

Implementation of a National Electronic Health Information System in Gabon: A Survey of Healthcare Providers' Perceptions.

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Abstract

Background: Health information systems bring several benefits for the health system, healthcare providers, and the population. As a set of tools for the collection, storage, management and transmission of health data, their role to support the modernization of health systems, improve access to quality health care and reduce costs in developing countries is unquestionable. However, HIS implementation in low-income countries face several challenges. In Gabon, a unique initiative called eGabon has been launched in order to modernize the country's infrastructures, notably through the deployment of a unique national electronic HIS that will connect health care institutions and providers at all levels in the whole country.

Objective: This study aims to identify the factors influencing the optimal use of the national electronic HIS by healthcare providers in Gabon.

Methods: We used an adaptation of the Information System Success Model (and developed a questionnaire that was distributed to 2600 healthcare providers across the country). Reliability and validity of the instrument were tested, and we performed a logistic regression to identify the factors influencing healthcare providers' perceptions towards the national electronic HIS.

Results: A total of 2327 questionnaires were received from healthcare providers, of which 1930 were usable in the analyses. The reliability and validity of the questionnaire were supported. The logistic regression identified five constructs that significantly influence perceived system impact: System quality, Information quality, Support quality, Actual use and Useful functions. The model explains 30% of the variance in providers' perception that the HIS leads to positive impacts.

Discussion: This study provides support to the use of an adapted ISSM in the context of HIS implementation in a low-income setting. The results show that health care providers' perceptions regarding the positive impact of the HIS are influenced by their previous use of a HIS, the extent of their use, their perceptions of system quality, information quality and quality of the support provided to users. These results could inform the development of strategies to ensure adequate change management and user experience for the implementation of the national electronic HIS, and eventually in other low-resources settings.

Background

Health information systems(HIS) allow the collection, storage, management and transmission of data related to activities of healthcare providers, health organizations, patients and health consumers[1]. HIS include electronic health record (EHR) systems, clinical and hospital management systems, epidemiological and public health information systems, clinical decision support systems, patient portals and remote monitoring systems.

HIS are now implemented, at least partially, in several developed countries [2]. One of the major benefits of HIS is the capacity of generating timely information about patient and population health to support

health care provision and management at all levels[3]. Improved coordination of care is also achieved through health information exchange that allow information sharing between all health care providers[4]. It is also expected that HIS could contribute to improve population health by processing large sets of epidemiological data to identify trends and adjust public health interventions [5].

In developing countries, governments are also investing in national HIS and expect it will contribute to improve access to quality health care and reduce costs[6]. However, many previous initiatives of HIS implementation in developing countries have not been successful due to poor planning [7]. The first obstacle to the implementation of HIS in developing countries is the current state of health systems that often lack the basic infrastructure[8].

In order to ensure that the conditions are in place for successful implementation of HIS in developing countries, it is necessary to investigate providers' acceptance of these technologies, as well as the potential facilitators and threats to their adoption and integration[2].

Studies focusing on the adoption of HIS in developing countries are scarce[3, 9] and to the best of our knowledge, such study are inexistent in Gabon. In Gabon, a national initiative called "eGabon" has been put forward by the government in order to modernize the country's infrastructure based on the rapid advances in information technologies. The uniqueness of this initiative lies in the fact that it encompasses several sectors of activities, notably healthcare. A national electronic health information system is thus being developed, adopting a systemic vision that will allow the deployment of an integrated HIS that will connect health care institutions and providers at all levels in the whole country. An external evaluation has been mandated in order to accompany the development of the project and one of its first task has been to assess the conditions for success of such large-scale project, taking into account the perspectives of end-users, including health organisations, professionals and patients.

This study is part of the larger evaluation strategy of the Gabon national HIS initiative and aims to identify the individual determinants of healthcare providers' perceptions of the impact of implementing a national electronic health information system in Gabon. The perspective of healthcare providers is particularly important to consider since they are those who will have to integrate the new system into their practice, which supposes important changes[10–12].

Theoretical Models of HIT Acceptance

Technology acceptance is considered as an essential condition for technology adoption and use[13]. In developed countries, acceptance of health information technology has been the focus of research since the 1990's. Over the last decade, rapid technological advances, notably with the expansion of mobile telecommunication networks, have stimulated the application of information and communication technologies (ICT) for health purposes in developing countries.

