0,19308	0,26695	-0,090744	0,19931	0,28863	0,30102	0,024294	0,08136	0,14135	0,25359	0,089301		0,0056131
M	0,044381	0,033702	0,14161	0,17854	0,18258	-0,070003	0,030665	0,28235	0,20024	0,23988	0,1894	0,21972	

Histogram of Figure 4 indicates that the most respondents answered 74 questions related to the construct Perceived Usefulness with an evaluation located between 3 and 4 points. For example, nurse M (blue) answered 64% of the questions with 4 points.

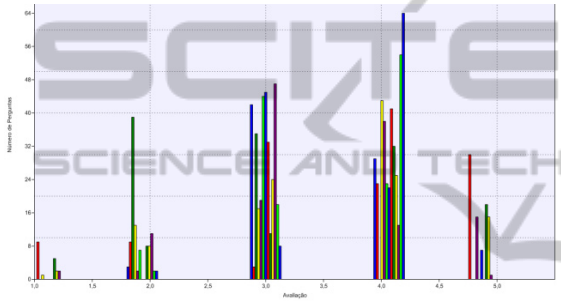

Figure 4: Histogram (PFU).

4.1.4 Analysis of Behavioral Intention

Table 10 indicates that only 5 nurses used all point scales. Standard deviation (STD error) is not dispersed. For example, nurse M showed a deviation of 0, 07173386.

Table 10: Results of univariate analysis (BI).

	A	B	C	D	E	F	G	H	I	J	K	L	M
N	41	41	41	41	41	41	41	41	41	41	41	41	41
Min	2	1	2	2	1	2	3	2	1	1	1	2	2
Max	4	5	4	5	5	4	5	4	5	5	5	4	4
Sum	137	140	113	133	145	125	149	135	147	133	123	144	156
Mean	3,341463	3,414634	2,756098	3,243902	3,536585	3,04878	3,634146	3,292683	3,585366	3,243902	3	3,512195	3,804878
Std. error	0,09878128	0,2443898	0,07635354	0,1342572	0,1565542	0,09847136	0,1090765	0,07996876	0,1709828	0,1905719	0,1561738	0,09319459	0,07173386
Variance	0,3304878	2,44878	0,2390244	0,7390244	1,004878	0,397561	0,4878049	0,2621951	1,19878	1,488024	1	0,3560976	0,2109756
Stand. dev	0,5748807	1,564658	0,4889012	0,8596653	1,002436	0,6305244	0,6984303	0,5120499	1,094888	1,220256	1	0,5967391	0,4593208
Median	3	4	3	3	4	3	4	3	4	3	3	4	4
25 prcntil	3	2	2	2,5	3	3	3	3	3	3	2	3	4
75 prcntil	4	5	3	4	4	3	4	4	4	4	4	4	4
Skewness	-0,1624447	-0,4098993	-0,5418552	-0,2575142	-0,9663725	-0,03480328	0,6498088	0,3451698	-1,490397	-0,5811312	-0,4730768	-0,7910926	-2,374608
Kurtosis	-0,8329033	-1,466505	-0,1415529	-1,144527	1,210273	-0,3281228	-0,6847166	-0,6003359	1,630189	-0,464072	-0,3340081	-0,2924871	5,362167
Geom. mean	3,290698	2,960475	2,709721	3,12201	3,333252	2,981827	3,572174	3,254176	3,309855	2,932094	2,78955	3,45636	3,770805
Coeff. var	17,20446	45,82798	17,73689	26,50096	28,34474	20,6812	19,21655	15,55115	30,5377	37,61691	33,33333	16,99049	12,07189

In Table 11 nurse G already showed a bigger divergence of responses, since values were very close to -1. However, the nurse B and J showed a lower divergence with a correlation coefficient near to 0,86.

Histogram of Figure 5 indicates that the most respondents answered the 41 questions related to the construct Behavioural Intention with an evaluation located between 3 and 4 points. For example, nurse M (blue) answered 35 % of the questions with 4 points. At same time is possible observe that only 35% of the nurses answered questions with 1 point.

Table 11: Results correlation coefficient Kendall's tau (BI).

