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TELEHEALTH: TOWARDS A GLOBAL INDUSTRIAL ENGINEERING FRAMEWORK BASED ON VALUE CREATION FOR HEALTHCARE SYSTEMS DESIGN

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1. Introduction

Most of the economic evaluations in the medical sphere focus their studies on comparing the consequences of a project and its cost in order to determine if it has to be developed in a larger scale [Drummond et al. 1997]. These methods were, at the beginning, created to compare different ways of therapeutic recovery, for example comparing the cost-effectiveness of two drugs. But thereafter, they were also used to help choosing between different healthcare organizational strategies. The difficulty is that these analyses only focus their studies on choosing (and not designing) the most cost-effective processes comparing their outcomes. The main purpose of this article is to describe a new method based on value creation to help design projects and processes in healthcare contexts.

Industrial Engineering tools can be used to help design these new organisational processes in the healthcare context [Reid et al. 2005]. In this article, we propose a new multi-scalar method of value creation to design processes. This method focuses on the systemic approach and the concept of value creation. The ultimate goal is to build a robust and generalizable model to simulate and optimize value creation in the healthcare context. The method takes into account multi-stakeholder and multi-criteria aspects to determine a future organization of the healthcare system.

This method is applied to a major organisational change: the increasing use of telehealth. In fact, France, like many other western countries, observes a massive increase of healthcare costs. This is partly due to the rapidly ageing population and the growth of the number of patients suffering from chronic diseases. Simultaneously, the number of medical staff decreases in many regions [Jean et al. 2011]. To overcome these developments, telehealth seems to be one of the responses that ensure accessibility for all to quality care. The main idea of telehealth is to provide a remote access of healthcare services thus closing the distance with appropriate healthcare professionals. However, the introduction of telehealth involves a major organizational change.

Therefore, we propose a framework based on value creation to help design and optimize telehealth processes. A first application of these methods and tools is discussed regarding the telehealth experience named Télégéria at the Georges-Pompidou European Hospital of Paris.

2. State of the art and concepts definitions

The three most used economic evaluations in the medical sphere are:
- Cost-minimisation analysis comparing the cost of two or more projects when they have exactly the same consequences,

- Cost-effectiveness analysis (CEA) comparing the cost and outcomes of two or more projects without assigning monetary value to measure the effect, but using other indicators like the Quality Adjusted Life Year indicator (QALY),
- Cost-benefit analysis (CBA) comparing the cost and outcomes of two or more projects, affecting monetary value to the outcomes.

The main challenge of these methods is to find a common "outcome" denominator in order to compare the projects using the ratio outcomes/costs. But these analysis strategies do not help design adequate processes for new healthcare organisation like the design of a telehealth network. In fact, they only consider a project by its entries "costs" and its exit "outcomes" without describing the internal system with its phases, stakeholders and processes. Therefore, we propose a new multi-scalar methods of value creation based on the constructivism and the systemic approach. The figure 1 compares these two different strategies.
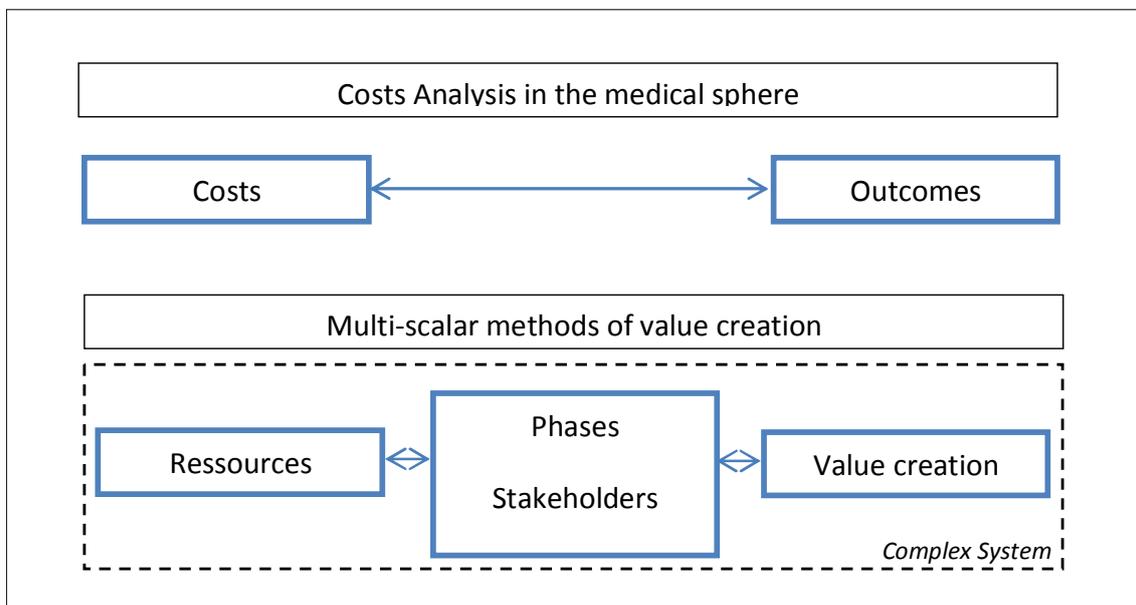