There is generally a variety of models used in evaluating the implementation of health ICT in developing countries. The Technology Acceptance Model (TAM), developed by Davis and collaborators [14], and its several extensions, such as the Unified Theory of Acceptance and Use of Technology (UTAUT)[15] have been extensively applied for assessing technology acceptance. However, the adequacy of these models to study technology acceptance in the context of developing countries has been criticized or showed mixed results[16]. For instance, the fact that technologies such as EHR are not widespread in the daily life of the population limits the relevance of some variable of the UTAUT[9].

According to many authors, those models should be adapted to context of developing countries[2, 3, 16, 17]. Thus, researchers often decide to adapt these acceptance models either by adding new variables[3, 9, 16] or by deleting variables [8, 16]. The addition of variables is done to facilitate the consideration of cultural specificities or technical issues specific to developing countries[3, 8, 16]. For instance, an adaptation of the UTAUT has proved conclusive in the case of a study on HIS acceptance conducted in Cameroon [16]: the percentage of explained variance increased from 12% to 46% when the moderating effect of age was considered in the model.

Other models have also been used to study technology acceptance in developing countries. For instance, several authors used the DeLone and McLean Information System Success Model (ISSM)[18] to measure the success of implementing a HIS [19–23]. These studies generally support the use of this model when it comes to evaluating the success of an implantation in a developing or resource-limited country. In Ethiopia, for instance, the study by Tilahun and Fritz [20] provided satisfactory results to support the relevance of this model in a low-resource system.

Methods

Study population and setting

The target population of this study was healthcare providers, including health professionals (physicians, nurses, midwives, etc.) or people working in health care services (managers, administrators) employed in different health structures of the 10 health regions of Gabon. A convenience sample of 2600 participants was selected reflecting the proportion of healthcare providers within each region.

Theoretical model

The theoretical background of this study is inspired by the DeLone and McLean ISSM[18, 24]. This model recommends taking into account five variables to measure the success of the implementation of an information system: system quality, service quality, information quality, actual use, satisfaction and net benefits (impact).

In this study, we extended the ISSM by adding sociodemographic variables (age, sex, profession, experience, organization, and ICT skills) and psychosocial factors (useful functions, overload, and

compatibility). Figure 1 presents the adapted conceptual model.

A questionnaire was developed based on previous studies and validated among experts of the project team (see Additional file 1). The questionnaire comprised 14 questions, totalising 44 items. Theoretical constructs were assessed by 5-point Likert scales, and a “not applicable” option was available for participants without previous experience of using a HIS.

Figure 1 Theoretical model adapted from DeLone& McLean

Data analysis

All responses were encoded into numerical values and questionnaires with too many missing values were eliminated. First, we used Cronbach alpha and congeneric reliability (CR) coefficients to assess the internal consistency of each theoretical construct. Confirmatory factor analysis (CFA) was then used to evaluate construct validity. Observations with “not applicable” answers were eliminated for the validation analyses. However, they were kept for construct computation if at least half of the items for the associated construct were valid responses.

Due to the non-normality of the dependant variable, logistic regression was used in order to test the study hypotheses and identify the variables associated with perceived system impact (Impact) by healthcare providers. Ordinal variables with more than two modalities and Impact, the dependant variable, were dichotomized in order to perform the logistic regression. Age was dichotomized (“less than 40 years old” and “40 years old and above”). Work experience was also divided in two categories (“less than 10 years” and “10 years and more”). With respect to ICT skills, the average category was chosen as the cut-off point. For nominal variables (organization and profession), we also performed a dichotomization considering the mode of the series. Impact was dichotomized at the median while the other theoretical variables were considered as continuous variables.

An alpha level of 0.05 was set for testing the statistical significance for both correlation and regression analyses. All statistics were performed with SAS 9.4.

Results

Characteristics of participants

Figure 2 presents the flow diagram of the study. A total of 2327 participants returned their questionnaires, for a global response rate of 89.5%. There were 397 unusable questionnaires due to a high number of missing values, notably on socio-demographic questions. Of the 1930 questionnaires with usable observations, many included “not applicable” responses for some items, but they were kept for the reliability tests if there was at least 50% of the items with a valid response for a given construct. Finally,

781 questionnaires with complete observations were retained to test the theoretical model after eliminating those that were not eligible due to “not applicable” answers (Figure 2).

