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A comparison between the logit and probit model to evaluate the utility of new technologies in Healthcare

Gravili Ginevra

Department of Economics, University of Salento
Lecce, 73100, Italy

Abstract

The growth of Information Technology has developed new ways to engage with patients. Thus, Health organizations have had to examine the potentialities offered by technological landscape, and developing strategies that are suitable to their management. Nevertheless, it appears that doctors are not always ready to use technology to communicate in Healthcare. So, it's necessary to identify change management strategies that facilitate the success of new tools. This empirical study focused on Asian Health System measuring, through the Logit and Probit method, several variables that can have a positive or a negative effect on the perception of the utility of technological tools. This study could be useful to Health Organizations to manage their strategies of change management.

Keywords: *Healthcare system, Information Technology, Engagement, Logit model, Probit model.*

1. Introduction

Today Information Technology (I.T.) represents a new strategy to develop the patients' engagement in Healthcare.

Several studies have shown that the accessibility of health, the emotional support to individuals [1], including those with various illnesses [2],[3], is a priority in the Healthcare. At the same time, I.T. represents a way for patients and doctors to generate, share, receive, and comment knowledge on healthcare [4].

Thus, for Health Organizations to understand why patients and doctors use new communication platforms [5] it is crucial to manage collective social action [6] and, of consequence, to orient their strategies [7]. Health organization is a social system, to introduce changes therefore, it's necessary to act with caution focusing on the cultural, personal value and interpersonal relationships.

Even if, today, there is still a lot of skepticism in Health world, the awareness for Health organizations of the potentialities offered by technological landscape are forcing them to use new managerial strategies that consider that the patients like to exchange information on their pathologies, to interact, to share and to act through a continuous sharing of information [8]. This means that they can interact with physicians in an unconventional way [9], imposing the implementation of strategies, able to go beyond the normal resistance imposed by a widespread traditional culture and to begin a process of change of type botton-up.

This change is a complex, dynamic process, which evolves all organization: to understand why change is happening and how it could be affected can help managers in the transforming period. It is never a choice between technology or people, but it is a combination of the ability to change and adapt. Of course, changes in healthcare practices are welcome if they improve quality and safety, or save money and if the perceptions of users is good.

In the light of these aspects this study intends to analyze which is the true perception of I.T. among Asian population (doctors and patients) to help managers to guide the change.

It's necessary to consider that the use of technological tools into healthcare systems has to be approached with the greatest of caution: there could be legal matters. For example, there are a lot of personal health records, which should be managed with attention and then a doctor who belongs to a hospital "adds" to a patient on a social network, he also has the right to access the information that the person concerned or his / her friends have posted on his / her profile and, so much, his / her friends have the possibility of accessing the patient with the doctor on his / her wall infringing, in this way, the patient's right to privacy. Inappropriate use of technological tools, then create serious problems relationship between healthcare operators or between administrators and healthcare operators.

Sharing confidential information, inadequate qualifications can have a negative influence [10], persuading a patient to choose a specific healthcare structure or healthcare operator rather than others.

The problem, however, is not only the legal issue but also the ethical-moral aspects. The information published could be the same as "nosing" into other people's lives, even if you do not should not be published.

2. Method and Hypotheses

This study is an exploratory study on the use of I.T. by Asian doctors and patients. We start from the idea that perception of I.T.'s utility in Health communication, as shown by Figure 1 below, is determined by two independent variables, socio-demographic profile and presence of disease.

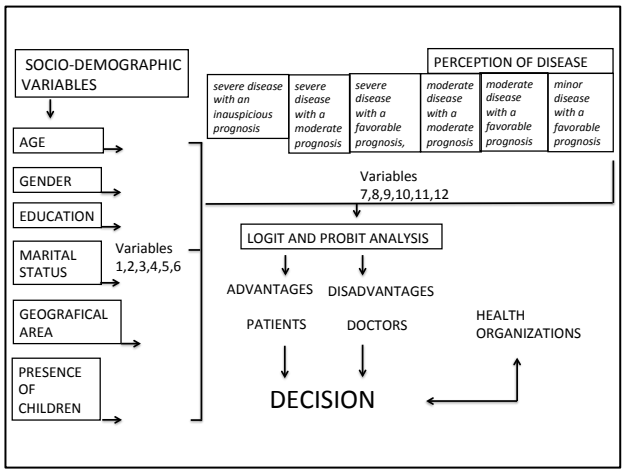

Figure 1: Model of Analysis

In this paper we want to analyze if:

- There is a relation between the presence of disease and the use of I.T.'s communication in Healthcare system.
- The presence of differently serious diseases affects the perception of the advantages resulting from using a new communication tool.