Figure 1. Comparison between the costs analysis methods used in the medical sphere and our new multi-scalar methods of value creation

The objective of our method is to design and evaluate different processes of a project using the value creation concept in order to find the best cost effective processes that create values.

2.1 Constructivism and systemic approach

The scientific field in which we propose to base our analysis is in line with the constructivist approach and the systemic approach [Simon 1969], [Le Moigne 1985]. Opposed to the positivism (which is the reduction of a system by elementary components governed by linear laws), these approaches argue that analytical models can help to explain only complicated problems and not complex ones. In fact, complex systems are systems, whose size, dependence on context, variety of elements and interdependence, make them unable to be fully predictable and therefore controllable.

In this article, we use the following definition of a system based on the systemic approach: "A system is an object which, in a given environment, is seeking to achieve goals (teleological axis) by running activities / processes (functional axis), and its internal structure (ontological axis) changes over time (genetic axis), without losing its own identity" [Bocquet 2008].

Given this definition, we consider health and telehealth organizations as complex systems, where the multiplicity of its elements is as important as the relationships and interactions uniting them. We will see in more detail in the development of the method of design by value creation how it will be useful to understand those complex systems.

2.2 The nature of value

The notion of value is difficult to grasp as its definition includes a large number of concepts coming from the philosophy, the economy and the industrial engineering [Ueda et al. 2009]. But, as our method is based on the concept of value, it seems necessary to define the concept.

A complete philosophy has been developed around this concept: the axiology (αχιοη = praiseworthy). Its objective is to study the value (*valor* = merit / quality) and to answer of two key questions: What determines and justifies our choices and our actions? and How to measure and define the value of a choice, of a conduct or an artefact?

The first question comes down mainly to the definitions of moral values which are the principles that will guide our choices. As shown in figure 2, these values can come:

- intrinsically from an object (usage value, utility value, value in exchange),
- from the individual opinion (taste, whim of those who want to own such items),
- from the society [Durkheim 1911] (What is put as true, beautiful, good, according to the criteria of the society, what is given as an ideal to achieve, as something to defend).

The paradox of the second definition is that once the value is reduced to the freedom of our own choices, we do not have value to guide them. But it is to guide our choices that we are using values.