Table 1 presents the profile of respondents with a description of their socio-demographic characteristics. Among the 1930 usable questionnaires, 1275 were completed by women (66.1%) and 655 by men (33.9%). The majority of participants (47.5%) were between 40–49 years old. Regarding ICT skills, a majority reported an average level (36.6%). However, more people (51.8%) reported having a low level (null or elementary) than a high level (advanced or expert) (11.6%). With respect to occupational characteristics, there was a majority of nurses (55.5%), and professionals from a regional hospital (HR) with 29%. A majority of respondents had a long tenure in their profession: most of them have been in this profession for more than 10 years (60.8%).

Figure 2 Study flow diagram

Reliability and validity

Pearson correlations were performed between the different items as a first consistency check (Additional file 2). The coefficients were generally significant, high (>0.4) and positive for items belonging to the same construct. The values obtained with the Cronbach alpha (Table 2) and with the CR (Table 3) were all above the minimally accepted value (0.7) used to support a consistency of the constructs [25, 26]. To test the construct validity, 385 observations with absolutely no “not applicable” value were used. All factor loadings were higher than 0.7 (Table 3). Fit indices were also in the recommend threshold, except for RMSEA which was slightly above [27] (Table 4).

Normality and multicollinearity

Two assumptions have to be examined before performing a logistic regression. There should not be high multicollinearity between independent variables, and the dependant variable should not have a normal distribution. Correlations between variables are generally inferior to 0.3 (Additional File 3). However, some variables have a higher correlation score. For instance, SQ has high correlation (>0.5) with many variables such as Impact, IQ or SupQual. As high correlation may indicate multicollinearity, we performed a variance inflation factor (VIF) test. The VIFs obtained are all below 5, which is the maximum value proposed by several authors [28–30] (Additional File 3). To test the normality, the Shapiro-Wilk test was performed on the dependant variable. The null hypothesis was rejected, which implied a non-normal distribution of Impact.

Logistic regression

The logistic regression model was first tested with all independent variables (Table 5). Of these, four variables showed a significant odds ratio ($p < 0.05$): SQ, IQ, SupQual and UF. All these variables had a

positive coefficient, which means that the higher their values, the more likely the individual will evaluate the impact of the HIS as strong. IQ had the highest standardized estimate, which implies it has the highest importance in this model.

We performed a stepwise regression by testing a model in which only the significant variables were kept (Table 6). Consequently, one additional variable was retained in the model, namely AU. People who have already used an HIS were about 1.5 more likely to consider that HIS has a high impact.

The final model was able to explain 30% of the variance in the dependant variable. Using a cross-validate method (leave one out) we calculated the area under the curve (AUC). The model was able to predict correctly 78% of the cases (AUC = 0.78).

The final model is represented by the following equation:

$$\text{logit}(p) = -5.7 + 0.32\text{SupQual} + 0.53\text{SQ} + 0.52\text{IQ} + 0.34\text{AU} + 0.13\text{UF}$$

Where p is the probability that Impact = 1.

Figure 3 Final theoretical model with estimates

Discussion

This study aimed to identify the individual determinants of healthcare providers' perceptions regarding the national electronic HIS in Gabon. We used a model adapted from the Information System Success Model [18, 24] that showed very good measurement properties and acceptable predictive power. In fact, a total of 30% of the variance in providers' perceptions of the positive impact resulting from the use of the HIS was explained by five variables of our adapted model, namely Support Quality, Information Quality, System Quality, Actual Use and Useful Functions. This latter variable was added to the initial ISSM in order to consider not only the actual use of a HIS, but also the extent of its use by asking respondents to indicate which specific functions of the HIS they use. The more functions they use, the higher is their score. This variable could be related to the concept of 'meaningful use' of an information system by health care providers which implies that providers optimally use the core functionalities of an information system [31].

There are very limited data from similar studies in low-income countries. A study in Ethiopia [20] applied an adaptation of the ISSM and found that system quality, information quality and service quality had a significant influence on EMR use and user satisfaction. Both actual use and user satisfaction were significantly associated with perceived benefit of EMR use. Surprisingly, our results do not support the influence of user satisfaction on perceived benefits since this construct is not significantly associated with Impact in the final model. A plausible explanation could be that the ISSM variables are seen as interdependent, meaning that other constructs, such as useful functions and actual use might capture the influence of user satisfaction on perceived benefits [32].

