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Electronic health record acceptance by physicians: Testing an integrated theoretical model

Marie-Pierre Gagnon [a,b,*], El Kebir Ghandour [a], Pascaline Kengne Talla [a], David Simonyan [a], Gaston Godin [b], Michel Labrecque [a], Mathieu Ouimet [a,c], Michel Rousseau [d]

[a] Research Center of the CHU de Québec. 10 rue de l'Espinay, Quebec City, Quebec G1L 3L5, Canada
[b] Faculty of Nursing Sciences, Université Laval, 1050 avenue de la Médecine, Quebec City, Quebec G1V 0A6, Canada
[c] Department of Political Science, Université Laval, 1030, avenue des Sciences-Humaines, Quebec City, Quebec G1V 0A6, Canada
[d] Department of Psychoeducation, Université du Québec à Trois-Rivières, 3351, boulevard des Forges, C.P. 500, Trois-Rivières, Quebec G9A 5H7, Canada

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ABSTRACT

Objective: Several countries are in the process of implementing an Electronic Health Record (EHR), but limited physicians' acceptance of this technology presents a serious threat to its successful implementation. The aim of this study was to identify the main determinants of physician acceptance of EHR in a sample of general practitioners and specialists of the Province of Quebec (Canada).
Methods: We sent an electronic questionnaire to physician members of the Quebec Medical Association. We tested four theoretical models (Technology acceptance model (TAM), Extended TAM, Psychosocial Model, and Integrated Model) using path analysis and multiple linear regression analysis in order to identify the main determinants of physicians' intention to use the EHR. We evaluated the modifying effect of sociodemographic characteristics using multi-group analysis of structural weights invariance.
Results: A total of 157 questionnaires were returned. The four models performed well and explained between 44% and 55% of the variance in physicians' intention to use the EHR. The Integrated model performed the best and showed that perceived ease of use, professional norm, social norm, and demonstrability of the results are the strongest predictors of physicians' intention to use the EHR. Age, gender, previous experience and specialty modified the association between those determinants and intention.
Conclusions: The proposed integrated theoretical model is useful in identifying which factors could motivate physicians from different backgrounds to use the EHR. Physicians who perceive the EHR to be easy to use, coherent with their professional norms, supported by their peers and patients, and able to demonstrate tangible results are more likely to accept this technology. Age, gender, specialty and experience should also be taken into account when developing EHR implementation strategies targeting physicians.

1. Background

The electronic health record (EHR) is viewed as the backbone supporting the integration of various information tools (e.g., emergency information, test ordering, electronic prescription, decision-support systems, digital imagery, and telemedicine) that could improve the uptake of evidence into clinical decisions. Using such evidence in daily clinical practice could enable a safer and more efficient healthcare system [1–3]. International literature supports several benefits of EHR for patients [4–11]. One of the main benefits reported is the increased quality of care resulting from patients having their essential health data accessible to their different providers, which can significantly improve the coordination of care [12,13] and increase the efficiency of primary care practice [14].

Based on relevant disease management programs [15,16], the EHR could support empowered citizens to actively take part in decisions regarding their health, and could be used to track the delivery of recommended preventive care across primary care practices [17]. The EHR is also a tool that facilitates knowledge exchange and decision making among healthcare professionals by providing them with relevant, timely, and up-to-date information [13].

1.1. Current knowledge on EHR acceptance

The implementation of EHR systems is currently supported in many high-income countries [13,18,19]. For instance, the Institute of Medicine in the US has qualified the EHR as "an essential technology" for healthcare [20]. Nevertheless, the rate of EHR

* Corresponding author. Address: Research Centre of the CHU de Quebec, 10 rue de l'Espinay, Room D6-726, Quebec City, Quebec G1L 3L5, Canada. Fax: +1 418 525 4194.
E-mail address: marie-pierre.gagnon@fsi.ulaval.ca (M.-P. Gagnon).

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acceptance by office physicians remains slow in countries such as the United States [20–22], United-Kingdom [14,23–27], and Canada [28–31].

An increasing body of knowledge on EHR implementation shows that a majority of projects are discontinued after the experimentation phase of their assessment [22,32]. Issues associated with the slow diffusion of the EHR include: important start-up investments, lack of financial incentives, uncertain payoffs, suboptimal technology, low priority, and resistance of potential users [33–35]. EHR acceptance by physicians requires significant financial investment and learning effort, but also introduces radical change to every single aspect of clinical work [14]. Also, perceptions towards the use of EHR may vary between health professionals groups, adding to the complexity of implementing this technology in a pluralist healthcare system [32,36,37].

EHR acceptance by healthcare professionals is an essential condition to ensure that the expected benefits will materialize [38,39]. Thus, understanding factors influencing EHR acceptance is one of the key elements in ensuring its optimal integration and, ultimately, measurable benefits within health system and population. Factors related to users and their working environment have to be considered because many previous EHR projects have failed due to the lack of integration into practices and organizations [40,41].

Previous studies have looked at individual factors affecting physician EHR acceptance [42–45], but few employed a theoretical model. Among studies that used a theoretical model most were based on the Technology Acceptance Model (TAM). The TAM hypothesises that user intended behavior predicts their actual system use [46]. It proposes two main factors that determine users' *behavioral intention* (BI) toward using a new technology, specifically *perceived usefulness* (PU) and *perceived ease of use* (PEoU) [47]. This theory suggests that external variables, such as human and social factors, indirectly determine attitude toward technology acceptance by influencing PU and PEoU [47,48]. The TAM is one of the most influential frameworks for predicting users' perceptions about information system use [46,47,49–51].

A study used variables from the TAM to assess factors associated with physicians' attitude toward using EHR [52]. Overall, PU explained 73% of the variance in physicians' attitude toward EHR use, whereas PEoU did not significantly influence attitude. None of the physicians' characteristics (age, years in practice, clinical specialty, health system relationship, and prior computer experience) were correlated with any of the TAM variables [53]. This study did not assess physicians' intention to use EHR.

