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ASSESSING HOSPITAL PHYSICIANS' ACCEPTANCE OF CLINICAL INFORMATION SYSTEMS: A REVIEW OF THE RELEVANT LITERATURE

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In view of the tremendous potential benefits of clinical information systems (CIS) for the quality of patient care; it is hard to understand why not every CIS is embraced by its targeted users, the physicians. The aim of this study is to propose a framework for assessing hospital physicians' CIS-acceptance that can serve as a guidance for future research into this area. Hereto, a review of the relevant literature was performed in the ISI Web-of-Science database. Eleven studies were withheld from an initial dataset of 797 articles. Results show that just as in business settings, there are four core groups of variables that influence physicians' acceptance of a CIS: its usefulness and ease of use, social norms, and factors in the working environment that facilitate use of the CIS (such as providing computers/workstations, compatibility between the new and existing system...). We also identified some additional variables as predictors of CIS-acceptance.

Introduction

The importance of information technology (IT) in our daily life can hardly be overestimated, and in healthcare as well IT becomes increasingly important. It took healthcare decision makers – compared to business settings – a long time to acknowledge the beneficial effects (such as reduction of medication errors and radiological images that can be consulted from everywhere) and supporting role of IT in the quality of care (Helck, et al., 2009; Lee & Shim, 2007). Therefore, adoption of information and communication technology in healthcare (Ash & Bates, 2005) has long lagged behind. Now, for the sake of quality of patient care, policy-makers are increasingly focusing on promoting the introduction of clinical information systems (CIS) in medical settings (Davidson & Heslinga, 2007). However, for a clinical information system to be introduced into a hospital, several barriers have to be overcome (Paré & Trudel, 2007). One of the last hurdles implementers or hospital boards need

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to clear is getting the intended users (physicians, nurses, clerks) to use the system, which can be a burden, definitely in the case of physicians (Aarts & Berg, 2006; Lapointe & Rivard, 2005). In business settings, it is common practice to assess which factors influence a user's acceptance of a technology. However, just as healthcare lagged behind in implementing IT, user acceptance studies are also less prevalent in healthcare. The aim of this study is to propose a framework for evaluating hospital physicians' acceptance of a (new) CIS that can serve primarily as a guidance for future research in this domain, yet this framework may also guide hospital administrators or implementers who want to gauge physicians' perceptions of a CIS. Hereto, a review of the recent literature on hospital physicians' acceptance of a clinical information system is performed.

In the following paragraphs, we first give an overview of the field of research on technology acceptance. Then we outline the review strategy and results, to end with a discussion of the results and a conclusion.

Overview of the research on technology acceptance

In the field on Information Systems (IS) acceptance, a vast body of research and knowledge has been developed to understand user acceptance of technology. Theories were developed based on existing social psychology and sociology theories like the theory of reasoned action (TRA) (Fishbein & Ajzen, 1975), diffusion of innovations theory (Rogers & Shoemaker, 1971), theory of interpersonal behaviour (Triandis, 1980), and social cognitive theory (Bandura, 1986). The most dominant line of models departs from the TRA, with the Technology Acceptance Model (TAM) (Davis, Bagozzi, & Warshaw, 1989) being the most prominent model that has been applied in a wide range of settings. An overview of models used to study technology acceptance can be found in Venkatesh, Morris, Davis, & Davis (2003), and is also summarised in Figure 1.

Acceptance models aim to explain or predict as much of the variance in use or user acceptance as possible. In the absence of a measure for observed use, user acceptance is typically operationalised as behavioural intention and/or self-reported use (Pynoo, et al., 2011; Venkatesh, et al., 2003). Different conceptualisations for self-reported use exist: e.g. frequency, intensity, duration, extent,... Attitude has also been proposed as a measure for user acceptance, particularly in the case of mandatory usage (Brown, Massey, Montoya-Weiss, & Burkman, 2002; Davis, 1989). Behavioural expectation also served as a measure for acceptance in the early days of technology acceptance research, but it passed into disuse due to its conceptual overlap with behavioural intention (Warshaw & Davis, 1985).

