NEW SYSTEM ECONOMIC EVALUATION OF EHEALTH INNOVATIONS

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ABSTRACT

The aim of this study is to provide a new research framework for the economic evaluation of eHealth innovations by using system approach and value analysis. It offers stakeholders an explorative method to find the optimal organization following economic, social and quality of care value creation. It helps them design new process by exploring the link between resources, activities, indicators and expected values. Method application and main findings are discussed for EclairAge tele-expertise case study.

KEYWORDS

ICT, Evaluation, Innovation, Value Analysis, System Complex Modelling, Tele-Expertise Case Study

1. INTRODUCTION

Nowadays, rethinking eHealth business models is crucial. The value proposition of solutions should rely on the expected benefits of the innovation. Modelling the shared value of innovation is important for the decision-making process of both internal and external stakeholders. It also allows them to compare their strategies. Therefore, a systemic vision of the ecosystem is necessary to foster the emergence and the spread of original value propositions.

Facing technical and market uncertainty, one of the key issues of entrepreneurs is to anticipate value creation models at a very early stage. Consequently, there is a need to design business models that may enable the potential of a new technology or service to be fully exploited (Chesbrough *et al.*, 2009).

Among the frameworks provided, the business model canvas (BMC) introduced by Osterwalder and Pigneur (2010) is a tool that specifically helps entrepreneurs to design business models. Based on creativity methods such as design thinking, BMC are effective especially in the early stage of projects or in start-up environment. However, the BMC designed does not provide the support for field experimentation of innovation. Yet, this is the only way to identify and create the necessary inputs to justify new business models (Chesbrough *et al.*, 2009). Therefore, we need a method to successfully combine thinking and modelling with field innovation initiatives (Chanal, 2011).

Following a systemic approach, methods and tools of industrial engineering are suitable for the exploration of case studies from an economic point of view, while taking into account the creation of values pursued by all stakeholders (internal or external to the project). The value emerges at the intersection of performance, costs, planning and risk management. Process value means maximum quality at a minimum cost (Chase, 2001).

For the assessment of stakeholders' satisfaction, we add to the economic the social value and the quality of service/care to the global performance of the system. By expanding the range of indicators available, we design business models by taking into account the specific characteristics of the ecosystem and its stakeholders. The value creation is intrinsically subjective and contextual (Hahn and Kuhn, 2011). Yet, it drives the design and management of projects based on multiple values and no longer on cost minimization.

The goal of this paper is to provide a research framework for designing new telehealth systems based on economic shared value creation. Using complex system modelling, we tackle the complexity of evaluating an eHealth innovation according to the objectives set out by stakeholders. In the next section, we describe the methodology followed by its application to the case study and the discussion of results. Finally, we conclude.

2. METHODOLOGY

Our research framework is based on SCOS'M (Systemic for Complex Organizational Systems' Modelling) method aiming at integrating ex nihilo value creation for a maximum of stakeholders in the modelling of multi-criteria performance (Schindler, 2007). It allows the identification of shared value while taking into account stakeholder's expectations and their impact on system constraints at every phase: feasibility, conception, deployment, exploitation, end of life.

To transform shared value, milestones and expected deliverables, process must be designed to capture the set of redefined values. Resources (human, material, financial) are then mobilized to execute processes. This method also allows the steering of the system.

To tackle the complexity of eHealth ecosystems, we use Multiple Domain Matrix (MDM) applied to SCOS'M method to identify the link between resources, process, indicators, expected values and stakeholders (Jean, 2013). We build four matrix of OCSM (Organization Complex System Modelling) to answer to the following four questions:

- 1) What are the values expected by which stakeholder? => Stakeholders' Expected Value Analysis (OCSM1)
- 2) What indicator quantifies which expected value? => Indicators for Expected Value Measurement (OCSM2)
- 3) What activity is measured by which indicator? => Activity Analysis for Value Creation (OCSM3)
- 4) What resource finances which activity? => Identification of Resources financing activities (OCSM4).

The 4 matrix help design new process aiming to satisfy all stakeholders.

3. OCSM APPLIED TO A CASE STUDY

We use OCSM to model a telemedicine process for EclairAge project. It is an innovative project conducted by the Research Department of Altran Group. Selected and financed by the French Government, the goal is to prove its efficiency as an eHealth demonstrator in telemedicine on the French territory. The project aimed to create and test innovative services to improve elderly permanence of care in long-term dependency care centres (called EHPAD). Nowadays, French Emergency Services System (SAMU) assures the continuity of care. Two major challenges arise. Firstly, SAMU affiliated physicians are not specialized in elderly care. Secondly, SAMU may become quickly congested. To face these challenges, the tele-expertise service EclairAge is a geriatric hotline for EHPAD's residents during weekdays. We conducted an in situ and in vivo non-randomized trial in five French EHPADs situated in the South of the Essonne department (Ile de France region) for 18 months (August 2014- February 2016).