Because physicians may differ from other types of users in terms of IT acceptance, some authors have suggested adding other constructs to the TAM [54–56]. Ilie et al. [57] found the most significant factors influencing physicians' intention to use an Electronic Medical Record (EMR) were attitude, PU, logical access and physical access. Walter and Lopez [58] have highlighted the role of perceived threat to professional autonomy as an important antecedent to PU, intention, and EMR usage. For their part, Price [59] observed that PEoU, PU, and perceived patient record privacy have moderate positive effects on physicians' intention to use an EMR.

Holden [60] conducted a qualitative study of the effect of social influence on physicians' EHR use and their results suggested that role beliefs and moral norms could both encourage or discourage use. Besides, a study by Seeman and Gibson [61] investigated the factors associated with their acceptance of EMR using two models: the TAM and the Theory of Planned Behavior (TPB). Results from their multiple regression analyses showed that the TPB was more powerful than the TAM in explaining physicians' acceptance, but that a framework combining both models was even more powerful. Attitude toward EMR use and perceived behavioral control were the most important predictors of physicians' intention to use an EMR.

Archer and Cocosila [62] compared EHR perceptions of Canadian physicians already using EMR systems with those not yet using them through an integrated theoretical approach inspired by the Unified Theory of Acceptance and Use of Technology (UTAUT), a model offering an extension to the TAM by including key concepts from other technology acceptance models [63]. Their theoretical model explained 55.8% of the variance in behavioral intention to use EHR among physicians who were EMR users, and 66.8% among non-EMR users. Effort expectancy (a concept similar to PEoU) was found to be the strongest determinant of intention among EHR users, while performance expectancy (equivalent to PU) was the strongest determinant for nonusers. However, this study did not assess the role of context, particularly normative influences, which characterize the medical profession and could have an impact on the intention to use EHR [56]. Contextual factors could also play an important role as barriers or enablers to EHR use [64].

The role of context and social influence was taken into account in a recent study by Chang and Hsu [46] suggesting that a modified UTAUT model is useful in predicting medical staff intention to use an information system (IS). These authors used a framework that integrated the constructs of facilitating conditions and perceived consequence from the Theory of Interpersonal Behavior (TIB) [65]. Their results showed that performance expectancy, effort expectancy, social influence, facilitating conditions and perceived consequences explained 31% of the variance in physicians' intention. In addition, including gender, age, experience, and occupation as moderators increased the explanatory power from 31% to 39% [46].

In a recent study on EMR acceptance by physicians, Venkatesh et al. [66], tested a modified UTAUT that also considered the specificities of the medical profession. Accordingly, they hypothesised that only age would have a moderating effect on the predictors of behavioral intention of physicians. Their modified model was effective in predicting physicians' acceptance and use of the EMR, with 45% and 47% of variance explained, respectively.

Overall, previous studies have shown some support to using the TAM and the UTAUT as theoretical models of EMR and EHR acceptance by physicians. However, these models are still limited in their predictive power and, according to Venkatesh, future technology acceptance research should attempt to integrate other theories [66].

1.2. Goals and objectives

The aim of this study was to explore the determinants of physicians' intention to use an EHR in the Province of Quebec (Canada) using four theoretical models. Specifically, this study examined and compared the original TAM, a modified TAM, a psychosocial model inspired by Triandis' TIB, and an integrated model that combines elements from the previous models. In this study, we operationalized physicians' EHR acceptance as their behavioral intention to use (BIU) the EHR system when it becomes available. In Quebec, very few medical practices have started to use an EHR system; hence we did not assess effective EHR use in this study.

1.3. Theoretical models

Given the validity and the robustness of the TAM proven by previous researches, in both mandatory and voluntary usage settings [50,51,54,63,67–71], we have chosen this model as the reference to develop our theoretical framework predicting physicians' intention to use the EHR.

The original TAM (Model 1) is presented in Fig. 1. While the TAM has been proven to have good predictability [71] it has some limitations when applied to healthcare professionals [54].

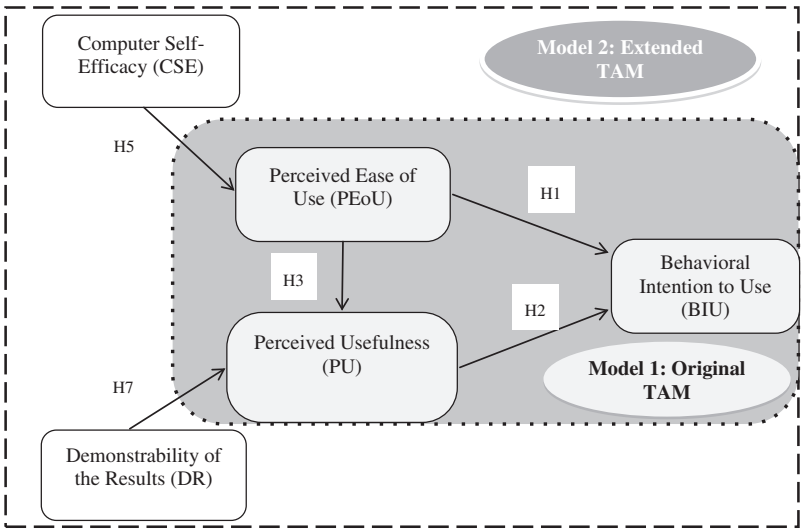
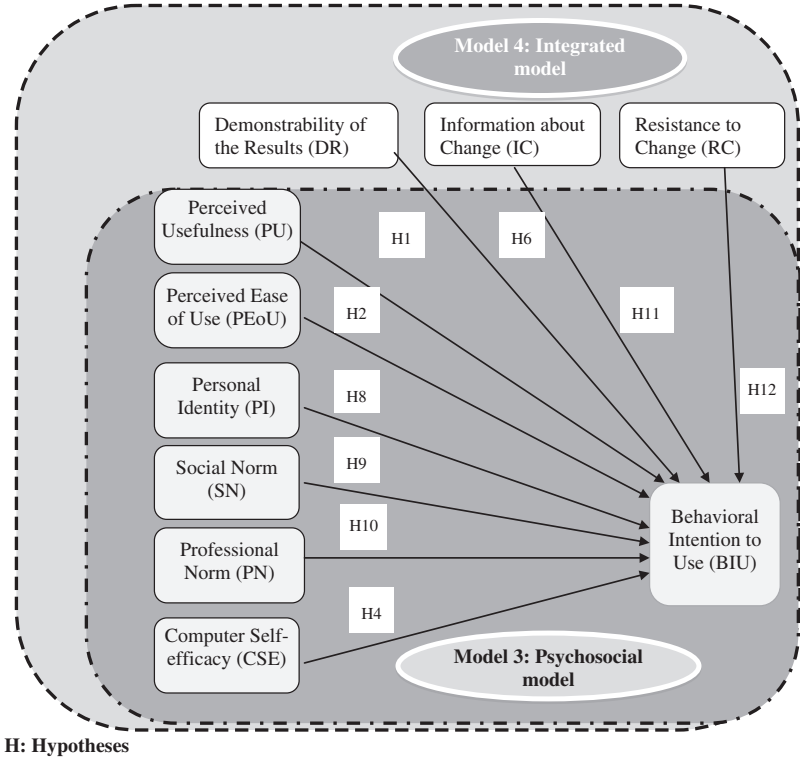


