Economic comparison between Hospital at Home and traditional hospitalization using a simulation-based approach

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***Abstract*— Hospital At Home (HAH) is a concept slowly expanding over time. At first this type of organization was used to accomplish low-technical tasks. The main objective was to increase bed availability in hospitals for new patients. Nowadays, HAH structures are able to undertake more technical complex care such as (but not limited to) end-of-life care, chemotherapy and rehabilitation. This article accomplishes two main objectives: (i) in the first part we propose a comprehensive literature review dealing with the comparison between traditional hospital and home care structures from an economic standpoint, showing that results are highly dependent on initial conditions of the study (patient health state, territory settings, bio-medical parameters); (ii) in the second part we propose an unbiased economic comparison approach between health care provided in traditional hospital and home care network using formal modeling with Petri nets and discrete event simulation. As an example for the comparison a multi-session treatment is proposed. Various scenarios are tested to ensure that results will be maintained even if initial conditions change. Relevant performance indicators used for comparison are economic costs from the point of view of the insurance and economic costs related to the consumption of resources. This work was founded by the Rhône-Alpes region in France as a part of OSAD project.**

Keywords- HAD, HAH, Hospital at Home, Cost comparison studies, Simulation.

I. INTRODUCTION

Hospital At Home (HAH) is often presented as an important organization of health care in developed countries. This alternative is interesting for several reasons, such as expanding the coverage of rural regions and increasing patient satisfaction. The economic stake is to maximize the benefit of these advantages avoiding drastic costs increase. Comparing HAH with traditional hospitalization can provide useful information to healthcare authorities when deciding to create or not new HAH structures.

Experiences of hospitalization at home are not so numerous. Technical care (such as chemotherapy, blood transfusion, rehabilitation…), once devoted to hospital, might now be dispensed at home, but experiences remained local and isolated. The first step of any study is the feasibility at home in terms of bio-medical impact and security of care. We postulate that authorities will not allow healthcare to be done at home if there is a medical risk for the patient. Then the question of motivation for home care will be related to the cost of allocated resources and to patient perspective, including quality of life, access to care when hospital is far from their home, and other satisfaction criteria. For the cost and resources perspective, technical difficulties exist. The first one is the perspective chosen when we calculate costs: what are the costs that will be included? Who is charged with these costs? How these costs will be calculated? Is it long term or short term costs? The result is highly sensitive to these questions and the same situation could lead to different conclusions when different costs are evaluated.

In this paper, we propose a new methodology to make an unbiased economic comparison between HAH structures and traditional hospitalization. To do so, a generic multisession treatment is modeled using Petri nets, taking into account bio-medical parameters and patient health status using the Karnofsky score. Discrete event simulation is then used to assess the model validity and perform a sensivity analysis to evaluate the impact of initial conditions on the results. Finally, various simulation scenarios are established to conclude about the economic pertinence of HAH structures

The remaining of this paper is organized as follow. A comprehensive literature review on HAH versus traditional hospitalization comparison is presented in Section II. The strategy to establish an unbiased comparison between HAH and traditional hospitalization from an economical point of view is presented in Section III. A formal model using Petri nets is presented in Section IV. Data collection and analysis is described in Section V. The simulation study is detailed in Section VI along this the sensivity analysis of initial parameters, simulation scenarios and results. Finally, conclusions and perspectives are proposed in Section VII.

II. LITERATURE REVIEW

A comprehensive literature review is presented in order to understand the added value of HAH structures compared to traditional hospitalization under various conditions. All articles presented in this literature review were published in the nineties and later, implying that home health-care organizations became a fundamental actor in the health-care landscape during the last decade in developed countries. The question about its pertinence and its cost-effectiveness is recent.

The research was conducted in various databases from the nineties to nowadays, including (but not limited to) the National Library of Medicine (of the National Institutes of Health, USA), the Cochrane database, the PubMed database, the Centre for Reviews and Dissemination (of the National Institute for Health Research, UK), the National Guideline Clearinghouse (USA), the European health for all database (of the World Health Organization, Regional Office for Europe) and the Institute of Health Economics (Canada) for the English-speaking bibliography. The bibliographic research strategy is presented in Table 1.

TABLE 1

The literature review is divided in three sections depending on the perspective used for the comparison between HAH and traditional hospitalization: bio-medical perspective, patient satisfaction, and economic stake.