Venkatesh, et al. (2003) proposed the Unified Theory of Acceptance and Use of Technology (UTAUT), following a review of acceptance models and building upon the Technology Acceptance Model. They stated that, in business settings, user acceptance of a technology is influenced by four groups of factors: usefulness (termed performance expectancy), ease of use (termed effort expectancy), social influence and facilitating conditions. Four variables are argued to moderate the relationships between these factors and user acceptance: gender, age, experience and voluntariness of use. Our review should enable us to conclude if these factors are also valid for predicting hospital physicians' acceptance of clinical information systems.

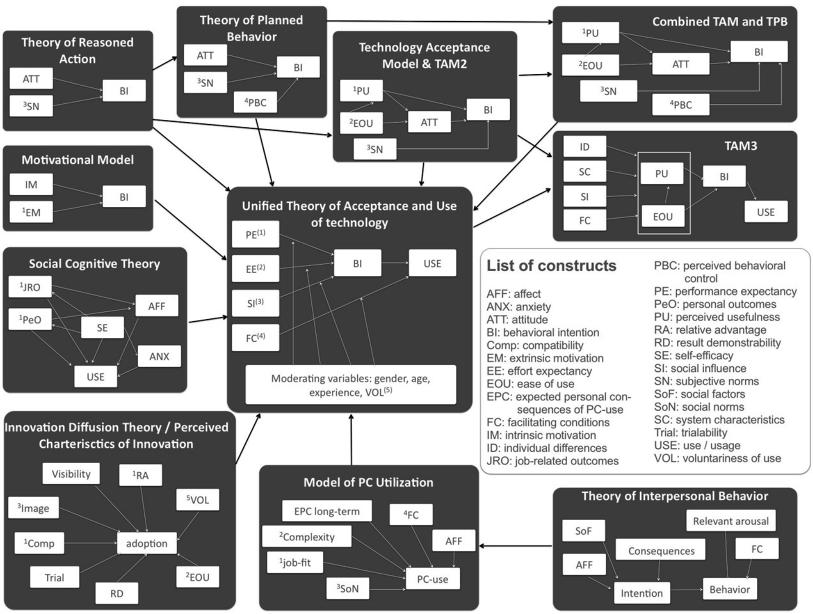

Figure 1

Overview of (technology) acceptance models

Notes: Black arrows indicate from which model(s) a model stems. Superscripts [1-5] refer to constructs that make up the UTAUT-variables: [1]Performance Expectancy; [2]Effort Expectancy; [3]Social Influence; [4]Facilitating Conditions; [5]Voluntariness of use

Methods

A review of the literature was performed on March 4th, 2010. The review procedure is summarised in Table 1. To qualify for selection, articles retrieved through the Web-of-Science database should be published as a journal article in the time span 2000-2009 and report a study in which hospital physicians' acceptance of a clinical information system is investigated. These selection criteria are elaborated below.

Selection criteria

Database: ISI Web-of-Science

An abundance of databases exists (over 400 can be accessed through our institutional library), making it difficult to select one or more databases to run a literature search. Some are targeted at specific disciplines, such as the IEEE Xplore database (Information Technology), the Cochrane library & PubMed (Health Sciences), PsycARTICLES (Social Sciences); while other databases are multidisciplinary, such as the Web-of-Science. We opted for the Web-of-Science as a sole source for this study for two reasons: (1) research on the acceptance of medical informatics is in nature multidisciplinary; and (2) articles published in the web-of-science underwent some form of quality control, namely peer-review.

Publication years: 2000-2009

The fast rate in which personal computers, networks, and (new) technologies are developed and subsequently improved, make it hard to draw a line between outdated technologies and technologies whose features are comparable to technologies that are currently implemented. A decade is in this respect a symbolic choice which also allows to reproduce the literature search.

Published as a journal article

In order to be selected, a study should report original results. Therefore reviews and editorials are excluded. Meeting abstracts and proceedings are also excluded for two reasons: (1) to maximise the chance of including only high-quality peer-reviewed studies, and (2) to minimise the chance on hard to identify duplicate datasets, as conferences are the perfect forum for presenting preliminary or partial results as a first step towards a full journal article.