Fig. 1. TAM and Extended TAM (adapted from [47,72,73]).

Consequently, many authors have proposed to extend the TAM by either introducing variables from other theoretical models or by examining antecedents and moderators of PEoU and PU [72–74]. Thus, an extended TAM is proposed (Model 2) and is presented in Fig. 1.

It has been recognized that physicians are characterized by their relative autonomy and their independence in decision-making [51,58,75]. However, a technology that could interfere with physicians' usual practice could affect their perception of their professional role. As suggested by Succi and Walter [56], the addition of specific determinants, such as the perceived impact of using the technology on professional status, should be tested in further studies of IT acceptance by physicians. Furthermore, context-specific variables should be added to the model in order to increase its explanatory power [54,64].

The third model (Psychosocial model), presented in Fig. 2, includes theoretical constructs from the TIB [65] and other theoretical studies of healthcare professionals' behavior [76–79]. Although the most recent versions of the TAM include some psychosocial constructs, the TIB encompasses most of the determinants found in other models and considers cultural, social, and moral factors that are not accounted for in other theories [80]. The TIB has been used in previous studies of information technology acceptance by different groups of workers [81–84]. According to Triandis [65], *Behavior* is determined by three dimensions: intention, facilitating conditions, and habit. *Intention* refers to the individual's motivation



H: Hypotheses

Fig. 2. Psychosocial and integrated models (adapted from [39,65,85,86]).

regarding the performance of a given behavior. *Facilitating conditions* represent objective factors that can make a given behavior easy to adopt. Conversely, *barriers* consist of factors that can impede or constrain the realization of the behavior. *Habit* constitutes the level of routinization of behavior, i.e. the frequency of its occurrence. Habit is not relevant in our model because we studied physicians' intention to use a new integrated EHR system that was to be implemented.

In the TIB, intention is formed by attitudinal, normative, and identity beliefs. Attitudinal beliefs include affect and perceived consequences. *Affect* represents an emotional state that the performance of a given behavior evokes for an individual. It is considered as the perceived affective consequences of the behavior, whereas *perceived consequences* refer to the cognitive evaluation of the probable consequences of the behavior. Affect is not included in the proposed model because the behavior of interest is a professional behavior (using an EHR for a physician), which is less likely to be influenced by affective consequences Godin et al. 2008 [77].

The TIB incorporates two different normative dimensions: social and personal norms. Perceived *social norms* (SN) are formed by normative and role beliefs. *Normative beliefs* consist of the internalisation by an individual of referent people or groups' opinion about the realization of the behavior, whereas *role beliefs* reflect the extent to which an individual thinks someone of his or her age, gender and social position should adopt the studied behavior or not. The other normative component of the TIB is the *personal normative belief* that represents the feeling of personal obligation regarding the performance of a given behavior or not. Finally, *self-identity* refers to the degree of congruence between the individual's perception of himself or herself and the characteristics he or she associates with the realization of the behavior. Furthermore, in an effort to better adapt the TIB to health professional behavior, another dimension was added to the personal normative beliefs – the *professional norm* (*PN*) [79]. This variable refers to the integration by the self of the specific normative pressures of one's professional group. In a previous study on physicians' decision to adopt a new technology [81], adding the professional norm to the personal normative construct significantly improved the predictive validity of this construct.

In the Psychosocial model, PU is equivalent to the concept of perceived consequences from the TIB, whereas PEoU and CSE correspond to the concept of facilitating conditions.

The fourth model (Fig. 2) is an integrated model that is based on the combination of the TAM and the psychosocial model, but also combines theoretical constructs that have emerged in recent studies on physician acceptance of information technologies: demonstrability of the results (DR), resistance to change (RC), and computer self-efficacy (CSE). *Demonstrability of the results*, a concept originating from Rogers' Diffusion of Innovations theory [86], consists in the possibility to demonstrate the results of the new system Moore and Benbasat (1991) [87]. DR has been found to significantly influence information technology acceptance in healthcare professionals [88]. *Resistance to change* is defined by Nov and Ye [89] as a personality trait of people who find it difficult to break their routines and are emotionally stressed when expecting change. RC was suggested as a possible determinant of physician satisfaction with EMR and a potential determinant of its continuing use [39]. *Computer self-efficacy* represents the self-evaluation by an individual of their capacity to use the technology [90], and its role in improving the TAM has also been demonstrated [74].

A new construct, *information about change* (IC) was added because of the recognized importance of change management when implementing disruptive innovations in healthcare [41,91]. Based on previous work [92], we have added this construct to the theoretical model in order to address the potential influence of evidence-based knowledge on the acceptance of information technology in healthcare practices.

Subsequently, we tested the effect of external variables (age, sex, prior EMR experience and specialty) on the revealed significant relationships between the independent variables and physicians' intention to use EHR. Table 1 presents the research hypotheses tested in relation to the four models.