To analyze these aspects the research is subdivided into two parts.

In the first there has been the identification of all healthcare structures present in Asian Countries in 2017. This phase has required a year study with the aim of evaluating the communicative systems used by hospitals. We have use the data of "World Hospitals' ranking on the Web" an initiative of the Cyber metrics Labwebranking. So we have constituted our sample: 46 Asian countries in which there are 3844 Health Organization that use I.T. Each Organization has been controlled, analyzing the web site of each structure.

The second part of the research was administered to doctors and patients to evaluate if there was a correspondence between the real use by Health Organization and the potential benefits' perception of the use of I.T. to communicate. The research was developed directly on the Internet by distributing a questionnaire among physicians and patients, randomly selected. We have used the same method of a previous research conducted for European countries [11]. So, in order to facilitate the accurate and consistent acquisition of information we have posted the questionnaire in the message form on the web page for physician and patients.

The questionnaire has been initially tested on a limited number of users (35 physicians and 35 patients), in order to understand at which point the questions were correct and the presentation form was accepted. Then it has been posted to the entire sample.

3. Methodology

3.1. Sample

The data were collected through a pilot project, which involved 3.000 people, including doctors and patients who have been asked to make some choices using an unidirectional preference pattern.

Originally, the sample of study has consisted of 6.000 members, constituted by 3.000 physicians and 3.000 patients. After having trasformed the quality variables in dummy, they will be used as explanatory variables.

As for the subjective variables, in order to analyze the dummies and to gain true accurate results, the sample has been made so to have an equal distribution of the population relating to the different kinds of diseases, independently from other variables. For this reason the sample was significantly reduced.

The sample at last was composed of N=1.727 physicians and N= 1.275 patients.

3.2. Empirical Model

The pilot project has the aim to identify among the different variables those with a superior explanatory power, that is, those which are determinant about the possession or not of a quality: according to the fact that they are linked in a positive or negative way to the observed phenomenon, they can whether be considered risk elements or benefits elements.

The pattern used in this work aims to explain the perception of the use of I.T. in Healthcare as a result of a pattern which evaluates the probability that this event occurs in the presence of a series of variables which influence the preferences.

Three types of variables have been analyzed:

1. The dependent variable: I.T.'s perception
2. The control variables include gender, age, education, marital status, geographical area and presence of children;
3. The Independent variables, that is, the presence or absence of diseases.

3.3. Dependent Variable

The dependent variable is closed related to socio-economical variables, to presence of diseases and to elements which can not be observed, defined by "u"="margin of error".

Therefore,
Ui=a+bx+u u=error, E(u)=0

E(ui+xi)= a+bxi = Pr (Ui=1/xi) P (Ui=1/X) ⇒ Given a set of explanatory variables
It has been evaluated the utility for each alternative. The difference among these utility levels expresses the positive or negative perception about the alternative. In such a manner, the advantage of using Fb in Healthcare will be analyzed only in relation to the choice the individual has made.
The variable, which assumes a modality of binary response, has a value between
$0 < Ui < 1$
U = discrete variable
0: if the event does not occur – no :Value read as "negative sign/ unfavourable to the use"
1: if the event occurs – yes ⇒ Value read as "positive sign/favourable to the use"