Type of study: quantitative acceptance study

Researchers can adopt two perspectives when studying the implementation or use of clinical information systems: quantitative or qualitative. Both types of studies have their own pros and cons, and will – irrespective of the perspective – yield interesting information for the researcher. The main difference between quantitative and qualitative research concerns the dependent variable, which is respectively CIS-acceptance and CIS-success or failure. And although acceptance (intention/use) can be considered as part of IS-success (Delone & McLean, 2003), the research focus is too different. In view of the focus of this review on acceptance, only studies conducted from a quantitative perspective will be taken into account.

Sample: hospital physicians

Two major groups emerge as patient care providers: physicians and nurses, while patients can either opt for treatment in a hospital or in a private practice. Here, we will focus on studies involving hospital physicians. The reasons for focusing on physicians are the following. Physicians and nurses are different user types and they use different components of the same system, possibly leading to very different evaluations of the same system (Aarts & Berg, 2006; Lapointe & Rivard, 2005; Sicotte, et al., 2009). Moreover, in many cases and unlike nurses, only a few physicians are directly employed by the hospital (Ilie, Van Slyke, Parikh, & Courtney, 2009), so the hospital management cannot exert much pressure. Physicians, unlike many other IT-users, also have a greater freedom of choice (or professional autonomy) to use or not use a technology (Lapointe & Rivard, 2005; Walter & Lopez, 2008).

Only studies conducted in hospitals are included because, we believe that major differences exist between private practices and hospitals definitely when it comes to adopting CIS. Cost is a major impediment for a CIS to be implemented (Paré & Trudel, 2007), and in small practices the cost might be too much of a problem. Also, because physicians in a small practice can opt for the system (and interface) that best fits their needs or practice. Physicians in a small practice are (or should be) also more aware of the consequences in terms of software, hardware, network capabilities,... And they can more or less control the timing of the purchase and implementation of the technology. This is not the case for hospitals. A CIS is chosen because it best meets the predefined requirements, while the timing of the introduction is (quasi) entirely in the hands of the implementers/hospital management/IT department. The responsibility for meeting the requirements (in terms of hardware, software, network,...) lies either outside the physician (e.g. the IT-department), or the physician can be strongly urged to purchase an upgrade by the hospital management (or IT-department). And these differences undoubtedly have a differential effect on physicians' acceptance of a (new) CIS.

Technology: Clinical Information Systems

Applications used in hospitals can be grouped according to several criteria. When clustered based on their primary purpose, three healthcare IT clusters can be identified (Bhattacherjee, Hikmet, Menachemi, Kayhan, & Brooks, 2007). The first cluster are the strategic applications that are aimed at improving critical decision-making activities. The second cluster contains the administrative applications that are intended to streamline and improve internal data processing activities. These systems are widespread in the healthcare sector, as they prove their efficiency very fast and are not costly to install (Gans, Kralewski, Hammons, & Dowd, 2005). The third cluster is made up of the clinical applications that are designed to improve patient care, such as PACS (Picture Archiving and Communication System), CPOE (Computerised Physician Order Entry), EMR (Electronic Medical Record), CDSS (Clinical Decision Support System). These systems are typically interconnected, but they can be implemented and studied as separate systems. Throughout this article we focus on the latter category, the clinical information systems, as these systems have a direct impact on patient care.

Table 1

Review procedure and result: search terms per category were combined using "OR", categories were combined using "AND"

Category (boolean "AND")	Search term (boolean "OR")
Sample	physician*; specialist*; doctor*; "medical practitioner*"; surgeon*; radiologist*
Acceptance study	accept*; adopt*; use; usage
Technology: CIS	"computerised physician order entry"; CPOE; "clinical decision support system"; CDSS; "electronic medical record"; EMR; "electronic patient record"; EPR; "electronic health record"; EHR; "radiology information system"; RIS; "picture archiving and communication system"; PACS; "laboratory information system"; "medical record imaging"; "bar-coded medical management"; "clinical data repository"; "clinical resource scheduling"; "critical care bedside"; telemedicine; "emergency department medical system"; "medical bedside terminals"; "surgical bedside terminals"; "order communication results"; "operating room system"; "chart tracking and locator"; "bioterrorism disease surveillance system"; abstracting; "scanning clinical documents"
Publication years	2000-2009
Document type	article
	=> Dataset of 797 articles