2. Methods

2.1. Studied population and sample

The Quebec Medical Association (QMA) sent an email invitation to participate in the study to all its members with a valid email address. The QMA includes general practitioners and specialists with license to practice medicine in the province of Quebec. Interested physicians could click on the link that was provided in the message to access a web-based questionnaire posted on a secured website. The number of email sent was about 6000, but there is no information about the number of physicians who actually read the message or clicked on the invitation link. Due to the exploratory nature of the study, we did not calculate a sample size a priori. Physicians were invited to read and sign the consent form, indicating their agreement to participate in the study. This study received ethical approval from the Quebec University Hospital Research Centre (SIRUL #85320).

2.2. Variables measured and psychometric properties of the measures

In this research, the targeted behavior was physicians' behavioral intention to use (BIU) a new interoperable EHR system that was to be launched by the Quebec government. The term EHR was defined at the beginning of the questionnaires (see Appendix A). All questions, except those aimed at collecting sociodemographic information, captured responses via a 7-point Likert scale with responses ranging from "strongly disagree" (1) to "strongly agree" (7). All constructs were operationalized as the mean of the sum of their corresponding items, which are provided in Table 2.

Survey items measuring theoretical constructs came from a previous qualitative study on EHR acceptance in a primary care clinic [92] and a pilot validation of the integrated theoretical model based on a literature review [93]. The items measuring RC were adapted from Lapointe and Rivard [94], those measuring DR were adapted from Moore and Benbasat (1991) [87], and those measuring CSE were adapted from Compeau and Higgins [90].

Construct validity was assessed with item loadings and internal consistency reliability. Thus, exploratory factor analyses were first conducted to ensure that the survey items converged on factors that would be predictors of physicians' intention to use EHR. Hence, construct validity was evaluated by examining the factor loadings within the constructs as well as the correlation between the constructs, according to the theoretical models used [95]. Reliability of the instrument was measured by means of the Cronbach's alpha value for each theoretical construct.

2.3. Statistical analyses

First, we conducted descriptive analyses to explore sociodemographic and theoretical data distribution. Then, we computed Pearson correlations between all constructs to establish the magnitude and significance of associations between theoretical variables and BIU.

Subsequently we performed path analysis using maximum likelihood method of parameter estimation to test direct and indirect effects of original and extended TAM. As a first step, we entered

Table 1
Summary of research hypotheses.[a]

Hypotheses		Model used to test hypotheses
H1	PU has a positive direct effect on BIU	Original TAM/Extended TAM/Psychosocial model/Integrated model
H2	PEoU has a positive direct effect on BIU	Original TAM/Extended TAM/Psychosocial model/Integrated model
H3	PEoU has a positive direct effect on PU	Original TAM/Extended TAM
H4	CSE has a positive direct effect on BIU	Integrated model
H5	CSE has a positive direct effect on PEoU	Extended TAM
H6	DR has a positive direct effect on BIU	Integrated model
H7	DR has a positive direct effect on PU	Extended TAM
H8	PI is positively associated with BIU	Psychosocial model/Integrated model
H9	SN is positively associated with BIU	Psychosocial model/Integrated model
H10	PN is positively associated with BIU	Psychosocial model/Integrated model
H11	IC is positively associated with BIU	Integrated model
H12	RC is negatively associated with BIU	Integrated model
H13	Age modifies the association between theoretical variables and BIU	Original TAM/Extended TAM/Psychosocial model/Integrated model
H14	Gender modifies the association between theoretical variables and BIU	Original TAM/Extended TAM/Psychosocial model/Integrated model
H15	Speciality modifies the association between theoretical variables and BIU	Original TAM/Extended TAM/Psychosocial model/Integrated model
H16	Prior EMR experience modifies the association between theoretical variables and BIU	Original TAM/Extended TAM/Psychosocial model/Integrated model

[a] PU – Perceived Usefulness; PEoU – Perceived Ease of Use; CSE – Computer Self-Efficacy; DR – Demonstrability of the Results; BIU – Behavioral Intention to Use; RC – Resistance to Change; IC – Information about Change; PI – Personal Identity; SN – Social Norm; PN – Professional Norm; CSE – Computer Self-efficacy.

Table 2
Respondents' profile.

Characteristics		N	Percentage (%)
Gender	Male	96	64.0
	Female	54	36.0
Specialty	General practitioner	89	59.3
	Specialist	61	40.7
Age group (years)	30 Or less	7	4.7
	30–39	16	10.7
	40–49	34	22.7
	50–59	60	40.0
	60 and over	33	22.0
Type of practice	Hospital	60	41.4
	Private clinic	29	20.0
	Family Medicine Group	17	11.7
	Local Community Health Center	11	7.6
	Other	28	19.3
Tenure (years)	<10	23	15.3
	10–19	23	15.3
	20–29	50	33.3
	30–39	44	29.3
	⩾40	9	6.0
Practice setting	Rural/remote	20	13.3
	Semi-urban	25	16.7
	Urban	105	70.0
EMR experience	No	74	49.3
	Yes	76	50.7

the dimensions pertaining to the original TAM (PU and PEoU). Next, two other dimensions, namely demonstrability of the results (DR) and computer self-efficacy (CSE), were added to the TAM in order to improve its predictive power (Extended TAM).

Then, we performed a multivariate linear regression using maximum likelihood method of parameter estimation to test both the Psychosocial and the Integrated models which contained only direct effects on BIU. All relationships between predictors and BIU were hypothesized as direct in the Psychosocial and Integrated models, in accordance with the TIB that inspired these models. Thus, as a third step, we tested the variables PEoU, PU, PI, CSE, PN and SN from the psychosocial model based on the TIB. We then added three other theoretical constructs, IC, DR and RC, to test the integrated model. Subsequently, we tested the influence of professional and sociodemographic characteristics on physicians' intention to use EHR in order to detect potential modifying effects. To do so, we performed multi-group analyses of invariance of all structural weights simultaneously in each of the four steps of modeling to test whether age (less or more than 50 years), gender (male or female), speciality (GP or specialist) and prior EMR experience (yes or no) had a modifying effect on each of the regression weights.

We checked multicollinearity diagnostics before modeling and the results were satisfactory. All statistical analyses were performed with the SAS®9.3 and AMOS 18.0. The p-value $\leqslant 0.05$ was taken as the level of statistical significance. The final models presented in this paper include only significant predictors of BIU and all regression weights presented hereafter are standardized.