In our study, we interview the stakeholders to identify their expectations in order to determine their values (subjective and personal satisfaction). The overall value of an organization is collective and shared.
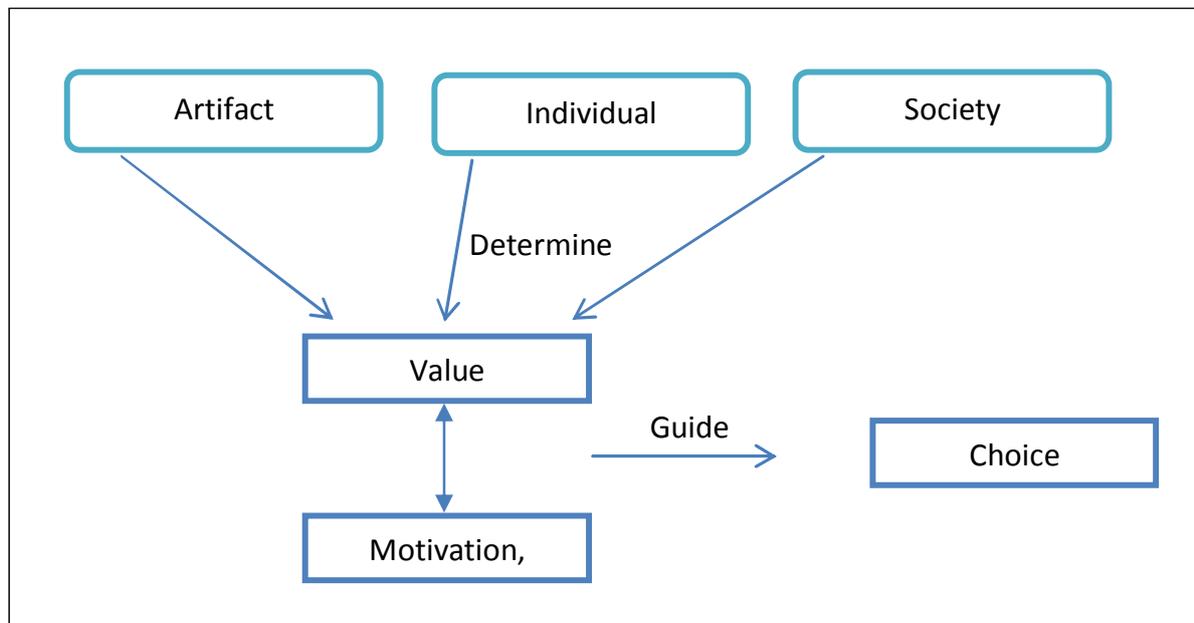

Figure 2. Relation between value, motivation and choice

The second question leads to the economic value concept. The "Theory of value" is a generic term which encompasses all the economic theories that attempt to explain the exchange value (which determine the price) of goods and services. The value is determined by the exchange between an offer (production capacity) and desire (request). In industrial engineering the definition of a value can be set at the intersection of performance, cost, schedule and risk when developing a product [Chase 2001]. The value of a process also involves a maximum quality at minimum cost. However, in order to integrate other aspects in judging the overall value of a complex system it is important to take into account a set of parameters to assess the satisfaction of its stakeholders as a whole. Therefore, we propose the following definition: "Values of a system are both the characteristics of a system, based on both qualitative and quantitative measures, and both objective and subjective criteria, to evaluate the system as a whole and its overall performance with respect to the satisfaction of its stakeholders".

Thus, this definition will include the existence of societal values (our preliminary investigations highlighting the demand for special consideration of human aspects of care). This is not to replace the standard performance indicators such as quality, cost and delay (QCD), but to expand this set to take into account the specificities of such health systems and their stakeholders' expectations.

2.3 The value creation approach

The value creation is a concept that seeks to measure the contribution, the creation of wealth achieved. In Industrial Engineering, the definition of values is often defined with regard to the relation between the input of a function and its cost [Save international 2007]. But that definition cannot be helpful in designing a complex organisation based on the expectations of society and stakeholders.

In fact, our method of value creation is based on the hypothesis that individuals choose the option which seems the most beneficial because it maximizes gains and minimizes losses by an optimal balance point (the theory of rational choice). The practical objective is to represent and validate the values of an organisation to guide its design. The allocation of resources will be related to the values created through adapted processes. Hence, our main objective is to propose a design support for complex health systems.

3. Description of a new multi-scalar method of value creation in the healthcare context

The objective is to help the overall design of the process in the healthcare organization finding the best organization to ensure an optimal set of values expected by all stakeholders. The operational implementation consists in designing and piloting organizational processes according to their value creation including the largest number of stakeholders and the possible largest number of their expectations.

3.1 The multi-scalar method of value creation

As illustrated in the figure 3, we consider the global life-cycle of the system. In each phase (feasibility, conception, deployment, exploitation, end of life) different stakeholders are involved. With the knowledge of these stakeholders, we propose to realise an identification of a set of shared values, considered as the expectations of the stakeholders and the constraints which these ones exercise on the system. The identification of these values passes then by the definition of objectives and deliverable waited. These deliverables are realized themselves by processes, which can be designed from then in a robust way as far as they must be defined in exact adequacy with values shared beforehand defined. Finally these processes require the mobilization of resources as human or material resources. The resources are defined themselves in a strong way as far as they must be defined in exact adequacy with the processes beforehand defined.