Results

Retrieved articles had to pass two rounds to be included in the review. In the first round, titles and abstracts were scanned, leading to the removal of 728 articles. This large number of rejected items was mainly due to the inclusion of the search term "use", which was used in another sense than referring to acceptance, e.g. "... and use of information seeking tactics" (Borycki, Lemieux-Charles, Nagle, & Eysenbach, 2009). The remaining articles were read leading to the exclusion of another 58 articles, while 11 articles were selected for the review. These are summarised in Table 2, organised per technology. The findings are integrated in a graphical way in Figure 2.

Clinical Information Systems

Acceptance studies on six different clinical information systems were retrieved. Although these systems were studied separately, most are closely interconnected, with the Electronic Medical Record (EMR), containing both administrative and clinical patient information, as central system. In the most integrated scenario, a Clinical Decision Support System (CDSS) is embedded within a Computerised Physician Order Entry (CPOE), which is in turn integrated into the EMR. All kinds of tests and medication can be ordered through the CPOE while the CDSS flags possible drug interaction effects or warns for overmedication, based on the patient information in the EMR. Radiological exams can also be ordered through a CPOE, and the resulting radiological images and reports are stored in the Picture Archiving and Communication System (PACS). A physician can access these images and reports through the patient record in the EMR. Speech recognition is typically used by radiologists to dictate their reports. In the case of Alapetite, Andersen, & Hertzum (2009), the speech recognition is used to dictate in the EMR. The last clinical information system, Telemedicine, is a broad concept encompassing all kinds of medicine at a distance through the use of information and communication technologies (Bashshur, 1995; Chau & Hu, 2001; Gagnon, et al., 2003).

Table 2
Overview of selected studies

$	Clinical Information System	Setting	Population	Timing of the study	Model	Dependent variable (Variance explained)
(A) Chang, et al. (2007)	CDSS (prototype)	3 hospitals (a medical center, a district teaching, and a local hospital)	115 physicians	System is in use	UTAUT	BI (.28) s-r Use (.43)
(B) Bhattacherjee & Hikmet (2007)	CPOE	acute care hospital	129 physicians	System is in use by 25% of the hospital physicians	TAM + resistance to change	BI (.55)
(C) Ilie, et al. (2009)	EMR	Multi-site acute care community hospital	199 physicians	System is in use by a large majority of physicians	TAM + logical & physical accessibility	BI (.64)
(D) Duyck, Pynoo, Devolder, Voet, et al. (2008)	PACS	University hospital	19 radiologists 37 technologists	pre-implementation	UTAUT	BI (.48)
(E) Duyck, Pynoo, Devolder, Adang, et al. (2008)	PACS	University hospital	184 (T1) and 147 (T2) physicians	T1: pre-implementation T2: 1.5 years post-implementation	UTAUT	BI (T1: .35; T2: .31) s-r Use (T2: .03)
(F) Paré, et al. (2005)	PACS	Multi-site university hospital	218 (24 Radiologists, 77 technologists and 117 physicians)	System is in use	D&M IS success framework. Dependent variables: System Continuance Intention (SCI); Net Benefits (NB); User Satisfaction (US)	SCI (Phys .43; Rad .41; Tech .47) NB (Phys .34; Rad .23; Tech .40) US (Phys .64; Rad .79; Tech .59)