The data set includes missing values for some items. Given the small size of the study sample, all participants were kept in study. Imputation of missing data was performed by the regression method available in AMOS 18.0. The estimates of missing data were reasonable: the differences before and after imputation for missing items on means and standard deviations were negligible (data not shown).

3. Results

3.1. Sample profile

We received a total of 157 questionnaires from unique respondents, from which seven were excluded due to missing data on QMA membership identification which made it impossible to check for duplicates. The final sample consisted of 150 physicians whose characteristics are presented in Table 2.

Despite the low response rate of 2.5% among the convenience sample of physicians who were members of the QMA, the study sample is rather representative of physicians practicing in the province of Quebec. The mean age (50.6 years), the proportion of male and female (64% and 36%) and the proportion of GPs and specialists (59% and 41%) in our sample are close to those in the general population of physicians in Quebec in 2009 (52.4 years; M/F: 60%/40%; and GPs/Specialists: 49%/51%) [96]. There are no statistical difference between our sample and the general physician population in Quebec by age (one sample t-test, $p = 0.260$) and gender (one sample z-test for proportion, $p = 0.3173$). However, the proportion of GPs in our sample is higher than in the general population of Quebec physicians (one sample z-test for proportion, $p = 0.0143$). This does not constitute a limitation because primary care physicians are the main target group for the provincial integrated EHR in Quebec.

3.2. Variables measured and psychometric properties

According to the Kaiser criterion, confirmatory factor analysis was satisfactory for all theoretical constructs. This analysis showed that all items of corresponding constructs converged to a single factor. All items weights ranged from .60 to .93 (Table 3). Also, Cronbach's alpha values were adequate for the majority of theoretical constructs, ranging from .75 to .91, except for DR (.66) and CSE (.68), which were nonetheless acceptable [97] (Table 3).

We used the absolute and relative fit indices to test and validate the measurement model. All fit indices of the measurement model fell within acceptable ranges and support reasonable fit assumption (Table 4).

3.3. Factors influencing physicians' intention to use EHR

The correlations between theoretical constructs ranged from −0.24 to 0.69 (Table 5). It should be noted that all constructs except IC had a statistically significant correlation with BIU.

3.4. Structural path models

We applied path analysis using structural equation modeling to evaluate the two first theoretical models (TAM and Extended TAM) because these models include both direct and indirect relationships.

Table 4
Measurement model fit indices and their acceptable thresholds.

Model fit	Indicator value	Thresholds
χ^2/df	1.48	$\leqslant$2 [98,99]
RMSEA (Root Mean Square Error of Approximation)	0.057	$\leqslant$0.07 [51,98,100,101]
CFI (Comparative Fit Index)	0.94	$\geqslant$0.90 [51,100,102]
IFI (Bollen's Incremental Fit Index)	0.94	$\geqslant$0.90 [51,100]
TLI (Tucker-Lewis Index)	0.92	$\geqslant$0.90 [51,100]

Table 3
Theoretical constructs items and psychometric properties of the measures.

Construct		Mean ± SD	Factor loading	Cronbach's alpha
Perceived usefulness (PU)/perceived consequences		6.2 ± 1.0		.88
PU1	Using the EHR will allow me to have quick access to patients data	6.2 ± 1.3	.85	
PU2	Using the EHR will facilitate communication of information between various care providers	6.3 ± 1.1	.86	
PU3	Using the EHR will avoid duplication of examinations	6.4 ± 1.0	.79	
PU4	Using the EHR will improve the quality of care	6.1 ± 1.2	.86	
PU5	Using the EHR will reduce the risk of error	5.9 ± 1.3	.84	
Perceived ease of use (PEoU)/facilitating conditions		4.4 ± 1.4		.77
PEoU1	Learning to use the EHR will require much time (*inverted*)	3.6 ± 1.7	.69	
PEoU2	I think the EHR will be easy to use	4.7 ± 1.5	.92	
PEoU3	I think the EHR will be simple to use in my consultations with patients	4.9 ± 1.7	.90	
Computer self-efficacy (CSE)		6.3 ± 1.1		.68
CSE1	I will use the EHR if I get training	6.3 ± 1.3	.90	
CSE2	I will use the EHR if I can get technical support	6.3 ± 1.2	.90	
Demonstrability of results (DR)		5.7 ± 1.1		.66
DR1	I can easily communicate to others the impact of my use of the EHR	5.5 ± 1.2	.86	
DR2	For me, the impact of the use of the EHR will be visible	5.8 ± 1.3	.86	
Personal identity (PI)		6.4 ± 0.8		0.75
PI1	I am comfortable with information and communication technology	5.9 ± 1.5	.61	
PI2	I consider myself a person that embraces change	6.5 ± 0.9	.89	
PI3	I have a good adaptability	6.5 ± 0.9	.88	
PI4	I am a conscientious person	6.7 ± 0.7	.79	
Social norm (SN)		6.1 ± 0.9		.81
SN1	Other health professionals (nurses, pharmacists) would approve that I use the EHR	6.2 ± 1.0	.77	
SN2	My medical colleagues would approve that I use the EHR	6.1 ± 1.2	.88	
SN3	Most patients would welcome that I use the EHR	5.9 ± 1.2	.83	
Professional norm (PN)		6.1 ± 1.0		.86
PN1	It would be normal for a doctor in my organization to use the EHR	6.2 ± 1.2	.77	
PN2	A doctor in my specialty should use the EHR	6.0 ± 1.2	.82	
PN3	I think using the EHR would be proper for a doctor in my area	6.3 ± 1.0	.75	
Information about change (IC)		3.5 ± 1.8		.90
IC1	I have access to all the information I need to make my decision whether to use the EHR	3.3 ± 1.9	.92	
IC2	The information provided seems sufficient to support my decision whether to use the EHR	3.9 ± 2.1	.92	
IC3	I have received information regarding the use of the EHR in a timely manner	3.3 ± 2.0	.92	
Resistance to change (RC)		5.0 ± 1.6		.86
RC1	I do not want that the EHR changes the manner that I interact with patients	5.1 ± 1.8	.91	
RC2	I would not like that the EHR changes the way I make my clinical decisions	5.4 ± 1.7	.90	
RC3	I do not want the EHR to change my daily work	4.5 ± 1.9	.86	
Behavioral intention to use (BIU)		6.0 ± 1.3		.91
BIU1	When available in my clinical practice, I intend to use the EHR for all my clinical activities	5.9 ± 1.4	.92	
BIU2	When available in my community, I intend to adopt the EHR for all my clinical activities	5.8 ± 1.5	.92	
BIU3	The chances that I use the EHR for all my clinical activities when available in my organization are very high	6.0 ± 1.5	.92	
BIU4	Whatever the circumstances, I do not intend to use the EHR when it becomes available in my organization (*inverted*)	6.2 ± 1.5	.81	

Table 5
Correlations matrix of the theoretical constructs with 95% confidence interval (z-transformation of Fisher).