	A	B	C	D	E	F	G	H	I	J	K	L	M
A		0,024865	0,49987	0,37466	3,5412E-05	0,0059433	0,14353	0,27013	0,30181	0,03421	0,51981	0,0035942	0,52078
B	0,24355		0,22949	0,0027875	0,00034937	0,00087462	2,4347E-05	0,087523	0,56215	0,85963	0,00017773	0,014212	0,1099
C	-0,074973	0,13047		0,0039004	0,24082	0,30935	0,86372	0,014945	0,0015815	0,00030777	0,00070468	0,0010814	3,9959E-05
D	-0,086391	0,23467	0,31336		0,010378	0,28241	0,15709	0,98424	0,054592	9,8644E-06	7,3381E-06	0,0069271	1,2089E-05
E	0,44902	0,38823	0,12735	0,27828		0,012399	0,0089092	0,26104	0,015288	0,030838	0,033511	3,5412E-05	0,0075672
F	0,29928	0,36134	0,11038	0,11431	0,2715		0,38902	0,13528	0,5916	0,85014	0,10269	0,0062157	0,050093
G	-0,15882	-0,45827	-0,047206	-0,15363	-0,28398	-0,093527		0,31738	0,025271	0,15518	0,014347	0,28341	0,016415
H	0,11973	0,16551	0,26424	0,0021447	0,12203	0,16217	0,10856		0,00016826	0,07579	0,78921	0,0047565	0,031799
I	0,11211	0,062935	0,34302	0,20969	0,26335	-0,058252	-0,24291	0,40651		0,033372	0,11466	0,15842	3,2662E-06
J	-0,22992	0,0192	0,39181	0,47992	0,23443	0,020514	0,15434	0,19279	0,231		0,0038038	0,011732	0,0001043
K	0,069884	0,40702	0,36783	0,49881	0,23082	0,17719	-0,26584	0,029026	0,17129	0,31422		0,14756	0,000547
L	0,31614	0,26621	0,35467	0,29319	0,44902	0,29708	-0,11647	0,30652	0,15388	0,27362	0,15724		0,00043507
M	-0,069721	0,17358	0,446	0,47512	0,28998	0,20826	-0,26053	0,2331	0,50524	0,42131	0,3753	0,38195	

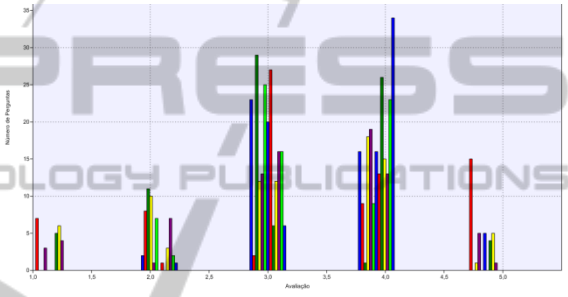

Figure 5: Histogram (BI).

4.1.5 Analysis of Use Behaviour

Through a brief analysis of Table 12, it was found that the average of responses/evaluations in this construct was approximately around three points. Standard deviation (STD error) is not dispersed.

Table 12: Results of univariate analysis (UB).

	A	B	C	D	E	F	G	H	I	J	K	L	M
N	47	47	47	47	47	47	47	47	47	47	47	47	47
Min	2	1	2	1	1	2	3	2	1	1	1	2	2
Max	4	5	4	5	5	4	5	4	5	5	5	4	4
Sum	152	137	125	145	161	141	174	159	155	149	138	162	178
Mean	3,234043	2,914894	2,659574	3,085106	3,425532	3	3,702128	3,382979	3,297872	3,170213	2,93617	3,446809	3,787234
Std. error	0,0816842	0,226214	0,07619899	0,1354398	0,1385289	0,0804704	0,117462	0,07785985	0,1822739	0,1646883	0,140714	0,09036896	0,07410377
Variance	0,3135985	2,393904	0,2728955	0,8621647	0,9019426	0,3043478	0,6484736	0,2849214	1,561517	1,274746	0,9306198	0,3826787	0,2580944
Stand. dev	0,5599987	1,54399	0,522394	0,9285262	0,9497066	0,5516773	0,8052766	0,5337803	1,249507	1,129046	0,9646864	0,6188527	0,5080299
Median	3	2	3	3	4	3	3	3	4	3	3	4	4
25 prcntil	3	2	2	2	3	3	3	3	3	3	2	3	4
75 prcntil	4	4	3	4	4	3	4	4	4	4	4	4	4
Skewness	0,0347682	0,1482166	-0,2111098	-0,1745652	-0,8107587	1,227903E-11	0,6043103	0,04501098	-0,8777169	-0,6337899	-0,3234844	-0,6520819	-2,418977
Kurtosis	-0,2173748	-1,581107	-0,9328628	-1,061126	1,009745	0,5376623	-1,18515	-1,072398	-0,4504617	-0,3842824	-0,3835737	-0,4719953	5,26833
Geom. mean	3,18491	2,46842	2,606675	2,931474	3,245037	2,947832	3,621435	3,341041	2,951255	2,898323	2,743637	3,365945	3,743696
Coeff. var	17,31575	52,96899	19,64201	30,09712	27,72435	18,38924	21,75178	15,77841	37,8913	35,61421	32,85526	17,95437	13,41427

Table 13: Results of the correlation coefficient Kendall's tau (UB).

