User acceptance of Clinical Information Systems: A methodological approach to identify the key dimensions allowing a reliable evaluation framework

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Abstract

The introduction of Computerized Information Systems (CIS) in clinical settings encountered difficulties. These difficulties highlight the lack of understanding of factors and mechanisms influencing user acceptance. The existing tools and research obtained contradictory results that point out the existence of neglected aspects, such as impacts of CIS, in computer science developments in complex settings.

This paper proposes to identify key dimensions which make up user acceptance in clinical settings through the union of three methods. They define five main dimensions which require a concrete evaluation to validate the underlying proposed framework and to complete the description of the acceptance phenomenon.

Identifying key dimensions opens the gate to comparative evaluation of many CIS and adds new indicators to evaluate the highlighted dimensions. A long-term aim is the development of longitudinal studies and to state priorities and guidelines for new CIS designs.

Keywords:

Clinical Information System, Acceptance, Satisfaction, Key dimension, Evaluation framework.

Introduction

Communications in health care settings constitute a critical part of the information flow [1]. Most of these communications are dedicated to management, coordination and sharing of information between colleagues and services [2-4]. Thus, difficulties of communication are significantly associated with adverse events encountered in health care [1].

Computerization, available in most industrial, sectors seeks to improve individual and organizational performances [5]. In clinical settings computerization could sustain communication processes. It also aims to clarify or make more effective the execution of tasks with a reduction of human factor risks [2].

Computerization of clinical data increases because of the large amount of information to process. Thus Computerized Information Systems (CIS) affect two vital aspects involved in health care quality: information and knowledge [4]. Experience shows that CIS have unexpected side effects in various domains such as workers' professional status [6]. This may happen when CIS questions the role of skilled professionals.

Because of the growing of CIS in health care and the existence of real and potential impacts on the professionals, the environment and care, a systematic validated and adapted framework for evaluation is required.

For more than twenty years, evaluation of CIS has been a subject of research, mainly focused on the measurement of system success. Most researchers came from management where evaluation can improve management and enhance productivity [7, 8]. In parallel, more theoretical investigations aimed to model causal links between CIS characteristics and their acceptance or satisfaction by users [9, 10].

Several evaluation tools exist, but a lack of consensus and disappointing results [5] indicate that key dimensions might have been neglected [11]. In a clinical setting this problem is even more intense because of the specifics and complexity of the care system [12].

This study aims to develop a unified framework to evaluate user acceptance of CIS. This framework should compare evaluation results of many clinical systems and state priorities and guidelines for new CIS's designs.

Building such a framework requires establishment of necessary and sufficient criteria for evaluation. The existing literature does not provide a firm foundation. In this project, the dimensions are selected by the union of three approaches:

- A *literature review* with a factorization of criteria from previous works;
- A *synthesis of dimensions* identified and suggested by the professionals of care;
- A *modelling of the studied system*, with identification of key factors.

This paper focuses on a methodology to identify key dimensions and proposes a relevant set of apects for the evaluation of user acceptance. This set of aspects is of prime

importance to allow comparison of various CIS in terms of acceptance, and to understand underlying mechanisms to design guidance for future developments.

Methodology

Literature review: main points

Studies referenced by this project focus mainly on two concepts: *success* and *acceptance*. The former is the most studied but also the most discussed. Among the listed success evaluation axes extracted from literature, satisfaction is by far the most widely used measure [11] as a substitute for success.

Acceptance, far less quoted, is in fact similar to satisfaction with fewer theoretical and methodological inconveniences than the latter. In agreement with other research about CIS evaluation using both notions indifferently [13], we chose the second one.

Definition

The definitions found in the literature vary enormously, but are compatible. By merging the contributions of various authors, the following definition of acceptance regarding human-machine interaction can be given:

"Acceptance is the result of an affective [8, 9] and a cognitive [11] evaluation of an end-user regarding to internal (past experiences, expectations, etc.), external (context of use, etc.) referents [9, 11] and multiple factors [7] of variable weights implied in his experiment with an information system."

The internal referents, external referents and interindividual variability will be explored later using longitudinal studies.

Main research

Research about evaluation began in the sixties and expanded during the next two decades. Bailey [7], Ives and al. [14] and Baroudi [15] belong to the first wave. Their work highlights three dimensions: EDP staff and service, information product and involvement/knowledge. The critics used these results to create new dimensions. The most important ones are content, accuracy, format, ease of use and timeliness [8]. Other aspects were overall reaction to the system, screen, terminology/system information, learning and system capabilities for Chin [16] who focused on subjective end-users evaluation of man-machine interfaces. Most research published since then propose revisions and consolidations of these dimensions.

At the end of the nineties, synthesis attempts were published [11, 17, 18] and radically different models appeared [19, 20]. Common investigations failed to reveal psychological intricacies and underlying reasons of user acceptance [11]. They contained a lack of theoretical foundations [5] and results were mixed [11]. Moreover, models considered *change* as being a linear process or a step function [19].