In particular, the estimate of the variables has been obtained from the individual choices of interviewed people who answered the questionnaire. The principles of the theory of random utility have been the basis for this type of patterns, whose starting hypothesis are [ ](Ortuzar e Willumsen, 2001):
• individuals belong to two homogeneous populations, they are rational and have a perfect information;
• the choice options xj are defined by a set of attributes xk (with a number of attributes which range from 1 to K). In our choice the attributes are: sex, age, education, marital status, presence of children;
•a certain level of individual net utility Ujq is associated for each option of choice Xj (where the index "q" refers to the "q-th" individual).
The analysis models used are that one of "binary logit" and that one of "ordinal probit".
The logit model is based on the assumption that the random components are identically and independently distributed among them according to the Gumbel distribution function IID.
In the logit model we will analyze "ODDS", that is the ratio between the probability of success and of failure:

$$\text{ODDS: } \frac{P(Yi=1/X)}{P(Yi=0/X)}$$

The ordinal Probit model relies instead on the hypothesis that the random variable is distributed as a normal one with average zero and a matrix of arbitrary co-variation.

3.4. Control Variables
The determinants of the use of Fb, analyzed as explanatory variables, are gender, age, education, marital status, and geographical area.

Sex is a dummy that indicates the gender of the respondent (the value 1 is associated with male gender and the value 0 to the female gender.
Age shows the age of the respondent at the time of the interview. For the purposes of this analysis individuals under the age of 25 and above 77 have been excluded. They were divided equally among 24-34 years; 35-54 years; over 55 years .The lowest age limit has been taken into account by determining the minimum number of years required for the attainment of a medical degree, while the highest limit has taken into account the retirement age. In order to compare the responses, we have adopted the same values for patients.
The variable education expects one answer for doctors (graduation) and five options for patients (primary school, secondary school, degree, PHD, other).
The variable marital status defines two categories: married, not married (including actually separated, legally separated, divorced, widow).
The variable geographic residence assumes three categories (East Asia= value 3, West Asia = value 2, South Asia = value1).
Presence of children is a dummy that indicates if the respondent has children (the value 1 is associated with presence and the value 0 to absence)

3.5. Independent Variables
The variables used in this study take into consideration a number of aspects that can have a significant influence on the necessity to use I.T. in the Health Organization. In particular, it was assumed that the presence or absence of diseases could affect the emotional perception of the interviewee. The latter - due to the presence of more or less serious diseases- could feel the necessity to have a faster and immediate communication with the doctor: these are typical characteristics of the social communication. For this reason, six dummies were inserted: minor disease with a favorable prognosis, moderate disease with a favorable prognosis, moderate disease with a moderate prognosis, severe disease with a favorable prognosis, severe disease with a moderate prognosis, severe disease with an inauspicious prognosis (Hypothesis 2).
In the second phase of the test, the interviewees indicated the order of preference (ranking exercise) of the reasons that could lead them to implement the use of I.T. (except for those attributes which they consider absolutely not acceptable), indicating, on a scale from 1 (not important) to 4 (extremely important), the importance assigned to each of the attributes.
The answers given during this phase are used to analyze the veracity or not of the Hypothesis 1 and 2 of the conceptual model.

4. Data Analysis and Results

In Asia we have analyzed 44 regions for a total of 3844 Health Organizations that are on the web. The research was very complex because the territory of analysis is various. Asian countries are at different stages of development when it comes to healthcare. In fact while many countries adopt new models of organization others try to learn from the mistakes of others: Singapore, Indonesia, Thailand and the Philippines have an advanced healthcare system and there have ambitious and innovative plans to reform their systems. China began health-care reform in 2009 but this reform doesn't regard social media communication, because there is a strong control of government in each communication's system.

The use of logit and probit models showed very similar values of probabilities. Both models provide an indication of the possibility that the considered variables influence positively or negatively the choices of the sample analyzed. Using the dummy, a ranking of the variables has been defined according to the degree of influence on the probability of choice, and for analysis macro-classes.

In the Logit model (Table n.1,2,3,4) all the observed coefficients show a significance level very close to zero (Hypothesis 1). The signs of the coefficients confirm the expectations of a utility function (for doctors) decreasing with increasing age, marital status and residence in the West or in the South increasing for residents in the East.

As for the subjective variables, being male has a statistically significant effect. The perception of the usefulness of I.T. decreases for men.