	BIU	PU	PEoU	IC	PI	CSE	SN	PN	RC
PU	0.55 [0.43; 0.65]	–	–	–	–	–	–	–	–
PEoU	0.59 [0.48; 0.69]	0.50 [0.36; 0.61]	–	–	–	–	–	–	–
IC	0.13 [−0.03; 0.28]	0.17 [0.01; 0.32]	0.30 [0.15; 0.44]	–	–	–	–	–	–
PI	0.27 [0.12; 0.42]	0.20 [0.04; 0.35]	0.29 [0.13; 0.43]	0.03 [−0.13; 0.19]	–	–	–	–	–
CSE	0.36 [0.21; 0.49]	0.39 [0.25; 0.52]	0.25 [0.09; 0.39]	0.02 [−0.14; 0.18]	0.01 [−0.15; 0.17]	–	–	–	–
SN	0.59 [0.47; 0.68]	0.51 [0.37; 0.62]	0.48 [0.34; 0.59]	0.14 [−0.02; 0.29]	0.33 [0.18; 0.47]	0.27 [0.12; 0.42]	–	–	–
PN	0.62 [0.51; 0.71]	0.63 [0.52; 0.71]	0.47 [0.33; 0.58]	0.10 [−0.06; 0.26]	0.27 [0.11; 0.41]	0.48 [0.35; 0.59]	0.64 [0.53; 0.72]	–	–
RC	−0.21 [−0.36; −0.05]	−0.14 [−0.30; 0.02]	−0.24 [−0.38; −0.08]	−0.07 [−0.22; 0.10]	−0.08 [−0.24; 0.08]	−0.04 [−0.20; 0.12]	−0.12 [−0.27; 0.04]	−0.14 [−0.30; 0.02]	–
DR	0.55 [0.42; 0.65]	0.65 [0.55; 0.73]	0.43 [0.28; 0.55]	0.15 [−0.01; 0.30]	0.18 [0.02; 0.33]	0.23 [0.07; 0.37]	0.49 [0.36; 0.60]	0.58 [0.46; 0.67]	−0.23 [−0.37; −0.07]

3.4.1. Model 1: original TAM

The result of the path analysis model testing the original TAM is reported in Fig. 3. This model provides empirical support for H1, H2 and H3. Thus, PU and PEoU have a direct and positive association with BIU, and PEoU has a direct positive association with PU. This model explains a total of 44.0% of the variance in BIU, with PEoU as the strongest predictor.

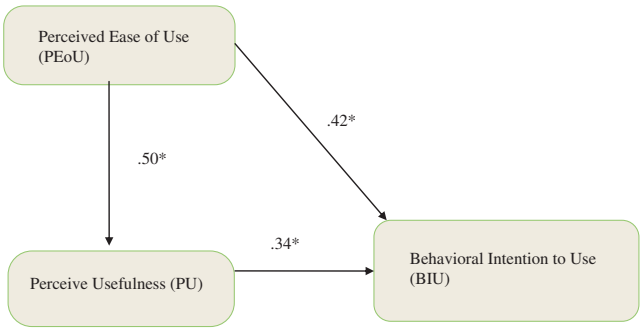


Fig. 3. Original TAM, standardized regression coefficients (*p value $\leqslant 0.001$).

3.4.2. Model 2: extended TAM

In the second model (Extended TAM), we added DR as a direct antecedent of PU [48,72] and CSE as a direct antecedent of PEoU [48]. This model provides empirical support for H1 and H2, suggesting that PU and PEoU have direct and positive associations with BIU. Fig. 4 presents the path analysis for the extended TAM. The extended TAM also explains a total of 44.0% of the variance in BIU. In addition, 48.1% of the variance in PU is explained by PEoU and DR, thus supporting H3 and H7. CSE explains 6% of the variance in PEoU, which supports H5. All indirect effects are significant in both the TAM and the extended TAM (results not shown).

3.5. Multivariate linear regression models

3.5.1. Model 3: psychosocial model

We used multivariate linear regression to evaluate models 3 and 4 because they only contain direct relationships between theoretical constructs and BIU, thus a structural model was not appropriate.

Model 3 (Psychosocial model) explains 53% of the variance in BIU (Fig. 5), after removing the variables that were not significant in the stepwise regression (PI, CSE and PU). Thus, we reject H1, H4, and H8 for this model. The remaining predictors of BIU are PEoU, PN and SN, which supports H2, H9, and H10.

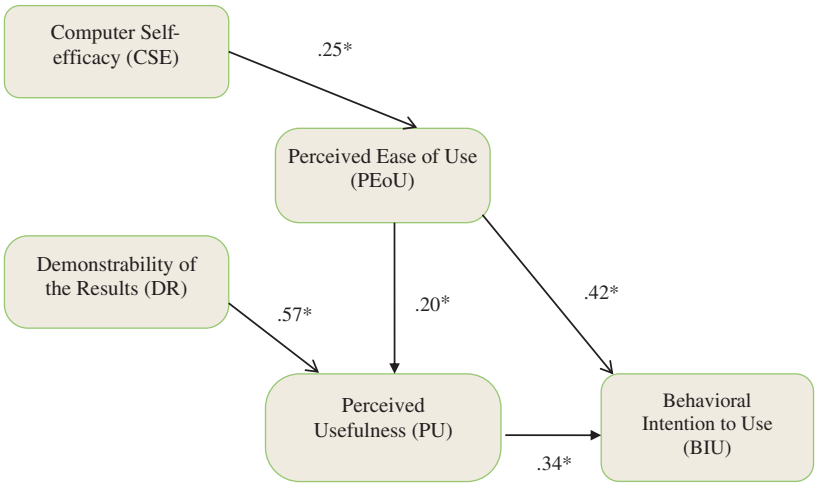


Fig. 4. Extended TAM, standardized regression coefficients (*p value $\leqslant 0.001$).