Three improvements have been attempted. The first one concerns inclusion of socio-technical factors with induced impacts of technologies [17, 21, 22]. The second improvement proposes an alternative to linearity by using the cusp catastrophe theory [19]. This proposal considers discussed variables, like amount of use, as splitting factors. The last improvement adds theoretical foundations such as system theory [17], equity and needs theory [11, 20] or communication theory [21] allowing a great evolution of models. The main new dimensions are:

- Task support satisfaction, Quality of work life satisfaction, Interface satisfaction, Decision making satisfaction [17];
- Perceived benefits, Organizational support, User background [18];
- IS performance, IS performance expectation, IS performance expectation disconfirmation, Equitable work performance fulfilment, Equitable self-development fulfilment and Equitable relatedness fulfilment [11].

Specific research: clinical context

Unfortunately, little methodological and empirical work have been done in the area of technology acceptance in the field of health [6, 12, 23]. These studies generally reference research mentioned above while stating specifics and mentioning reservations about the existing tools.

Computerized information systems have been developed relatively late in health care and frequently have encountered resistance by professionals. Half of the CIS projects fail, partly, but not only, for technical reasons [23]. Social, organizational and environmental factors have a remarkable influence [24]. CIS aim to improve the processes of health care and quality of health care systems. However, improvement is a change and in fact any change is an alteration of the steady state of the organization. Considering success as a perfect match between new CIS and actual process of health care raises a contradiction between the changes required for improvement and the necessity to keep the system in state [24].

In addition, a well-known effect of abrupt or huge change is an increase in the risk of failure [25]. CIS success depends on its integration into the characteristics of the organization [23]. When a system is a failure, put forward reasons are mainly the negligence of social and political considerations, the resistance of users to change and the interferences of teams.

Changes can arise at different levels: individuals, services, structures and health care. However, most of the evaluation tools focus on efficiency and performances of CIS without considering the importance of social impacts [26].

Dimensions provided by professionals

The professionals are really well placed to give information about what influences user acceptance. The following dimensions have been defined during individual and group interviews with professionals belonging to three groups: 1) Health care providers (users); 2) User support and teaching (support) and 3) IT specialists and developers. Indicated dimensions have been divided into four categories according their properties and are detailed in Table 2.

U	characteristics of users
S	characteristics of system
E	characteristics of environment
I	consequences and impacts

Table 1 – Categories of dimensions

Users	
U	Lack of availability, no expectation
S	Adequacy, slowness, bad integration of tools, increase of communication possibilities
E	Importance of the diversity of practices, involvement in the process
I	Sharing of tasks and roles, organization of the services, traceability, professional status
Support	
U	Users have no expectations, no desires. Taking into account various ways of using systems, informatics experience and the lack of availability
S	Slowness, software and hardware problems, quality of user interface, system complexity, task support provided by the system.
E	Organization's goals, opinion of colleagues, involvement in the process
I	Organization of the services
Software designers and developers	
U	Motivation, user's sensibility, lack of availability
S	Slowness, bad integration of tools, matching needs
E	Involvement, training, support

Table 2 – Characteristics of professionals

As expected, several dimensions match with the literature, but some usually neglected aspects are put forward. The involvement of users is a dimension often studied in literature [11] and has actually been mentioned by three groups (users, supporters, software designers and developers). Availability, also highlighted by all groups, relates mainly to the time users might need to adapt themselves to the system in order to use it. Surprisingly, environment revealed to be important for all groups and not as usually stated only for involvement. Finally, impacts preoccupies the professionals. Some preoccupancy are effective and others are anticipated and revealed by their questions or fears.

Interaction model or system model

A modelling of the interactions between users and the system helps provide a better view of a particular system. The modelling proposed is a sub-set of a complete model reduced to relations which take part into widened human-machine interaction. This model is from model of HCI adapted from Eason by Preece [27].

The division of the model into sub-systems has been made according to the user point of view because acceptance concerns the user perception of the system.

The first key dimension of the model is the *user*. It concerns all personal characteristics such as perception of his own status/role, past experiences, personal and professional goals, general attitudes with technologies, etc. There is a wide choice of personal characteristics; this research retains only the most important.

The second key dimension is the CIS as perceived by the user. It includes performances, user interface and all observable characteristics.

The third key dimension is the user's perception of his interaction with the CIS. It includes perceived usefulness, support to task and all characteristics normally attributed to a partner.

The fourth dimension is the environment. This component is very wide; it includes all components which surround the user in interaction with the CIS such as colleagues, institution or patients, etc.

A computerized information system produces results, provides assistance and has effects on its environment and all components in interaction with it. Therefore, the last dimension relates to all impacts. They include all negative, positive and indifferent consequences induced by the CIS on any component that interacts with it.