In order to design EclairAge new process, we started by collecting data. Firstly, we conducted a literature survey to map all the stakeholders of the system and to identify a first list of expected values. Every stakeholder expects different values from the deployment of the innovation. We have consulted over 100 publications: international telemedicine survey (Davalos *et al.*, 2009, Bergmo (2009), public reports (FIEEC and ASIP, 2011, Lasbordes, 2009) and private reports (CSC, 2001, OPIIEC, 2011). Secondly, in order to complete the list iteratively (Miles and Huberman, 2003), we conducted two workshops and individual interviews on expected values with different stakeholders of the local experimentation. These stakeholders are the EclairAge Project Manager, the CEO of the software company that developed the EclairAge solution, a geriatrician, a physician from SOS Doctors, a SAMU representative, an economic expert, an eHealth specialist and 4 elderly patients. Consequently, we mapped sixteen stakeholders into several categories (with subcategories): patients, caregiver, healthcare professionals, industrial, financier, EHPAD (long-term dependency care centres), health institutions (see the columns of the matrix OCSM1, in table 1). The categories of values (see the rows of the matrix OCSM1, in table 1, from A01 to A15) are quality of care, social and economic to facilitate the creation of future process. If the stakeholder expects this value, then the intersection between values and stakeholders is "1".

In the matrix OCSM1 (table 1), we observe that telemedicine expected values are:

- For the patient (EHPAD's residents in the case of EclairAge), we notice an improved access to healthcare and to specialists (e.g. geriatrician) (A01), telemedicine development for improving continuous care (A06), risk reduction related to unnecessary transportation and hospitalizations (A14), and also a new way to interact with healthcare professionals and help shared medical decision (A03).
- For the healthcare institutions and personnel requesting telemedicine (EHPAD in our case study), the stakes are on the collaboration among HP (A02) and shared medical decision (A03).
- For national or regional health institutions for instance, the quality of access to healthcare (A01), the healthcare professionals' collaboration (A02), shared medical decision (A03), improving medical knowledge (A09), better control of health spending (A11), and the number of unnecessary hospitalizations or avoidable transportation (A14).
- Almost all stakeholders expect the creation and evolution of jobs and medical practices (A05), and emphasize issues concerning data security and safety (A08).

Table 1. Stakeholders' Expected Value Analysis

OCSM N°1 : Stakeholders' Expected Value Analysis																				
				STAKEHOLDERS																
				PATIENT		CARE-GIVER	HEALTHCARE PROFESSIONALS (HP)				INDUSTRIAL				EHPAD*		FINANCER		HEALTH INSTITUTION	
				Elderly person	Legal guardian		Geriatric ien	Nurse and care assistant	Emergency physician	Other	Manufac turer	Digital	Medical Transpor tation	Other		Public	Private	National	Regional	
EXPECTED VALUES	QUALITY OF CARE	A01	Improving access to healthcare	1	1		1	1	1	1	1	1		1	1			1	1	
		A02	Improving coloboration among HP	1		1	1	1	1	1	1	1		1	1			1	1	
		A03	Shared medical decision	1		1	1	1	1	1		1		1	1	1	1	1	1	
		A04	Work delegation				1	1		1					1					
		A05	Creation/ Evolution of jobs and medical practices	1			1	1	1	1	1	1		1	1	1		1	1	
		A06	Improving continous healthcare	1	1		1	1	1	1	1	1		1	1	1		1	1	
		A07	Transport risk reduction	1		1									1					
		A08	Data security and safety	1	1		1	1	1	1	1	1	1	1			1	1	1	
	SOCIAL	A09	Improving medical knowledge			1	1	1	1	1		1			1			1		
		A10	Improving the quality of life	1	1							1						1		
	ECONOMIC	A11	Better control of health spendings	1		1	1	1		1	1	1		1	1	1	1	1	1	
		A12	Activity development								1	1	1	1				1	1	
		A13	Creation of new jobs	1			1					1		1	1			1	1	
		A14	Reduction of unnecessary hospitalizations / transport	1		1	1	1	1	1	1	1		1	1	1	1	1	1	
		A15	Medical time optimization				1	1		1					1	1		1		

After the identification of expected values by stakeholders, we searched for indicators to measure the creation of these values (see in table 2 below). The rows of the first matrix OCSM1 (A01 to A15) are now the columns of the second one OCSM2. If the indicator influences the value creation, the intersection is "1".