This approach thus allows designing a complex system for the project life and for the result of the project life.

3.2 Value and trade-offs

The difficulty of this approach is to define system of shared values considering different stakeholders of the system. As all value-based approaches, the final goal is to permit to decision-makers to compare different values and visualize potential trade-offs. For example, if we put in parallel Vproj and Vso (represented in figure 3), we compare the interest of the project objectives and preoccupation of the society. In the same way with Vst and Vproj: expectations of the stakeholders in front of objectives of the project (can define the payers); Vproc and Vproj: effective success of the project; Vproc and VSt : Effective success for each of the stakeholders.

The potential trade-offs are important in view to trying to maximize to global impact of value creation on the system.
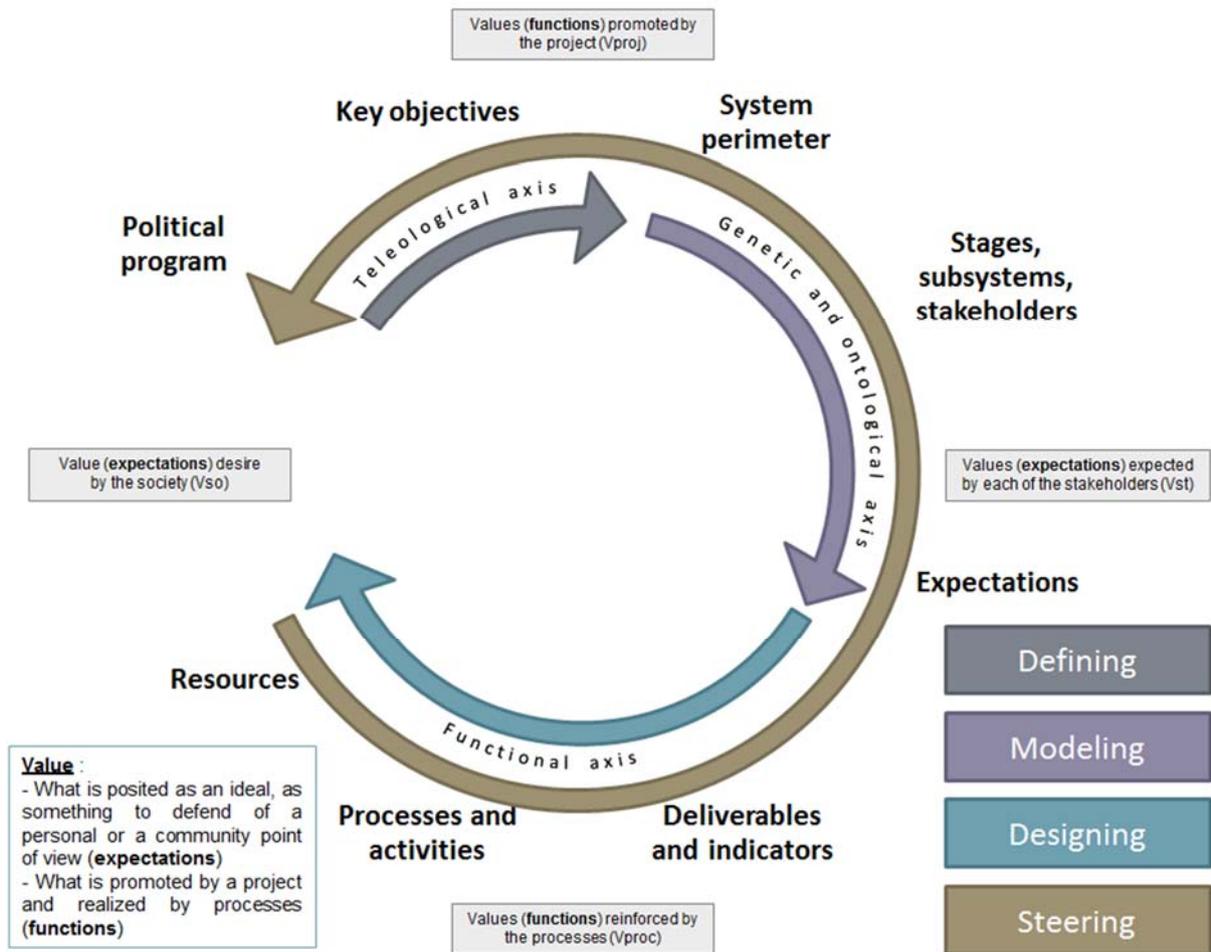
Figure 3. Multi-scalar method of value creation