Table 2
Overview of selected studies

$	Clinical Information System	Setting	Population	Timing of the study	Model	Dependent variable (Variance explained)
(G) Alapetite, et al. (2009)	Speech recognition (for EMR)	2 hospitals of one regional association	112 physicians of which 39 on two occasions	T1: one month before introduction T2: 4 or 8-12 months after introduction (depending on hospital department)	UTAUT	Overall assessment of speech recognition – attitude (N/A)
(H) Chau & Hu (2001, 2002a, 2002b)	Telemedicine	8 tertiary care hospitals	408 physicians	during the early stages of telemedicine implementation	TAM TPB decomposed TPB	BI (TPB: .32; TAM: .40/.42; d-TPB: .42/.43)
(I) Gagnon, et al. (2003)	Telemedicine	32 hospitals in one telemedicine network	506 (220 GP's and 286 hospital physicians)	System in use for pediatric cardiology; expected diffusion to other specialties	Theory of Interpersonal Behavior	BI (.81)

$ Note: (A) to (I) are used in Figure 2 to refer to these studies

Models and Influencing factors

With the Technology Acceptance Model as most prominent model, the models building upon the Theory of Reasoned Action (see Figure 1) have been dominant in technology acceptance research. This is reflected in this review where nine (out of eleven) studies employed a model derived from the Theory of Reasoned Action. TAM was assessed in four studies and perceived usefulness was identified as a consistent strong predictor of behavioural intention throughout all four studies, while perceived ease of use was of no importance. TAM has been criticised for being too parsimonious as it includes only two beliefs as predictors for behavioural intention (see Figure 1), and remarkably, in all four studies with TAM, the authors either added one or more constructs (Bhattacherjee & Hikmet, 2007; Ilie, et al., 2009) or compared it to a combination of TAM and TPB which extends TRA in a complementary manner (Chau & Hu, 2001, 2002b). Both resistance to change (Bhattacherjee & Hikmet, 2007) and logical access (Ilie, et al., 2009) were significant predictors of behavioural intention. Variance explained in behavioural intention was a lot higher in the studies who added a predictor compared to the studies who tested the basic version of TAM (Chau & Hu, 2001, 2002b). Integrating TAM and TPB into one model (referred to as decomposed TPB) did not lead to a significant increase in variance explained in intention.

Decomposed TPB (Chau & Hu, 2001, 2002a, 2002b) holds – except for attitude – conceptually the same constructs as UTAUT which was used in four studies. All UTAUT-predictors were found to influence acceptance. As in the studies with TAM, performance expectancy was a consistent strong predictor of acceptance. Effort expectancy – unlike perceived ease of use in TAM or decomposed TPB – was also found to be important, while social influence and facilitating conditions were of minor importance for predicting acceptance. Variance explained in behavioural intention was in the range .28 to .48, thus somewhat lower than in the TAM-studies, while a sharp contrast in the prediction of self-reported use (variance explained .43 vs. .03) between Chang, Hwang, Hung, & Li (2007) and Duyck, Pynoo, Devolder, Adang, et al. (2008) existed. The very small amount of variance explained in the latter study could however be attributed to a ceiling effect as their physicians scored very high on both behavioural intention and self-reported use.

Gagnon, et al. (2003) adapted the Theory of Interpersonal Behaviour for their study and they found that normative factors and self-identity accounted for 81% of the variance in physicians' behavioural intention to use Telemedicine. The authors did not assess the effect of facilitating conditions because of its low internal consistency.

Paré, et al. (2005) used the DeLone & McLean IS Success model for their study. This model discerns several dimensions of system success, including "Intention to use/use" and "user satisfaction". They found that depending on the population, users' system continuance intention was positively influenced by user satisfaction, net benefits and confirmed expectations. Predictor variables differed depending on the user group. The most remarkable difference was that radiologists' satisfaction was positively influenced by PACS' ease of use and not by usefulness, while physicians' satisfaction was positively influenced by PACS' usefulness and not by ease of use. Variance explained in system continuance intention and user satisfaction was moderate to high, respectively in the range .41-.47 and .59-.79.

Figure 2 combines the findings from the review. Constructs from different research streams were used throughout the selected studies. The constructs used by Paré, et al. (2005) could not be grouped under one of the UTAUT-categories, but are displayed under "other factors". This is not the case for physical access and logical access (Ilie, et al., 2009), which have a large degree of conceptual overlap with, respectively, facilitating conditions and effort expectancy. Therefore, physical and logical access are grouped under these constructs although they were originally not considered by Venkatesh, et al. (2003).