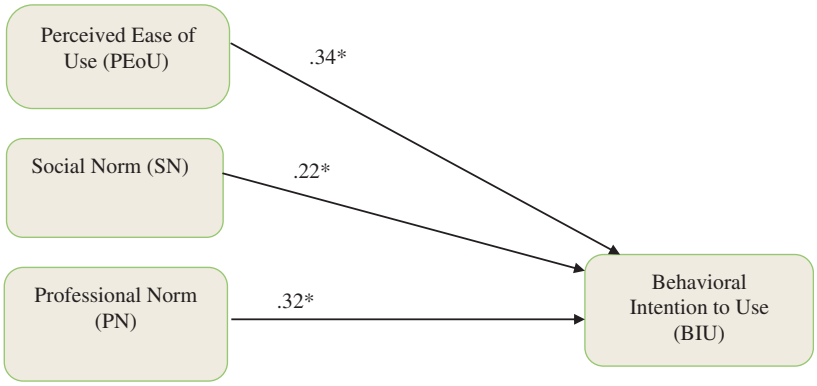


Fig. 5. Psychosocial model, standardized regression coefficients (*p-value ⩽ 0.01).

3.5.2. Model 4: integrated model

The Stepwise algorithm for best model selection led to the final Integrated model presented in Fig. 6. This model adds demonstrability of the results (DR) to the final Psychosocial model, which supports H6. Thus, PEoU, PN, SN, and DR explain 55% of the variance in physicians' intention to use the EHR.

3.6. Multi-group analyses

We checked whether model relationships on the whole differed between groups of age, gender, speciality, and prior EHR experience. Specialty (GP vs. specialist) is the only variable that has a significant modifying effect in all four models: TAM ($\Delta\chi^2 = 19.421$, df = 3, $p < 0.001$), extended TAM ($\Delta\chi^2 = 20.427$, df = 5, $p = 0.001$), Psychosocial model ($\Delta\chi^2 = 10.298$, df = 3, $p = 0.016$), and Integrated model ($\Delta\chi^2 = 15.490$, df = 4, $p = 0.004$), thus providing support for H15.

Age group (less vs. more than 50 years) shows a significant modifying effect in the TAM ($\Delta\chi^2 = 8.827$, df = 3, $p = 0.032$), the extended TAM ($\Delta\chi^2 = 33.319$, df = 5, $p = 0.046$), and the Psychosocial model ($\Delta\chi^2 = 7.974$, df = 3, $p = 0.047$), providing support for H13. Age is close to significance ($\Delta\chi^2 = 8.987$, df = 4, $p = 0.061$) in the Integrated model.

Prior EHR experience (yes vs. no) shows a significant modifying effect in the TAM ($\Delta\chi^2 = 11.887$, df = 3, $p = 0.008$) and the extended TAM ($\Delta\chi^2 = 10.615$, df = 5, $p = 0.060$), providing support for H16.

Finally, multi-group analysis revealed no significant modifying effect of gender in the four models.

We summarize the results of the different theoretical models in Table 6. The original TAM appears to be equal to the extended TAM in explaining physicians' intention to use EHR. The integrated psychosocial model explains the behavioral intention a little better than the psychosocial model, which is better than the original and extended TAM. Across all models, PEoU exhibits the strongest direct, indirect and total effects on BIU. In the Psychosocial and Integrated models, professional norm appears to have the second strongest direct effect on BIU. In the Integrated Model, demonstrability of the results shows a significant effect on BIU.

4. Discussion

The aim of this study was to identify factors influencing physicians' intention to adopt the EHR in the Province of Quebec (Canada) using different theoretical models. We initially tested the original TAM, in order to facilitate the comparison with previous studies and then we tested an extended TAM model. We then tested a psychosocial model adapted from the TIB and an integrated model that incorporates variables from the previous models.

Similar to other studies [63,103], the TAM explained 44% of the variance in physicians' intention to use EHR in our sample. Perceived usefulness (PU) and perceived ease of use (PEoU) explained a significant proportion of behavioral intention to use (BIU). These findings are consistent with most prior research [48,57,61,104]. Across the models investigated, PEoU is a strong and significant determinant of physicians' intention to use EHR, and also influences their PU. This finding is similar to what has been reported in several recent studies of EHR acceptance [50,59,62,66], but is not congruent with other studies that have shown that PU is the most significant factor affecting physicians' intention to use information technology [58,105]. In our model, PEoU is augmented by physicians' computer self-efficacy (CSE). According to Venkatesh [66], physicians who feel capable of using information technologies have little difficulty in using EHR. Through its indirect effect,

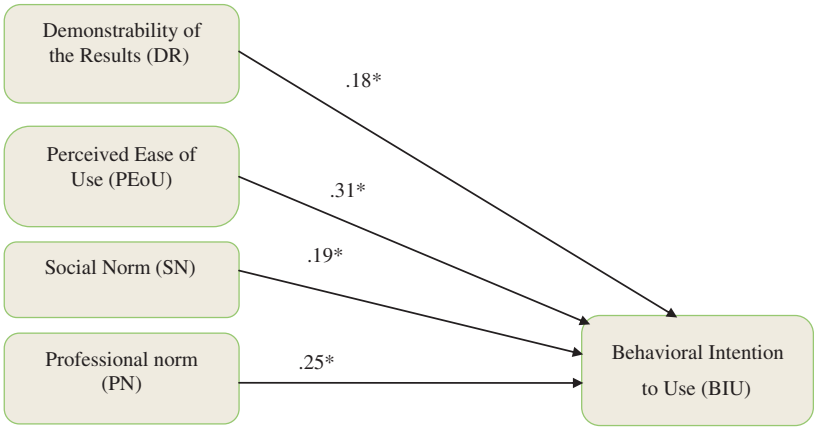


Fig. 6. Final Integrated model, standardized regression coefficients (*p value ⩽ 0.05).