	A	B	C	D	E	F	G	H	I	J	K	L	M
A		0,04034	0,77122	0,85418	0,00014468	0,038279	0,25807	0,10824	0,54055	0,041319	0,90386	0,41297	0,28091
B	0,20682		0,4301	0,0013676	0,0038319	0,0094286	6,173E-06	0,09512	0,050528	0,53847	0,0005662	0,4029	0,63754
C	0,029333	0,079582		0,00016573	0,0071382	1	0,93494	0,78647	6,4844E-06	1,1458E-05	0,00027646	0,0091526	0,00031128
D	-0,018539	0,32294	0,37992		0,04841	0,15657	0,0089467	0,020706	0,094372	0,0050804	0,00017909	0,044724	7,5544E-05
E	0,36333	0,2917	0,27139	0,1991		0,17733	0,098889	0,46516	0,057523	0,042882	0,11465	0,0052365	0,0035131
F	0,209	0,26188	0	0,14291	0,13608		0,045684	0,78664	0,62464	0,32594	0,14883	0,020222	0,083669
G	-0,11409	-0,45599	0,0082468	-0,26408	-0,16747	-0,20158		0,52074	0,00043936	0,27428	0,0022416	0,20831	0,034955
H	-0,16202	-0,17368	-0,027327	-0,23335	-0,073676	-0,029937	0,064783		0,011031	0,6655	0,82194	0,21599	0,080633
I	0,061734	0,19726	0,45494	0,16874	0,19159	0,049356	-0,3546	0,2564		0,13168	0,0047553	0,050805	1,2847E-05
J	-0,20582	-0,062052	0,4426	0,28264	0,20426	-0,090093	0,11028	0,043612	0,15207		0,012515	0,092713	0,00014534
K	-0,012164	0,34775	0,36682	0,37796	0,15914	0,14563	-0,30829	-0,022702	0,26479	0,25191		0,53752	0,00016089
L	0,082504	0,084377	0,26291	0,20248	0,28165	0,23425	-0,12692	0,12461	0,19694	0,1696	0,062197		9,784E-05
M	-0,10877	0,047527	0,36373	0,39927	0,29444	0,17449	-0,21273	0,17623	0,44009	0,38321	0,37771	0,393	

In Table 13 nurse G and H showed a bigger divergence of responses, since values were very close to -1. However, the nurse A showed a lower divergence with a correlation coefficient near to 1.

Histogram of Figure 6 indicates that the most respondents answered 47 questions related to the construct Use Behaviour

5 DISCUSSION

The obtained results show that the respondents are in accordance with the most of the questions. The majority of the questions were evaluated with three or four points.

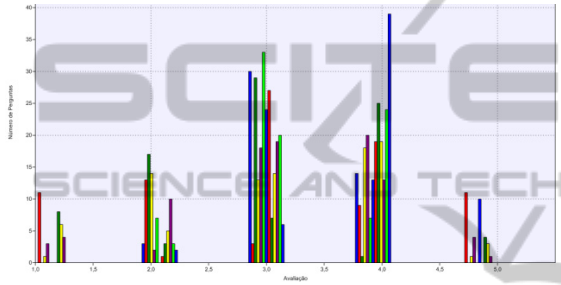

Figure 6: Histogram (UB).

Table 14: Top 3 questions with the highest and lowest evaluation.