Logit doctors						
Socio-demographic variables	Coef.	Std.Err.	z	P >|z|	[95% Conf.	Interval]
intercept	2.389	1.227		<0.001		
age	-0.59	.243	-1.29	<0.023	-0.90	-0.08
X sex	0.43	.124	3.41	<0.041	0.21	0.823
education	0.02	.523	3.02	<0.02	0.01	0.67
X marital status	-0.23	.70388	-4.14	<0.03	-0.65	-0.12
EST Asia	0.071	.67548	6.20	<0.001	0.05	1.2
West Asia	-0.52	.002	-2.29	<0.012	-0.743	-0.02
South Asia	-0.437	.100	-1.23	<0.01	-1.2	-0.23
X children	0.63	.00243	6.20	<0.001	0.14	1.356

Table 1 Results Socio-demographic variables for doctors

Logit patients						
Socio-demographic variables	Coef.	Std.Err.	z	P >|z|	[95% Conf.	Interval]
intercept	2.6350	0.198374		<0.001		
age	-0.53	.263	-2.256	<0.001	-0.7240	-0.1
X sex	0.34	.0198	2.13	<0.023	0.14	0.823
education	0.7431	.492	2.72	<0.085	0.561	1.934
X marital status	0.01	.6983	-3.44	<0.02	0.0065	1.12
East Asia	0.091	.0932	2.32	<0.01	0.05	1.2
West Asia	-0.023	.74536	-1.829	<0.053	-0.43	-0.01
South Asia	-0.021	.84632	-2.42	<0.031	-1.2	-0.013
X children	0.46	.01245	4.620	<0.001	0.14	1.356

Table 2 Results of Socio-demographic variables for patients

With regard to patients, the results in terms of age and sex are the same as those shown by the doctors; while considering the level of education, the effect is significant only for graduates: the probability of using I.T. increases of 0.7 compared to the base category of people with no qualifications (Hypothesis 1).

With regard to the geographical area, it can be seen that the West and South Asia inhabitants have a lower perception than people of the East Asia area. These values allow to make an identikit of the Asian user most inclined to the use of I.T. in healthcare: woman, aged between 30 and 55, living in East Asia, with a degree.

Then, observing the presence of diseases in the surveyed people, it can be seen that there is a significant effect for all types of diseases (Hypothesis 2). The perception of I.T. as an useful tool for communication increases in people with severe illnesses. A different situation is when patients and doctors are in presence of several diseases with inauspicious prognosis: the use of I.T. decreases.

Logit doctors						
Disease	Coef.	Std.Err.	z	P >|z|	[95% Conf.	Interval]
Intercept	1.8122	.13245		<0.001		
minordiseasewithfavourpro	0.223	.23	2.29	<0.03 42	0.134	1.53
moderdiseasewithfavourpro	0.34	.1593	1.23	<0.01	0.04	0.2763
moderdiseasewithmoderapro	0.431	.84986	2.92	<0.03 24	0.135	1.524
severdiseasewithfavourpro	0.45	.07970	2.54	<0.001	0.05	1.23
severrdiseasewithmoderapro	0.53	.070388	3.51	<0.01	0.125	1.254
severdiseasewithinauspicio	-0.98	.1098	-1.79	<0.001	-1.601	-0.023

Table 3 Results in presence of diseases for doctors

Logit patients						
Disease	Coef.	Std.Err.	z	P >|z|	[95% Conf.	Interval]
Intercept	1.9235	.362548		<0.0023		
minordiseasewithfavourpro	0.35	.3001325	3.67	<0.0243	0.12	1.151
moderdiseasewithfavourpro	0.95	.84078438	1.25	<0.001	0.14	1.051
moderdiseasewithmoderapro	0.356	.7342	2.46	<0.03	0.262	0.995
severdiseasewithfavourpro	0.765	.69341	6.44	<0.001	0.143	1.321
severrdiseasewithmoderapro	0.9027	.008	2.20	<0.0123	0.824	1.546
severdiseasewithinauspicio	-0.923	.01287	-2.49	<0.02	-1.351	-0.43

Table 4 Results in presence of diseases for patients

The coefficients estimate of the attributes studied with the Probit are depicted in Table n. 5,6,7,8 (second column). Instead, the indexes of statistics reliability of these coefficients are shown in the last three columns.
Similarly to what we have observed for the estimates obtained with the Logit model, all the coefficients of the studied attributes are statistically significant (Hypothesis 1 and Hypothesis 2). The signs of the estimated coefficients are consistent both with the estimates obtained and with the Logit model.