4. Application of our method to the Télégéria project

In order to investigate and define the proposed approach we have developed collaboration with one of the major French healthcare organizations using telehealth networks. As a very experimented organization in this field, it is a relevant case study for the research and development in the investigated field.

4.1 Télégéria description

Télégéria is a telemedicine network between hospitals realizing tele-consultations, tele-expertizes and tele-assistance. This network is defined by a code of ethics and consent forms approved by the Legal Department of the AP-HP (Assistance Publique - Hôpitaux de Paris).
Two telemedicine platforms are installed at the European Hospital Georges Pompidou (HEGP) and Vaugirard-Gabriel-Pallas Hospital (VGR) and are linked by the Secure Gigabit network of the AP-HP. Each station consists of a main screen and two related screens: one connected to the radiology and medical records and the other one connected to the biomedical equipment for exchanging digital information (camera hand electrocardiograph, spirometer, dermatoscope, otoscope, and ultrasound).
Over the past 18 months, more than 1000 telemedicine sessions in 21 specialties were realized.

4.2 The use of the MAST project and interviews to build the shared values

4.2.1 The MAST project

Many local telemedicine experiments have emerged in recent years. Assessments are a major challenge to select the best of them and to implement them. To this end, some textbooks exist to assess

these projects. For example, the European Union has mandated a working group to produce a manual called MAST (Model for ASsessment of Telemedicine) to evaluate these telemedicine projects. MAST includes three elements: (1) recommendations on issues that should be considered before an assessment of a telemedicine application is initiated; (2) a multidisciplinary assessment of the outcomes of telemedicine within seven domains (Health problem and characteristics of the application, Safety, Clinical effectiveness, Patient perspectives, Economic aspects, Organizational aspects, Socio-cultural, ethical and legal aspects) of outcomes and aspects; and (3) an assessment of the transferability of results found in the scientific literature and results from new empirical studies. Each of these areas is composed of many criteria for assessing precisely an application of telemedicine.

However, it should be noted that telemedicine applications are currently not designed for a major territorial coverage. Indeed, many technological building blocks are missing to go from dual relationships (between two telemedicine sites) to multiple relationships (among many telemedicine sites in the network). It is therefore necessary, in a first stage, to design these organisations before evaluating them.

4.2.2 Research process

For identification and definition of health system values we have collected very different data (the adopted research methodology is presented in figure 4)
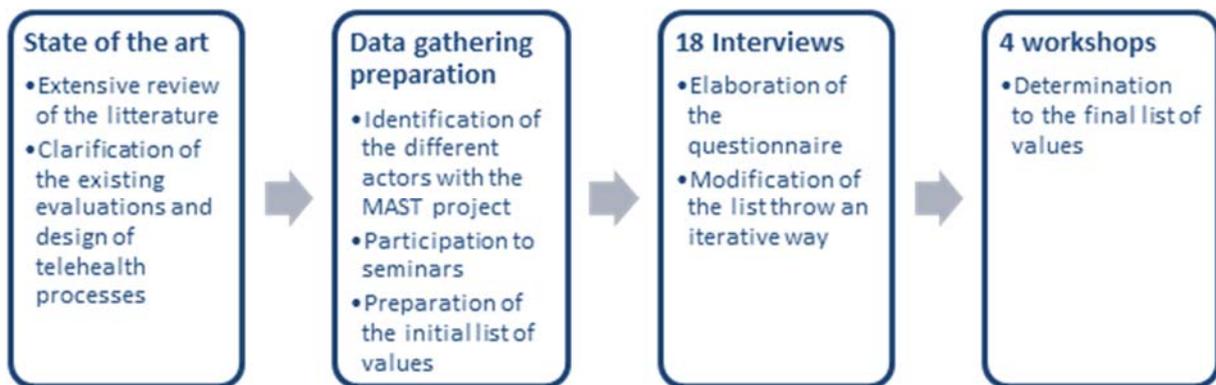