A recent study conducted in Tanzania has tested a model that combines constructs from the ISSM and the TAM to understand user satisfaction and use of an EMR system [19]. The final model suggests that attitude and system quality are the only significant predictors of user satisfaction and system use.

Another study from Tanzania applied a modified ISSM to identify the factors influencing user satisfaction with an electronic logistic management information system[22]. The model includes perceived usefulness, a variable from the TAM, as well as facilitating conditions from the UTAUT. These two variables, together with system quality, information quality, and system support, contributed significantly to the model, explaining 59.1% of the variance in user satisfaction.

Our adapted model allowed us to verify whether variables that are external to the ISSM could influence health care providers' perceptions towards the HIS. Thus, we included several sociodemographic (age, sex, profession, experience, region, organization, and computer skills) and psychosocial variables (useful functions, work overload, and compatibility). However, none of the added variables but useful functions did significantly contribute to the model.

Some authors have suggested that inadequate computer literacy could hinder the success of EMR implementation in low-income countries[33, 34] but this effect has not been rigorously tested[20]. In our study, we measured computer skills but we found no significant influence of this variable on healthcare providers' perceptions towards the HIS.

Strengths and Limitations

This study is one of the few focusing on the acceptance of a large-scale HIS in a low-income country and that considers the perceptions of various groups of end users, including nurses, physicians, midwives, and health administrators. The fact that the survey was completed by more than 2,300 participants is also noteworthy. Although we used an adaptation of a well-known theoretical model, the DeLone and McLean ISSM[18], the percentage of variance explained by this model is modest. Other models, such as the TAM and the UTAUT, are often applied to study user acceptance of HIS. However, some authors have questioned the appropriateness of such models to the context of low-income countries[16]. In future studies, it could be interesting to compare different models in order to assess their applicability to the context of resource-limited countries.

Our survey instrument showed very good psychometric properties and we are confident that it could be adapted and used in other similar settings. Our theoretical model adapted from the ISSM is also promising, but still needs improvement. Even though the scores obtained for the VIFs were relatively low, we cannot exclude the possibility of multicollinearity. Furthermore, the interdependence between the ISSM variables, particularly the mutual influence between use and user satisfaction, has been acknowledged previously and could constitute a limitation to this model[32, 35].

Nonetheless, based on our results and on those from other studies in similar contexts [19–22], we are confident that theoretical models such as the ISSM and the UTAUT could be adapted to low-resources settings and provide a useful framework to orient change management strategies when implementing HIS.

Conclusion

The implementation of a national electronic HIS in Gabon represents a unique opportunity to modernize the health system and improve the provision of health care and services to the population. The perceptions of healthcare providers are essential to consider in order to ensure their acceptance and use of this system in a low resource setting. Using an adaptation of the Information System Success Model, this study found that information quality, system quality, support quality, actual use and useful functions influenced the perception of positive impacts of the HIS by healthcare providers. These findings should be considered by decision makers and managers involved in the implementation of the national electronic HIS in Gabon in order to ensure the quality of the system in terms of usability, the quality of information and the support provided to end users. Potential users should also be trained to the various functionalities of this system in order to witness its benefits and increase the likelihood of success of this HIS.

Abbreviations

Actual use: AU

Confirmatory Factor Analysis: CFA

Congeneric Reliability: CR

Electronic Health Record: EMR

Electronic Medical Record: EMR

Health Information System: HIS

Information and Communication Technology: ICT

Information Quality: IQ

Support quality: SupQual

System quality: SQ

Useful functions: UF

Declarations

Ethics approval and consent to participate

This study received approval from the "*Commission des Lois et Textes*" of the Ministry of Health of Gabon during de the second Steering Committee of the Project.

All study participants signed an informed consent form.

Consent for publication

The publication of this work was authorized by "*Commission des Lois et Textes*" of the Ministry of Health of Gabon during de the second Steering Committee of the Project

Availability of data and materials

All data is available from the corresponding author (COB).