Probit doctors						
Socio-demographic variables	Coef.	Std.Err.	z	P >|z|	[95% Conf.	Interval]
intercept	2.53746	.64536		<0.001		
age	-0.55	.3243	-3.24	<0.023	1.230	-0.1
X sex	0.31	.2958	2.43	<0.001	0.13	0.657
education	0.724	.2384	2.232	<0.085	0.421	1.452
X marital status	0.034	.6352	-2.43	<0.02	0.015	1.034
East Asia	0.0882	.0853	1.32	<0.01	0.0234	1.185
West Asia	-0.0143	.4569	-2.456	<0.053	-1.043	-0.003
South Asia	-0.0178	.284632	-3.45	<0.031	-1.3	-0.009
X children	0.52	.0258	3.654	<0.01	0.2547	1.246

Table 5 Results of socio-demographic variables for doctors

Probit patients						
Socio-demographic variables	Coef.	Std.Err.	z	P >|z|	[95% Conf.	Interval]
intercept	2.3564	.6473526		<0.001		
age	-0.49	.263	-1.34	<0.01	-1.240	-0.09
Xsex	0.25	.0198	3.24	<0.001	0.04	0.92
education	0.654	.492	2.24	<0.085	0.0341	1.234
Xmarital status	0.023	.6983	2..44	<0.02	0.001	1.462
EastAsia	0.0876	.0932	1.46	<0.01	0.032	1.34
WestAsia	-0.087	.74536	-1.65	<0.053	-1.25	-0.076551
SouthAsia	-0.034	.84632	-2.34	<0.031	-1.34	-0.004
Xchildren	0.46	.01245	4.620	<0.001	0.14	1.356

Table 6 Results of socio-demographic variables for patients

Probit doctors						
Disease	Coef.	Std.Err.	z	P >|z|	[95 % Conf.	Interval]
Intercept	1.85463	.56345		<0.001		
minordiseasewithfavourpro	0.21	.1213	3.3	<0.002	0.0734	1.03
moderdiseasewithfavourpro	0.29	.0193	1.13	<0.021	0.0234	0.863
moderdiseasewithmoderapro	0.41	.7496	2.776	<0.2124	0.032	1.14
severdiseasewithfavourpro	0.40	.89970	3.454	<0.007	0.001	1.0023
severrdiseasewithmoderapro	0.21	.687388	1.230	<0.081	0.0185	1.024
severdiseasewithinauspicio	-0.9	.98	-1.469	<0.001	-1.01	-0.001

Table 7 Results in presence of diseases for doctors

Probit patients						
Disease	Coef.	Std.Err.	z	P >|z|	[95 % Conf.	Interval]
Intercept	.19673452	.8653456	1,3			
minordiseasewithfavourpro	0.32	.3001325	2.32	<0.243	0.08	1.23
moderdiseasewithfavourpro	0.9	.84078438	3.23	<0.001	0.234	1.131
moderdiseasewithmoderapro	0.346	.7342	4.53	<0.003	0.122	0.565
severdiseasewithfavourpro	0.0665	.69341	6.32	<0.001	0.005	0.972
severrdiseasewithmoderapro	0.87	.008	-2.45	<0.05	0.352	1.12
severdiseasewithinauspicio	-0.813	.01287	2.87	<0.02	-1.143	-0.3

Table 8 Results in presence of diseases for doctors

In particular, the estimates obtained using the logit model, from a technical and statistical point of view, are similar to those obtained with the ordinal probit model, whether for the sign of the parameters estimated and for the order of importance of the attributes constructed from these parameters. The characteristics of the answers given by the respondents, however, make the Logit model more suitable for this investigation. The comparison between the estimates showed that the variables that have the greatest impact in the choosing to use Fb in Health are linked to the disease factor,

Comparing, then, the change in the variables that most affect the use of Fb, it can be seen that the presence of diseases among people constitutes a primary condition in comparison with the other variables, since it focuses attention on the need of the individual to change their Knowledge and beliefs. The necessity dictated by the presence of diseases has a motivational drive to change, so strong as to lead to changes in the decision-making processes in order to achieve the objective, the healing.