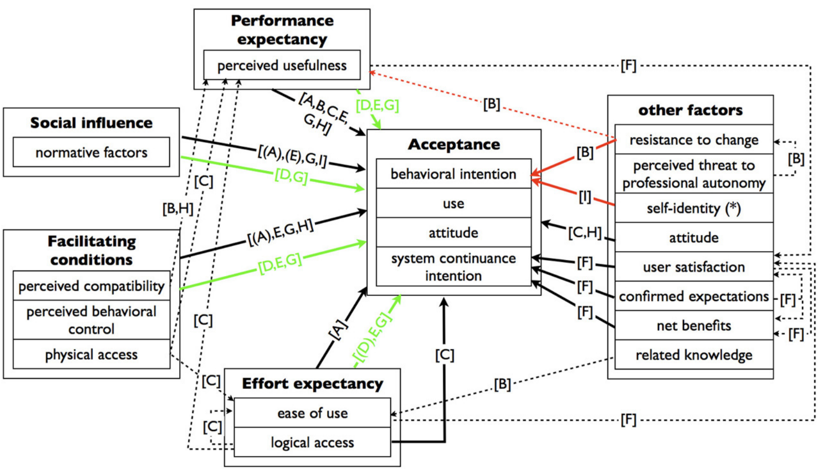

Figure 2
Integration of the findings

Notes: The letters refer to the studies in Table 2 where a significant relationship between the constructs was found. Letters between round brackets denote a marginally significant effect. Red lines indicate negative relationships. Full lines indicate constructs with a direct effect on acceptance, dotted lines indicate indirect effects on acceptance. Green arrows: pre-implementation; black arrows: post-implementation

Timing of the study

Nine studies adopted a one-shot approach: they assessed physicians acceptance on one occasion, either while the system was already in use (Bhattacherjee & Hikmet, 2007; Chang, et al., 2007; Chau & Hu, 2001, 2002a, 2002b; Gagnon, et al., 2003; Ilie, et al., 2009; Paré, et al., 2005) or pre-implementation (Duyck, Pynoo, Devolder, Voet, et al., 2008). In two studies (Alapetite, et al., 2009; Duyck, Pynoo, Devolder, Adang, et al., 2008) physicians' acceptance was assessed on two occasions: pre-implementation and while the system was in use. Comparing the results of the pre-implementation studies with those conducted while the system was in use, one observation stands out: the role of effort expectancy (or perceived ease of use). With the exception of Chang, et al. (2007), none of the post-implementation studies found a direct effect of ease of use on acceptance, whereas effort expectancy directly influenced acceptance in all pre-implementation studies, albeit only marginally in Duyck, Pynoo, Devolder, Voet, et al. (2008). Otherwise, the ease of logging in into the system (logical access), which is related to ease of use, was found to be important post-implementation (Ilie, et al., 2009).

Discussion

As the selected studies utilised several theories, sometimes stemming from different research traditions, not all studies questioned the same constructs. Nonetheless, some conclusions on the variables that predict physicians' acceptance of CIS can be drawn from the review. Figure 2 shows that all four UTAUT-variables predicted physicians' acceptance of a CIS.