Figure 4. Research process

The first stage consists of an extensive review of the literature in order to clarify the state of the art of the existing evaluations and design of telehealth processes (paragraph 2). During the second stage of our work, based upon the initial MAST project list and participation in different workshops with different stakeholders involved (we attended to seminars with speakers from the State, local authorities, Regional Health Agency, doctor, industrials and society) we have clarified the different stakeholder categories and a set a first list of value creation. The next stage is the elaboration of our questionnaire and the interviews. In this study, we interviewed the operational stakeholders of telehealth who have worked for the Télégéria project. We include:

- All the required medical specialists who have performed more than five sessions of telemedicine in the last six months;
- All the require doctors who have participated in more than five sessions of telemedicine in the last six months,
- All staff care (telemedicine assistants, nurses, health managers) who have assisted directly or indirectly to more than five session of telemedicine in the last six months (prescription writing, administrative tasks, patient management);
- All patients judged by medical staff as able to attend to an interview and who received at least one consultation in telemedicine (excluding patients with cognitive impairment);

The sampling technique was to previously categorize the operational actors by specialties (hematology, neurology, dermatology, etc.) and by services (MCO, SSR, and USLD), and then to choose in each of these categories the interviewees in order to have a good representative panel. The

table 1 outlines the stakeholders and the number of interview that have been made to collect the results.

Table 1. Number of interviews realized by stakeholders

Stakeholders	Number of interviews
Required hospitals	2 interview
Require hospitals	1 interview
Required doctors	7 interviews
Require medical and care staff	6 interviews
Patients	2 interviews

We conducted semi-directive interviews (that allow us to avoid bias obtained by intervention of the investigator [Michelat 1975]). Each actor expresses first his own perception of its professional practice and then the vision of other potential actors. The anonymity of the interview is guaranteed, most of the interviews are audio recorded and a report of each interview is realised in order to giving feedback to interviewees and taking into account their final recommendation in order to avoid incomprehension.

The general process of identifying values is an iterative process: the values and indicators are identified with the first actors and then proposed for approval to the following ones. So, the grid of values is enriched as it goes along. Finally, we propose to group all the values into appropriate taxonomy to facilitate communication and understanding for them with the help of expert judgments.

As the last step validation, four workshops were organized in order to present, discuss and validate the final list of value creations.

4.3 First results

The representation of the figure 5 identifies a synthetic part of the relation between values and stakeholders of our telehealth system. These values are grouped into four areas (medical, social, economic, and overall satisfaction) to facilitate the future process design. If there is a value creation, the intersection between values and stakeholders is represented by a green box. If there is a destruction of value, the intersection is represented by a red box.

This matrix allows us already to make conclusions for the different stakeholders. We can see that the required institutions and their practitioners are in considerable need of telehealth. Indeed, their expectations of quality of care, social (knowledge transfer, opening up) and economic values correspond perfectly to the outcomes of the process of telehealth.

We can also note that required doctors in large hospitals have also an interest in participating in telemedicine projects with the optimization of their consultation time and improvement of their working comfort.

Finally, we can take the example of the entities responsible for the reimbursement of healthcare (CNAM, mutual and insurance) for which development activity is a destruction of value contrary to health establishments for which it is a value creation. Indeed, more there are consultations, more there are the expenses for reimbursement but more are significant, for the health establishments, their revenues.

Our future work will concern the definition of core indicators for each of these values. For example, we can say that improving access to specialized care may depend on the time of access to health facilities, the waiting time between the date of the application for appointment and the date of teleconsultation and the density of healthcare professionals in an area. The ability to quantitatively measure each of these values by finding relevant indicators will allow us to construct the following process for each desired value creations for the stakeholders.