4. Conclusions

Starting from these observations, conducted at national level, we analyzed which is the impact (positive or negative) that exists between Health activity and the use of I.T. The key questions to which we have tried to answer are:

- Which are the variables that most influence the perception that the individual has of the use of I.T. in health care?
- Have socio-economic aspects a specific impact on communicative behavior?
- Did the process used to change behavior include communicative activities, such as goal setting, decision making, planning for specific behaviors, and self-evaluating physical, emotional, and cognitive responses associated with behavior change?

The presence of more or less severe diseases affects the perception of the benefits that may result from the use of a new communication tool)?

The current study has examined socio-demographic and health-related variables that can influence the perception of the use of I.T. in Healthcare. The results of this study offer new and important implications for health communication in this digital age: the potential use of I.T. in Health and on health behavior through social media is necessary.

For those who are suffering from diseases in general and severe diseases in particular, I.T. is almost a panacea. The perception of the severity of the disease and the need to have a constant comparison with doctors and other patients lead individuals to consider I.T. as an advantage and to change their communicative behavior.

On the one hand, this result highlights the enormous advantages that the Health Organizations would have if they used social communication, on the other hand, it requires further investigation. For example, if we extend the analysis sample we could observe the phenomenon on a larger scale, although it should be always considered that this kind of research could suffer from the inability to totally observe the analyzed phenomenon.

References

[1] Mo, P. K., & Coulson, N. S. (2008). Exploring the communication of social support within virtual communities: a content analysis of messages posted to an online HIV/AIDS support group. *Cyberpsychology & behavior*, *11*(3), 371-374.
[2] Scanfeld D, Scanfeld V, Larson EL., (2010), Dissemination of health information through social networks: twitter and antibiotics. Am J Infect Control 2010 Apr;38(3):182-188.
[3] Hwang KO, Ottenbacher AJ, Green AP, Cannon-Diehl MR, Richardson O, Bernstam EV, et al. (2010), Social support in an Internet weight loss community. Int J Med Inform 2010 Jan;79(1):54;
[4] Dawson J. (2010), Doctors join patients in going online for health information. New Media Age
[5] Chakrabarti, A. K., & Santoro, M. D. (2004). Building social capital and learning environment in university–industry relationships. *International Journal of Learning and Intellectual Capital*, *1*(1), 19-36
[6] Ordonez de Pablos, P. (2002). Evidence of intellectual capital measurement from Asia, Europe and the Middle East. *Journal of Intellectual capital*, *3*(3), 287-302.
[7] David I, Poissant L, Rochette A., (2012) Clinicians' expectations of web 2.0 as a mechanism for knowledge transfer of stroke best practices. J Med Internet Res, Sep;14(5):e12
[8] Lagu T, Hannon NS, Rothberg MB, Lindenauer PK., (2010), Patients' evaluations of health care providers in the era of social networking: an analysis of physician-rating websites. J Gen Intern Med, Sep;25(9):942-946.
[9] Mo PKH, Coulson NS. Exploring the communication of social support within virtual communities: a content analysis of messages posted to an online HIV/AIDS support group. CyberPsychol. Behav. 2008;11(3):371–374
[10] Lorenz, M. (2009). Nearly half of employers use social networking sites to screen job candidates. Retrieved June 10, 2011 from http://thehiringsite.careerbuilder.com/2009/08/20/nearly-half-of-employers-use-social-networking-sites-to-screen-job-candidates/
[11] Gravili G., (2014), Healthcare social media to improve a collaborative model of communication between doctors and patients, in "Organising for growth: theories and practices", Editore CreateSpace-Uniud, pag. 109-117.

Ginevra Gravili. She was born in Lecce on 07 October 1969. She graduated in Economic Studies in 1992, and she achieved PHD in Management and Organization in 1996. Since 2002, she is researcher of Organization Theory at University of Salento, Department of Economics, Lecce, Italy. She has written numerous books and articles on sme's, knowledge sharing, social recruitment, HRM of public administration, ICT, social media and organizations.