Synthesis of the three approaches

The analysis of literature, the contributions of professionals and the use of an interaction model allow a more accurate definition of the framework. The five dimensions obtained with the modelling cover the dimensions suggested by the professionals. In addition, they cover the dimensions found in literature. They make up the five base axis of the proposed framework. The indications provided by the professionals and results from previous studies allow a definition of the minimal and sufficient set of sub-themes for all five dimensions.

Characteristics of user

Standard demographic data, such as age, sex, function, service and features about informatics education and perception are gathered for each user. This information is useful to understand the users' background in their evaluation of CIS. It is important to know how computerization is used and perceived out of professional context to understand evaluation of the CIS [11].

Previous work identify two essential internal referents of comparison for evaluation: desires and expectation [9]. In clinical settings, concrete investigations show that desires and expectations about CIS could be nonexistent. However, the evaluation of all items in comparison to those referents can not be a rule, but they should be evaluated when available.

Characteristics of information system

"Characteristics of information system" is one of the main dimensions studied in previous research which provide many indicators. This dimension includes general characteristics of

the system, characteristics of user interface, ease of use, learning and retention facilities, etc.

This study has four themes: *content, use, interface* and *processing*. *Content* includes *quality* and *adequacy* of information. *Use* is *ease of access* (learning and using) and the amount of manipulations to reach the goal. *User interface* dimension concerns presentation of data, their coherence and localization. Finally, the *processing* dimension is the way by which the information system provides results, namely performances, behaviour (predictability, comprehensible for user, etc.) and integration with other computerized systems.

Perceived interaction with the system

It is not easy to distinguish univocally characteristics attributed to the CIS and these attributed to the interaction with it. To distinguish the two characteristics, this work considers the interaction as collaboration or partnership between user and CIS. This choice is supported by the fact that users consider computers and other medias as if they were persons [1]. A partnership relation is governed by some rules or expectations necessary to perceive the relationship positively. A partnership is a "common action between different organisms to a determined goal". This common action supposes reciprocity so that the two parts receive proportional rewards for the given efforts. It is also usual to wait from a partner characteristics like availability, helpful, efficiency and complementarily with other partners.

Perceived environment

The environment is a huge dimension; it covers organization, support, colleagues, etc. It needs to be divided into different themes. The proposed framework distinguishes between the following axes: goals and expectations of the organization, involvement of users, technical support, working support (includes learning) and working environment.

The organization follows its own goals, and so do users. It is useless to judge validity of these goals in the absolute. It is more useful to understand how user perception of goals influence the evaluation of the CIS. The main points are: congruence of goals, their communication, their comprehension and the affected thematic (involved themes of work).

Involvement of users is widely described in previous research [7, 11, 15, 18]. However, there is a lack of distinction between willingness of involvement, perceived involvement, perceived relevance of involvement and finally the feeling to be well represented.

User support has been divided into two categories according to the type of support: "technical support" for hardware problems and "business support" for specific problems linked to the use of the CIS. For both supports, three components are meaningful: availability, efficiency or competences and ability to communicate with users (understanding). For business support, it is also necessary to take into account training in term of completeness and fit with needs.

The last point considered is the influence of the working environment on acceptance. In their work about the use of advanced technologies, DeSanctis and Poole [28] show that appropriation varies with internal working procedure of the group. It is important to evaluate how work conditions influence acceptance. This aspect is a little bit ticklish and merits fuller investigation by qualitative methods. The work environment concerns themes such as workload, perception of environment, attitudes towards technologies or mutual help between users in the use of CIS.

Perceived impacts

Perceived impacts have been little studied in literature targeting general information systems. One reason is that impacts are mostly considered as consequences of acceptance and not as precursors [21, 29]. However, in literature about evaluation of CIS, they are considered as important [6, 26]. The impacts are not only outcomes of acceptance. Users anticipate real or supposed impacts and perceive consequences of computerization in everyday work. Impacts may affect users and their tasks, services at structural or processing levels and quality of services such as patient treatment. They also affect conditions given to professionals to do their works [23].

A careful study of impacts is important and interesting. Such studies cannot be carried out based exclusively on questionnaires and need qualitative investigations.

Conclusion

The present work aims to explore deeper the components of acceptance of computerized information system in health care. This project postulates that evaluation of user acceptance in such context has to take into account all components concerned in the system.

These components have to be constructed by the confluence of different approaches. Literature provides precious information about existing results and investigations but it is not sufficient. Every context of evaluation has its own settings. Health care context is particularly complex in its structures and processes. Actors implied by using, supporting or developing computerized information systems provide indications about dimensions to consider in real settings.

These two ways are not sufficient because they do not provide an understanding frame for underlying acceptance mechanisms. A modelling of context including the evaluated CIS finds out which interactions and components are implied in evaluation. The confluence of those three approaches provides five key dimensions and their associated indicators.

Key dimensions are a base for developing a generic tool to investigate all computerized clinical information systems. This construction constitutes also a good skeleton to add new indicators or test interactions between components. Results will sustain a common repository and allow comparisons, longitudinal studies and sketch priorities and guidelines for new CIS designs.

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