	Highest Evaluation			Lowest Evaluation		
Construct	**Question**	**Mode**	**Avg**	**Question**	**Mode**	**Avg**
PU	2.11.1	4	4,15	2.1.9	3	2,38
	2.11.1.1	4	4,15	2.2.2	2	2,46
	2.11.3	4	3,92	2.4.21	3	2,54
PEOU	2.4.1	4	4,08	2.1.9	3	2,38
	2.11.1	4	4,15	2.4.21	3	2,54
	2.11.1.1	4	4,15	2.4.22	4	2,61
BI	2.11.1	4	4,15	2.1.9	3	2,38
	2.11.1.1	4	4,15	2.3.2	2	2,31
	2.11.3	4	3,92	2.3.3	3	2,38
UB	2.10.1.2	4	3,77	2.1.9	3	2,38
	2.10.1.4	4	3,69	2.2.2	2	2,46
	2.11.3	4	3,92	2.3.2	2	2,31

To achieve the objectives originally proposed, a questionnaire was considered based on the four constructs (all areas) of TAM 3. The questionnaires addressed all the components (system features) exploited by the user in the ICU. The constructs with the biggest acceptance degree were studied by question and by each construct. For a better understanding of the results (Table 14), a selection was made on the three questions (Table 15) associated to the higher valuation (best results) and the three that presented the lowest valuation (worst results). Table 16 shows that the greater acceptance was the construct PEOU with an average of 3.45. At the opposite side is the Using Behaviour with an average of 3.23.

Table 15: ID and questions.

ID	Question
2.1.9	Can help to mitigate situations of an excessive workload?
2.10.1.2	Utility of GLASGOW CHART?
2.10.1.4	The graphics can help to a better understanding of the real patient's condition?
2.11.1	Utility of Information?
2.11.1.1	Utility of consulting information (hourly, daily, continuous)?
2.11.3	Global evaluation of the vital signs?
2.2.2	Can access to information quickly?
2.3.2	Do you think that other nurses should use the system as well?
2.3.3	Other professional colleagues think that you should use the system?
2.4.1	Monitoring of the patient?
2.4.21	The Balance is done correctly?
2.4.22	Evaluation of Performance (speed)?

Table 16: Global Analysis for each construct.

Constructs	Mode	Average
PU	3	3,34
PEOU	4	3,45
BI	3	3,34
UB	3	3,23

For a best visualization, was also made a global analysis on all the questions in the questionnaire (91). The tables 17 and 18 present the three questions with highest and lowest evaluations.

Table 17: Three questions with the highest evaluation.

	Mode	Avg
2.4.1 – Monitoring of Patient	4	4,08
2.11.1 – Utility of Information	4	4,15
2.11.1.1 – Utility of Consulting	4	4,15

Table 18: Three questions with the lowest evaluation.

Question	Mode	Avg
2.1.9 – Can help to mitigate situations of an excessive workload?	3	2,38
2.2.2 – Can access to information quickly	2	2,46
2.3.2 – Do you think that other nurses should use the system as well?	2	2,31

After an analysis of each construct, it was performed a global analysis of all the responses given by all the respondents. The answers presented an average value of 3.40.

In general, the nurses are satisfied with the ease of use of the technology. However, an obstacle is limiting a wider acceptance of the system INTCare: the operating speed of the user interface. This

implies an upgrade of the workstations in terms of RAM in the UCI. Another problem remains: the most part of nurses have no time available to operate with the information system.

6 CONCLUSIONS

The use of Technology Acceptance Model (TAM 3) combined with Delphi method to evaluate the acceptance by users, in order to understand their perceptions and impact on the behaviour of the system INTCare utility, is totally new. A set of questionnaires based on the four constructs have been answered by the nurses. In order to get a good understand of the technology acceptance by the users a set of analysis of the results (average, mode, Kendall, better and worst features) were performed having in consideration the TAM 3 methodology. Certain limitations persist in the data access, due to constant complaints from nurses regarding the speed of system. The acceptance of the technology by the nurses was very positive (between 3-4 points) for the four constructs evaluated (Perceived Usefulness, Perceived Ease of Use, Behavioural Intention and Use Behaviour).

In the future, the results will be used to: improve de system, mitigate some reported problems and add some new features. Then, will be performed another round of questionnaires, in order to understand if there was some improved to the user at level of TAM constructs.

ACKNOWLEDGEMENTS

This work is supported by FEDER through Operational Program for Competitiveness Factors – COMPETE and by national funds though FCT – Fundação para a Ciência e Tecnologia in the scope of the project: FCOMP-01-0124-FEDER-022674.

The authors would like to thank FCT (Foundation of Science and Technology, Portugal) for the financial support through the contract PTDC/EIA/72819/ 2006 (INTCare) and PTDC/EEI-SII/1302/2012 (INTCare II). The work of Filipe Portela was supported by the grant SFRH/BD/70156/2010 from FCT.

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