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

COB, MPG, DT, GML,APK, RO, MCO and OLD designed the study.COB and DT draft the first report. MPG and COB carried out the first draft of the manuscript. JTand DT did the statistical analysis. COB, MPG, DT and JT revised the manuscript. MPG draft the final version of the manuscript. All authors checked and approved the submitted manuscript.

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Tables

Table 1. Characteristics of participants

Variables	Categories	n (%)*
Age	0-29	101 (5.2)
	30-39	583 (30.2)
	40-49	917 (47.5)
	50-59	301 (15.6)
	60+	28 (1.5)
Experience	0-5 years	323 (16.7)
	6-9 years	434 (22.5)
	10+	1173 (60.8)
ICT Skill	None	564 (29.2)
	Elementary	436 (22.6)
	Average	706 (36.6)
	Advanced	209 (10.8)
	Expert	15 (0.8)
Organization	Regional hospital	559 (29)
	Medical center	348 (18)
	Other structure	316 (16.4)
	CHU	303 (15.7)
	Health center	196 (10.2)
	Private structure	145 (7.5)
	Dispensary	63 (3.3)
Profession	Nurse	1072 (55.5)
	Other health profession	412 (21.3)
	Midwife	140 (7.3)
	General practitioner	115 (6)
	Administrator	105 (5.4)
	Specialist practitioner	86 (4.5)
Healthregion	Estuaire (Libreville Owendo)	669 (34.7)
	WoleuNtem	296 (15.3)
	Ngounié	271 (14)
	Estuaire (Ouest)	182 (9.4)
	Haut Ogooué	146 (7.6)
	Ogooué Lolo	92 (4.8)
	Ogooué Ivindo	81 (4.2)
	Moyen Ogooué	75 (3.9)
	Ogooué Maritime	68 (3.5)
	Nyanga	50 (2.6)
Sex	Female	1275 (66.1)
	Male	655 (33.9)

*N=1930

Table 2. Internal consistency of theoretical constructs (Cronbach alpha)

Construct	Cronbach alpha	Nb. Items	n
Satisfaction	0.85	4	1104
Support Quality (SupQual)	0.85	4	889
System Quality (SQ)	0.90	7	663
Impact	0.96	10	1036
Information Quality (IQ)	0.91	5	1009

Table 3. Construct reliability of the model

Construct	Items	Label	CR	Factor Loadings
Satisfaction			0.90	
	q1a	HIS performance		0.81
	q1b	HIS ease of use		0.82
	q1c	HIS quality of information		0.88
	q1d	HIS support services quality		0.8
SupQual			0.89	
	q2a	The process of implementing HIS was adequate		0.76
	q2b	The level of training in the use of HIS is adequate		0.87
	q2c	The level of support offered for the use of HIS is adequate		0.84
	q2d	Accessing the HIS at your workplace is easy		0.79
SQ			0.92	
	q3a	The response time of the HIS against a request is acceptable		0.78
	q3b	The HIS is easy to use		0.75
	q3c	The required effort to use the HIS is acceptable		0.8
	q3d	The HIS ensures adequate privacy and security of patients' personal data		0.84
	q3e	Access to the HIS is acceptable		0.82
	q3f	The HIS has a reliable performance		0.74
	q3g	The HIS allows you to enter all the information you want		0.77
Impact			0.96	
	q4a	The HIS increases your productivity		0.71
	q4b	The HIS facilitates information exchange between different users of the system		0.77
	q4c	The HIS improves real time management of health care and services		0.8
	q4d	The HIS improves patient information management in real time		0.87
	q4e	The HIS provides easy access to the desired information		0.86
	q4f	The HIS makes it possible to visualize the information related to a patient		0.87
	q4g	The HIS allows to be informed about the care and services received by a patient		0.87
	q4h	The HIS allows for better planning of your clinical activities		0.88
	q4i	The HIS avoids unnecessary investigations and examinations		0.87
	q4j	The HIS facilitates access to information about a patient's results		0.84
IQ			0.92	
	q5a	The information provided by the HIS is complete		0.76
	q5b	The information provided by the HIS is accurate		0.82
	q5c	The HIS provides information quickly		0.9
	q5d	Information is available in the HIS when you need it		0.86
	q5e	The presentation and layout of information in the HIS are adequate		0.86