Values	State	Local Authorities (Town, department, region)	Regional Health Agency	Healthcare reimbursement	Require health-care establishment	Required health-care establishment	require doctors	Required doctors and medical staff	patients	Industrials	Society
• Medical											
Access to healthcare services	█				█	█		█	█	█	█
Access to specialty care and expertise			█		█	█		█	█		█
Cooperation between healthcare professionals from institutions and / or city			█		█	█	█	█			█
Ethical and good medical practice, informed consent of the patient			█			█	█	█	█		█
Prevention	█		█		█	█	█	█	█	█	█
Quality of care	█		█		█	█	█	█	█		█
Risk due to transportation						█	█	█			
Shared medical decision							█	█			
• Social											
Better quality of life / Well being	█		█			█		█	█		█
Geographical equalization of access to quality care for all	█		█		█	█	█		█		█
Knowledge and skills transfer between health professionals			█		█	█	█	█			█
Opening to the outside world		█			█	█	█	█			█
Patient therapeutic formation throw telehealth			█		█		█	█	█		█
Quality of the relation between patient and healthcare professionals					█	█	█	█	█		█
• Economical											
Attractiveness of the health territory: improvement of medical demography		█	█		█	█	█	█			
Attractiveness of the health-care establishment: reputation of the institution			█			█		█			
Coordination between medical and medico-social	█		█		█	█	█	█			
Control of health care costs	█		█		█						
Coordination of health facilities	█		█		█	█					
Creation of new jobs	█	█			█						
Fluency of the patients journey	█		█		█						
Efficiency of the health system	█		█		█	█	█				█
Limitation of the access to health emergency	█		█		█						
Medical activity development	▓	▓	▓		█						
New markets										█	
Optimization of medical time			█		█	█	█	█			
Optimization of the patient journey time			█		█	█			█		
Pooling of resources for care, prevention and training			█		█	█					
• General satisfaction											
Comfort of proximity care		█			█	█	█	█	█		█
Comfort of daily work					█	█	█	█			
Fame		█	█			█		█			
Develop new services		█	█			█		█			
Intellectual practice enhancer					█			█			
Satisfaction of participating in the effort of healthcare									█		█

Figure 5. Value stakeholders matrix

Correlated to this value creation identification, our objective is to go towards the proposition of a new business model to identify multiple potential payers. Due to the necessity of integration of this new system into existing one some of the trade-offs need to be considered. Indeed, if telemedicine brings so much value to required establishment and local authorities, why they should not participate to the financing of the system created. In addition for the Regional Health Agencies, why they should not ask their State Authority to get funding to pay the telehealth consultations in a sustainable manner.

So, this matrix of shared values, making a link between resources and values, will help in our future work to design the processes, to evaluate them and to build an economic model to finance telehealth.

5. Limits and perspective

Because of the weak number of large-scale telehealth experiences in France, it is difficult to find raw data from multiple sources. In fact, this study is mostly based on the Télégéria experience which members are volunteers. But as the new experimentations go along, all the operational actors involved

may be designated by hospitals authorities and not necessarily voluntary. In our future work, we must validate our initial results and complete them with new data avoiding this bias.

Another limit of this work is the difficulty of identifying all the values of the system because some stakeholders do not know exactly what they want. A special effort must be made in the field of qualitative interviews to bring out the desired values for the various identified stakeholders.

Finally, processes and business models will be different between the before and the after of the implantation of telehealth. Therefore, it is necessary to consider the change management step in our study as it might change the final results.

The next step of our work will be to use the value based approach and the change propagation concept in order to elaborate new organisations of telehealth. Scenarios-based decision-making technique will be used to determine the new processes that guarantee the value creation of our system. These works will allow to determine the advantages of the telemedicine and to organize its large-scale setting-up at the regional and national level.

6. Conclusion

Most of the economic studies in the medical sphere focus their analysis on the comparison of the outcomes of a project and its costs. But the difficulty is that these methods do not help to design processes of new organizations like telehealth because they only focus on choosing the most cost effective process and not designing it.

We propose a new method based on value creation and system approach to help design organization in healthcare. We investigate a first experiment of telehealth named Télégéria at the European George Pompidou Hospital, realize workshops and assist to dedicated conferences in order to extract a first set of value creation for each of the stakeholders. Based on these interviews, we proposed taxonomy of value in order to design the future processes of the new organisation.

Even if these are the first results we think that in the future, our method will help to design an efficient approach to design system integrating cost and other constraints like social, environmental and organizational values. Our future research will be to validate our method on other experiments and implementations. The ultimate goal is to build a robust and generalizable model to simulate and optimize value creation in the healthcare context.

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