For instance, for the creation of value "better control of health spending" (A11), we consider the indicators "service access cost" (I01) and "yearly average rate of medical expenses per patient" (I07). Another example: the indicators "number of telemedicine jobs" (I09) and "yearly telemedicine turnover in France" (I10) influence the value creation "activity development" (A12).

Table 2. Indicators for Expected Value Measurement

		OCSM N°2 : Indicators for Expected Value Measurement														
	INDICATORS	STAKEHOLDERS' EXPECTED VALUES														
		QUALITY OF CARE					SOCIAL					ECONOMIC				
		A01	A02	A03	A04	A05	A06	A07	A08	A09	A10	A11	A12	A13	A14	A15
		Improving access to healthcare	Improving collaboration among HP	Shared medical decision	Work delegation	Creation/ Evolution of jobs and medical practices	Improving continuous healthcare	Transport risk reduction	Data security and safety	Improving medical knowledge	Improving the quality of life	Better control of health spendings	Activity development	Creation of new jobs	Reduction of unnecessary hospitalizations / transport	Medical time optimization
I01	Service access cost	1										1				
I02	Advanced Encryption Standard (AES) encryption								1							
I03	No of emergency visits related to avoidable inter-institutions transportation per year		1													
I04	Average number of physicians consulted for a treatment decision			1												
I05	Availability rate of specialised medical time						1			1						
I06	Mortality rate related to inter-institutions transportation							1			1					
I07	Yearly average rate of medical expenses per patient											1				
I08	No of transports per patient per year							1							1	
I09	No of telmedicine jobs					1							1	1		
I10	Yearly French telemedicine turnover												1			
I11	The rate between the time spent with patients and total time activity				1		1									1

The next step is the design of EclairAge process. Based on the previous tables, we model the geriatric tele-expertise service taking into account the value creation expected by EclairAge stakeholders (OSCM1) and the indicators quantifying the value creation (OSCM2). The workflow described below (figure 1) was validated by the stakeholders involved (the geriatrician, EHPAD's medical staff, SAMU and SOS Doctors representatives, patients).

Figure 1. EclairAge Workflow

In case of an alarming situation, the nurse contacts EHPAD's coordinator physician or the patient's attending physician. If available, the case is treated. If not, the nurse calls the emergency service or EclairAge.

Two main benefits arise from the utilization of EclairAge geriatric hotline. First, based on the immediate transmission of EclairAge Emergency Files (containing the complete medical record of all EHPAD' residents), the on-call geriatrician is able to make personalized medical decisions to treat the case avoiding transfers to the hospital or SAMU.

In the case of a confirmed emergency, EclairAge can initiate the intervention of SOS Doctor (private emergency service). As a result, a physician was sent to the caller EHPAD. Therefore, the case was treated without transferring the resident to the hospital. Second, when transfers are unavoidable, the pre-diagnosis performed by EclairAge's geriatrician and the transmission of resident's emergency file may shorten the waiting time at the hospital reception desk.

In the case of a differed emergency, the on-call geriatrician can schedule a hospitalization and help find a hospital bed in geriatrics, saving time and improving residents' reassurance.

Summing up, EclairAge process was designed to improve access to healthcare, in particular to specialist consultation (geriatrician), to reduce transportation risks, to avoid unnecessary transfers, to improve collaboration among HP, to help shared medical decision, to avoid unnecessary hospitalizations by "filtering" patients, to save everyone's time (medical time optimization).

In order to quantify all these gains, we specify quantitative and qualitative indicators like EclairAge access cost, number of emergency visits related to avoidable inter-institutions transportation per year, mortality rate related to inter-institutions transportation, yearly average rate of medical expenses per patient etc.

All five experimenters EHPAD implemented EclairAge process (described in figure 1). Based on this process, the next matrix OCSM3 is Activity Analysis for Value Creation (table 3). We describe the main EclairAge activities (AC01 to AC10) in order to create the expected values for all stakeholders. If the indicator allows the measurement of the activity then the intersection between activities and indicators is "1". For instance, to measure the activity "intervention in EHPAD" we use the indicators: service access cost, number of emergency visits related to avoidable inter-institutions transportation per year and the yearly average rate of medical expenses per patient.