The most consistent and important predictor was the CIS' usefulness (or performance expectancy). Only one study found that (PACS-)usefulness was not important, but only for radiologists (Paré, et al., 2005). Ease of use (or effort expectancy) was of minor importance post-implementation, but important pre-implementation. This finding contradicts with researchers who claim that ease of use is of no importance for physicians because they evaluate a technology in terms of its usefulness for the quality of patient care, e.g. Chau and Hu, 2001; Duyck, Pynoo, Devolder, Voet, et al., 2008. Our results also suggest that effort expectancy should be extended with logical access (Ilie, et al., 2009). Logical access was not considered for UTAUT, but the ease of logging in into a system is also part of a CIS' ease of use. Although it has been argued that physicians make their technology acceptance decision independent from their peers (Chau & Hu, 2001, 2002a, 2002b), social influence also proved important. Facilitating conditions present an interesting case. Compatibility, one of the constructs that constitutes facilitating conditions proved to be an antecedent to CIS' usefulness (Bhattacherjee & Hikmet, 2007; Chau & Hu, 2001, 2002a, 2002b), while physical access (which overlaps with the availability of resources) affects both CIS' usefulness and ease of use. A recommendation to IS-researchers is to dissociate this construct into (1) compatibility, (2) provision of resources / physical access, and (3) provision of training and support. To develop these scales, researchers can utilise items from the same pool of items from which the facilitating conditions scale was deduced, see Venkatesh, et al. (2003, Table 12). By dissociating this construct, the possible problem (reliability was good in Chang, et al., 2007) of low reliability of the FC-scale as identified by Duyck, Pynoo, Devolder, Voet, et al. (2008) and Gagnon, et al. (2003) should be overcome.

Next to these constructs that can be categorised within the UTAUT-framework and which will already give a good insight in physicians' perceptions of the CIS, we identified also other factors that influenced physicians' acceptance: resistance to change, attitude and satisfaction. Researchers could consider to also include these additional factors, to get an even better image, yet they should be aware of a possible trade-off between survey length and response rate. Including more items will yield more information, yet fewer responses.

Moderating variables were not explicitly tested in the selected studies. Although UTAUT holds four moderators, none of the studies that tested UTAUT included moderating variables (Alapetite, et al., 2009; Chang, et al., 2007; Duyck, Pynoo, Devolder, Adang, et al., 2008; Duyck, Pynoo, Devolder, Voet, et al., 2008). Duyck, Pynoo, Devolder, Adang, et al. (2008) found some differences between male and female physicians and over time (as users got more experience), but just as in Alapetite, et al. (2009), the influence of growing experience on user acceptance was not statistically tested.

Putting this together leads to a model incorporating the following categories of constructs: (1) performance expectancy (Venkatesh, et al., 2003); (2) effort expectancy (Venkatesh, et al., 2003) and logical access (Ilie, et al., 2009); (3) social influence (Venkatesh, et al., 2003); (4) compatibility (Moore & Benbasat, 1991; Taylor & Todd, 1995), physical access (Ilie, et al., 2009) / resources (Taylor & Todd, 1995), and training and support (Thompson, Higgins, & Howell, 1991); and (5) resistance to change (Bhattacherjee & Hikmet, 2007). Hospital physicians' acceptance can then be measured as attitude (Brown, et al., 2002; Pynoo, et al., 2007), user satisfaction (Delone & McLean, 2003), behavioural intention (Venkatesh, et al., 2003), and/or use (Venkatesh, et al., 2003).

Future research

From this study, several directions for follow-up research can be proposed. First, as only eleven studies were identified, it is a call for more quantitative studies on physicians' acceptance of clinical information systems. Second, future research should also aim at testing and refining the proposed model. In this respect, researchers should focus primarily on: (a) assessing acceptance on multiple occasions, and definitely pre-implementation or shortly after the introduction of a new system; (b) the differential effect of ease of use and logical access; and (c) the differential effect of the different aspects of facilitating conditions. Finally, follow-up research should also investigate whether the proposed model is also valid for physicians in small practices.

Conclusion

In this article, we reviewed studies on CIS-implementations in hospital settings with physicians as target population. From a total of 797 articles, only 11 could be withheld. The review showed that, just as in business settings (Venkatesh, et al., 2003), hospital physicians' acceptance of clinical information systems depends mainly on four categories of constructs: the CIS' usefulness, ease of use, social norms concerning use of the CIS, and a broad category of facilitating conditions. Moreover, for physicians, it is also important that the system is easy to access (both the login procedure and availability of a computer or workstation) and that the compatibility between the work routine and the system is optimised. To evaluate hospital physicians' acceptance of a (newly introduced) CIS, researchers, implementers or hospital boards can utilise a modified version of UTAUT with effort expectancy incorporating logical access, and facilitating conditions divided into compatibility, resources/physical access, and training & support. This modified model might further be extended with resistance to change, attitude and satisfaction.

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