Table 4. Fit indices of the CFA

Model fit	Indicator value
RMSEA	0.071
CFI	0.925
IFI	0.925
TLI	0.918

Table 5. Logistic regression of the full model

Variables	Estimate	Estimate confidence interval		Odds ratio	p-values	Standardized estimate
Intercept	-5.68	-6.85	-4.51	0	0	0
Satisfaction	0.07	-0.11	0.26	1.08	0.44	0.05
SupQual	0.29	0.06	0.53	1.34	0.02	0.16
SQ	0.51	0.25	0.77	1.66	0	0.28
IQ	0.51	0.3	0.72	1.67	0	0.3
AU	0.19	-0.39	0.78	1.21	0.52	0.05
Compatibility	0.18	-0.35	0.71	1.2	0.51	0.05
Overload	0.14	-0.3	0.59	1.15	0.53	0.03
UF	0.12	0.03	0.21	1.13	0.01	0.12
Age (0-39)	-0.14	-0.53	0.24	0.87	0.47	-0.04
Sex (Male)	-0.08	-0.42	0.26	0.92	0.64	-0.02
Experience (0-9)	-0.11	-0.5	0.29	0.9	0.6	-0.03
Low ICT skill	0.19	-0.17	0.54	1.2	0.3	0.05
Profession (Nurse)	-0.01	-0.37	0.35	0.99	0.95	0
Organization (RegionalHospital)	0.22	-0.13	0.56	1.24	0.23	0.06

AUC:0.77; Nagelkerke r-square: 0.31; n=781

Table 6. Stepwise logistic regression of the final model

	Estimate	Estimate confidence interval		Odds ratio	P-Values	Standardized estimate
Intercept	-5.7	-6.67	-4.74		0	
SupQual	0.32	0.1	0.54	1.37	0.01	0.18
SQ	0.53	0.28	0.78	1.7	0	0.29
IQ	0.52	0.32	0.73	1.69	0	0.3
AU	0.34	0.01	0.68	1.41	0.04	0.09
UF	0.13	0.04	0.22	1.14	0.01	0.13

AUC: 0.78; Nagelkerke R-squared: 0.3; n=781

Figures

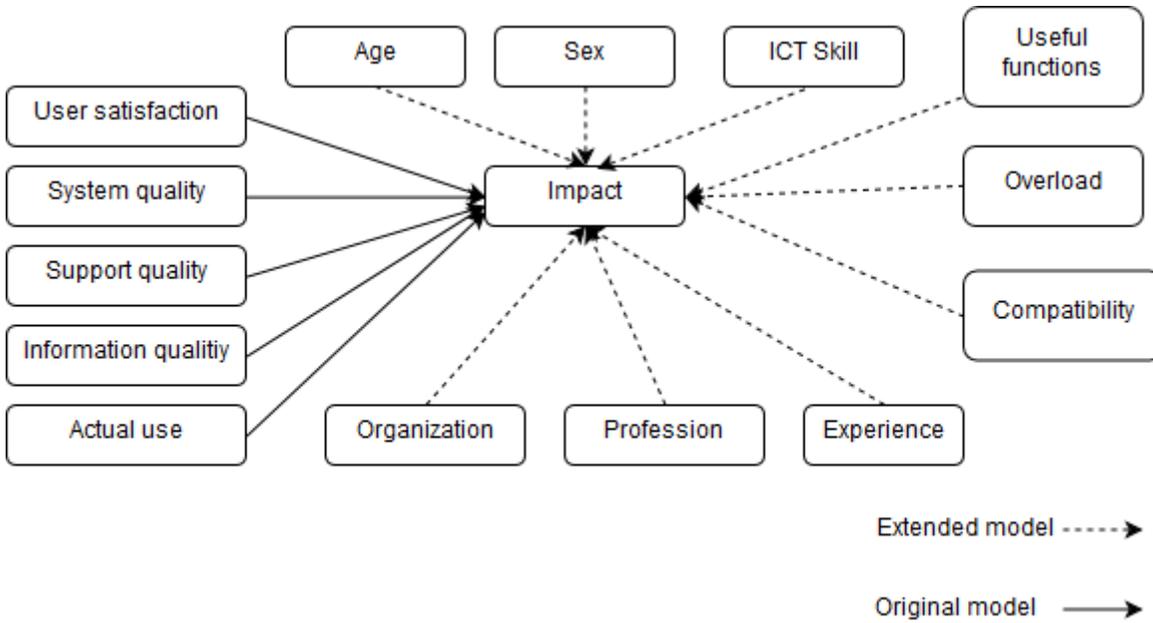


Figure 1

Theoretical model adapted from DeLone& McLean. The theoretical model is based on the DeLone and McLean Information System Success Model. This model proposes five variables to measure the success of an information system: system quality, service quality, information quality, actual use, satisfaction and net benefits (impact).