Table 3. Activity Analysis for Value Creation

OCSM N°3 : Activity Analysis for Value Creation									
		INDICATORS							
		I01	I02	I03	I04	I05	I07	I08	I09
		Service access cost	AES encryption	No of emergency visits related to avoidable inter-institutions transportation per year	Average no of physicians consulted for a treatment decision	Availability rate of specialised medical time	Yearly average rate of medical expenses per patient	No of transports per patient per year	No of telmedecine jobs
ACTIVITIES	AC01 Call EclairAge	1			1	1			
	AC02 Medical Decision				1				
	AC03 Call an ambulance			1			1	1	
	AC04 Plan an emergency visit								1
	AC05 Medical advice								1
	AC06 Call SOS Doctors								
	AC07 Send in the geriatric mobile team / Prepare the intervention						1		1
	AC08 Intervention in EHPAD	1		1			1		
	AC09 Report of decisions and outcomes								1
	AC10 Fill in patient's file	1	1						1

Table 4 illustrates the last matrix of OCSM linking activities to resources. If the activity consumes resources, their intersection is "1". For example, to perform the activity "call EclairAge", human resources (EHPAD's nurse, EclairAge geriatrician) and material resources (a telephone and subscription, a touchpad and EclairAge software) are necessary. To plan an emergency visit, the coordination responsible needs EclairAge software installed on a computer.

Table 4. Resource Identification to Perform the Activities

OCSM N°4 : Resource Identification to Perform Activities												
			ACTIVITIES									
			AC01	AC02	AC03	AC04	AC05	AC06	AC07	AC08	AC09	AC10
			Call EclairAge	Medical Decision	Call an ambulance	Plan an emergency visit	Medical advice	Call SOS Doctors	Send in the geriatric mobile team/Prepare the intervention	EHPAD Intervention	Report of decisions and outcomes	Fill in patient's file
RESOURCES	R01	EHPAD medical staff	1	1	1		1	1		1		1
	R02	Geriatrician	1	1					1			
	R03	Coordination responsible				1			1		1	
	R04	Computer				1			1		1	1
	R05	Telephone	1	1								
	R06	Phone subscription	1	1								
	R07	EclairAge software	1	1	1	1		1	1	1	1	1
	R08	Touchpad	1	1	1			1	1	1		
	R09	Nurse								1	1	

The advantage of using Multiple Domain Matrix (MDM) is to represent and visualise the links between resources, activities, indicators, value creation and stakeholders. We can multiply the matrix of OCSM, as the number of rows of the first matrix equals the number of columns of the second matrix. In the case of numerous rows and columns, calculating each indicator is fastidious. Hence, identifying key indicators helps the evaluation of expected values for all stakeholders. The matrix product of OCSM2 and OCSM1 shows *the importance of indicators by stakeholder*. In our case, *I09* number of telemedicine jobs and *I11* the rate between time spent with patients and total time activity are the most important indicators for a majority of stakeholders. We can explain the results by the following: by implementing EclairAge, job creation in telemedicine is expected. Patients living in EHPAD are complaining that the nurse's average time per patient per day is 11 minutes. By delegating some tasks to the tele-expertise, EclairAge service, patients and healthcare professionals expect better use of the medical time spent by patient.

Furthermore, by multiplying matrix OCSM3 and OCSM2 we find the *key activities that respond to the majority of expected values*. Here, activity *AC01* (call EclairAge), *AC08* (intervention in EHPAD) and *AC10* (fill in patient's file) covers a wide range of expected values. Therefore, by improving only this key activity, it will improve the whole system.

In addition, we can facilitate some activities to better satisfy expected values considered of high priority. We can therefore allocate more resources or of better quality to key activities. We can use OCSM matrix as a support to decision making by changing or suppressing non-core activities. Indeed, a time consuming activity or an activity that only answers to few expected values is inefficient.

4. CONCLUSION

Our research framework aims at defining the system boundaries of eHealth innovations. It uses complex system-modelling tools based on value analysis, suitable for the economic evaluation of projects. Organisation Complex System Modelling (OCSM) enables the design of new process based on the value creation expected by the system's stakeholders. Applying Multiple Domain Matrix (MDM) to OCSM helps us represent the resources used, by which process, for the creation of which values. Applied to EclairAge case study, this methodology helped us design the new process while tackling with the complexity of organizational change.

Further work is needed to exploit the process designed and to compare *a-posteriori* the expected values with the completed values.

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