Table 6
Summary of models.

	Model 1 TAM	Model 2 extended TAM	Model 3 psychosocial model	Model 4 integrated model
Total effects				
PEoU	0.59	0.49	0.34	0.31
PU	0.34	0.34		
CSE		0.12		
DR		0.20		0.18
PN			0.33	0.25
SN			0.22	0.19
Direct effects				
PEoU	0.42	0.42	0.34	0.31
PU	0.34	0.34		
CSE		–		
DR		–		0.18
PN			0.33	0.25
SN			0.22	0.19
Indirect effects				
PEoU	0.17	0.07	–	–
PU	–	–		
CSE		0.12		
DR		0.20		–
PN			–	–
SN			–	–
Percentage of variance explained (R^2)	0.44	0.44	0.53	0.55
Akaike information criterion (AIC)	12.00	42.53	20.00	30.00
Bayesian information criterion (BIC)	30.06	81.67	50.10	75.16

computer self-efficacy has a significant overall effect on BIU. Concretely, training physicians in the use of computers would improve their overall perception that using EHR is easy.

Physicians are likely to intend to use EHR when it is considered easy to use in their practice. Physicians know the importance and the necessity of using EHR in their practice, given its potential impact on the quality of care to patients [5–8]. Thus, PU would not be such an important issue compared to that of the ease of use or the existence of facilitating conditions that are captured by PEoU. Most physicians are not familiar with new technologies and will look for an easy tool that does not require major changes in their practice [50]. Involving physicians in the design of EHR, notably through user analysis, appears a good strategy to ensure that the system is intuitive for them and thus, more easy to use [106,107].

Several studies have insisted on the role of context in technology acceptance research. Particularly, health professionals have specific characteristics and are different from other categories of information technology users [56,66]. In our study, normative factors are among the most important determinants of physicians' intention to use an EHR. Specifically, professional norm (PN) is the second determinant of BIU in the psychosocial and integrated models. Other studies provide support to the importance of PN to explain behavioral intention in healthcare professionals [77,79]. The fact that physicians perceive that using an EHR is consistent with what they consider an appropriate behavior for a physician is likely to increase their acceptance of this technology, thus calling for strategies that will present EHR as an integral component of medical practice.

Social norm (SN) is the third most important determinant in the psychosocial and integrated models. Despite their professional autonomy, physicians' decisions regarding EHR acceptance could be strongly influenced by their peers, which is consistent with the strong acculturation associated with the medical profession [60]. Therefore, strategies that encourage role modeling and peer support, such as *champions* and *super users* [36], are likely to increase physician acceptance of EHR.

Regarding the effect of sociodemographic and professional characteristics (age, gender, pervious EHR experience and speciality), we note that PU has a higher effect on BIU for physicians under 50 years old and on GPs. In the Psychosocial and Integrated models, SN had a stronger influence on BIU in the group of physicians under 50 years and for GPs. Among physicians aged 50 years and over and physicians who have no previous EHR experience, PEoU has more impact on BIU. Also, we note that the effect of professional norm on BIU is stronger among women and that RD has more influence on BIU among GPs. Venkatesh et al. [66] found that age had a modifying effect on physicians' intention to use EHR. Also, Walter and Lopez [58] found that male physicians' intention to use EMR differed from that of female physicians [58]. Our results are also in line with those of Venkatesh et al. [66] and Walter and Lopez [58] regarding the modifying effect of age on physicians' intention to use EHR. These findings point out the need to develop strategies that are tailored to the individual characteristics of potential EHR users, such as age and gender.

These results add to the current knowledge in the fields of technology acceptance and healthcare IT implementation. First, this study confirms the limited applicability of the TAM to study healthcare professionals' acceptance of EHR. The Psychosocial model, inspired by Triandis' TIB, performed well for predicting intention. However, an integrated model that combined elements from the TAM, the TIB, and demonstrability of results was the most powerful. This study also provides some evidence on the need to incorporate other variables to increase the explanatory value of theoretical models. As such, sociodemographic variables and previous experience should not be discarded from acceptance models. Our results also support the importance of taking context into account in acceptance studies, thus calling for the use of models that include organizational and contextual factors [39,66].

These results have direct applications for practice. Thus, in order to encourage physician acceptance of EHR, the focus should be placed on the ease of use of the system, including proper computer training and familiarization with the EHR technology [108]. Involving users early in EHR design could also enhance the usability of the system [106,109]. The integration of EHR into professional norms could be supported by better integrating information technology into the continuing professional development programs targeting older physicians. Strategies using well-respected medical champions for EHR implementation would foster positive social norms towards this technology. Finally, demonstrating the results of EHR on patient care through the

diffusion of successful implementation stories would be another strategy to increase physician acceptance.

Despite its important contributions, this study has several limitations that could curb the interpretation of the results. First, as in all observational studies, we cannot conclude to causality relationship between variables. Second, as in other e-mail surveys and questionnaire-based studies, self-reported information can lead to a social desirability bias that could also affect the results. However, respondents were informed of the confidential nature of their answers. Third, the weak response rate and the small sample size prevented us from conducting structural equation modeling to adequately test the models. Fourth, we did not consider all the theoretical constructs from the TIB in the Psychosocial model. For instance, affect, personal normative belief and habit could also be important determinants of EHR acceptance but have not been measured in this study. Finally, the modest sample size and the recruitment of physicians through a professional association limit the generalization of the findings by speciality.

5. Conclusion

In summary, our study supports the importance of gender and social factors for promoting technology acceptance among physicians. The combined theoretical constructs into an integrated model that allows the consideration of several variables revealed to be a useful approach to the theoretical development of a model of EHR acceptance among physicians. In order to confirm its value, this model needs to be validated with larger samples and in other healthcare settings.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jbi.2013.10.010.

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