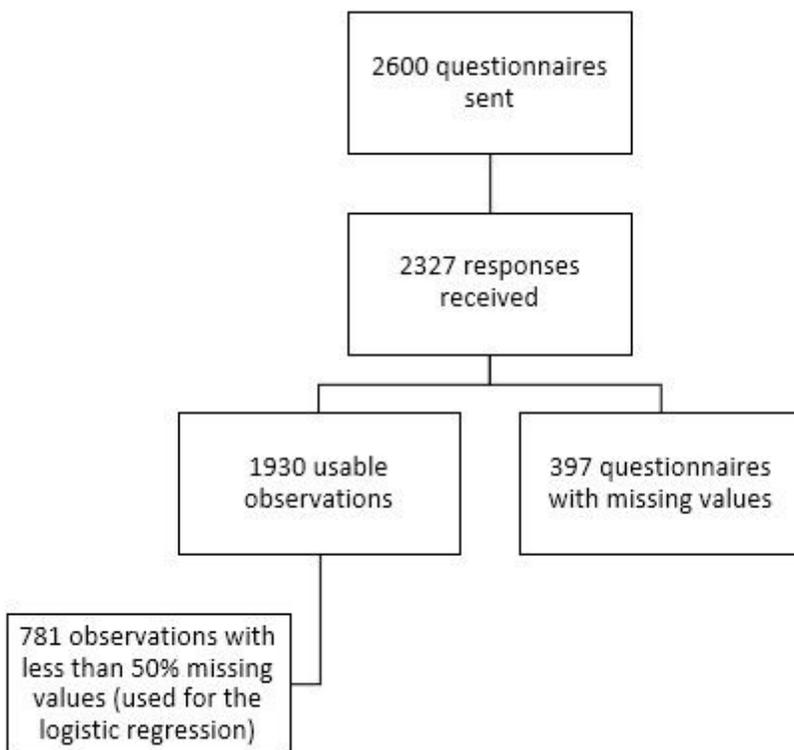


Figure 2

Study flow diagram. From the 2600 potential participants, 2327 returned their questionnaires. There were 1930 usable questionnaires, and 781 questionnaires with complete observations were retained to test the theoretical model.

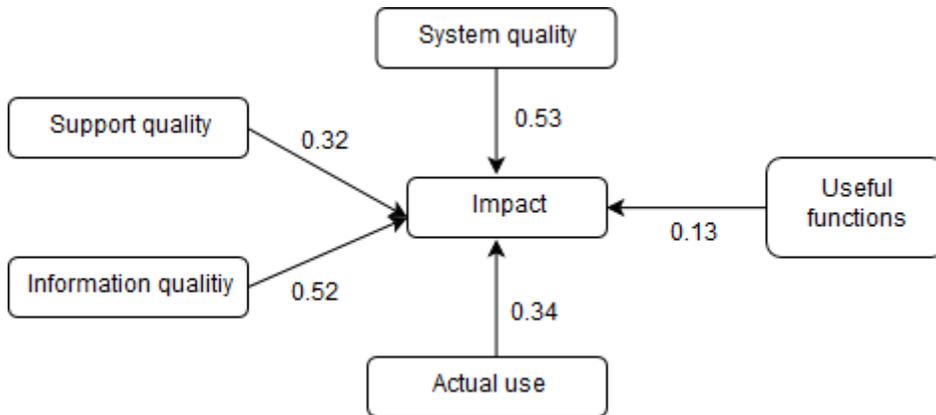


Figure 3

Final theoretical model with estimates. The final theoretical model explains 30% of the variance in providers' perception of the positive impact resulting from the use of the HIS. Five variables of the adapted model are significant, namely Support Quality, Information Quality, System Quality, Actual Use and Useful Functions.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Additionalfile1.doc](#)
- [Additionalfile2.xlsx](#)
- [Additionalfile3.xlsx](#)