Bio-medical perspective

Some studies show an equivalence or advantage of HAH from the bio-medical perspective for several medical treatments: colorectal cancer chemotherapy (Borras *et al*. 2001), perinatal services (Goulet *et al*. 2001), multiple sclerosis treatment (Chataway *et al*. 2006), dementia treatment (Tibaldi *et al*. 2004), non-massive pulmonary embolism and acute respiratory disease (Rodriguez-Cerrillo *et al*. 2009), hip replacement, hysterectomy, elder illness and respiratory obstructions (Shepperd & Iliffe 1998), chronic obstructive pulmonary disease (COPD) (B. Leff *et al*. 2005; Shepperd *et al*. 2009), cellulites (B. Leff *et al*. 2005; Shepperd *et al*. 2009), and others illnesses needing acute care (Shepperd *et al*. 2009), cardiac rehabilitation (B. Leff *et al*. 2005; Shepperd *et al*. 2009; Richards *et al*. 1998; Hermiz *et al*. 2002), community-acquired pneumonia (B. Leff *et al*. 2005; Shepperd *et al*. 2009). HAH is also an effective healthcare provider for elder patients requiring acute care and suitable for early discharge (Richards *et al*. 1998; Hermiz *et al*. 2002; Bruce Leff *et al*. 2009; Bruce Leff *et al*. 2008) and for behavioral disturbances such as agitation, aggressiveness, feeding and sleeping disorders (Tibaldi *et al*. 2004).

Patient satisfaction

Patients at home satisfaction was also studied in various studies: satisfaction is generally higher compared to traditional hospitalization (Borras *et al*. 2001; Goulet *et al*. 2001; Richards *et al*. 1998; Hermiz *et al*. 2002; R. S. Taylor *et al*. 2007; Shepperd *et al*. 1998) but not in the case were the bio-medical output was not adequate (Shepperd *et al*. 2009). It also has been proven that patients who already had a care episode at home are more favorable to HAH than traditional hospitalization (Rischin *et al*. 2000; Barcala *et al*. 2006).

Economic stake

As said before, there is an economic stake by introducing HAH in the healthcare system. Some studies compare both alternatives with different economic criteria founding that HAH can have economic advantages over traditional hospitalization (Borras *et al*. 2001; Chataway *et al*. 2006; B. Leff *et al*. 2005; Carrère *et al*. 2008; Remonnay *et al*. 2005). In these studies, it has been proven that the use of additional resources was not significant. A very important issue when comparing structures with economic criteria is the nature of the cost studied and who is paying for them.

From the insurance point of view, HAH is interesting in some studies (Chataway *et al*. 2006; B. Leff *et al*. 2005; Barcala *et al*. 2006; H. Anderson *et al*. 2003; Oterino-de-la-Fuente *et al*. 1998; Launois & Perrocheau 1996; Coast *et al*. 1998; Vergnenègre *et al*. 2006; Frick *et al*. 2009; C. Anderson *et al*. 2000). In some cases the economic pertinence of HAH compared to traditional hospitalization depends on patients' health status and disease gravity (Borras *et al*. 2001; Goulet *et al*. 2001). Contradictory evidence was found in (Shepperd & Iliffe 1998), (Frick *et al*. 2009) for COPD. For the same authors differences in points of view and cost analyzed make impossible to conclude which is the best structure (Shepperd *et al*. 2009).

From hospital perspective, HAH delivery of healthcare services can be more expensive (Rischin *et al*. 2000). In particular, medicines are less expensive when managed directly in a hospital pharmacy (Launois & Perrocheau 1996). This problem can be solved if the HAH structure works directly with a hospital pharmacy.

Finally, it is difficult to conclude about the economic pertinence of HAH compared to traditional hospitalization:

- From the insurance point of view, HAH organization can produce savings for definite illnesses, especially for those with long treatment but where the care is punctual, like end-of-life care and rehabilitation issues.
- HAH can produce the same bio-medical outcome quality with fewer resources. However, such economic benefit has not been proven on the long term, especially taking into account long multisession treatments. Additional factors may impact the economic viability of HAH structures, such as social and epidemiological parameters, or drastic changes in health policies that can occur.
- Results are highly dependent on the initial conditions of the study: geographical distribution of patients, health status of patients, or resources to take into account.
- Patient health status impact on economic pertinence of HAH is unclear: high cost variation may occur when long term illnesses are treated.

Economic comparisons using traditional approaches are difficult to perform when introducing a new pricing scale for activities, materials or medicaments. Difficulties to calculate costs in reality tend to prove that the question about the most efficient structure cannot be answered in absolute terms but in some conditions-dependent terms.

The proposed literature review is summarized in Tables 2 and 3. In Table 2, articles comparing home-based hospitalization and traditional hospitalization with non-economic criteria are presented, including results of the comparison (advantage/disadvantage for each), type of study and used criteria. Table 3 present results of the comparison with economic criteria (illness, amount of patients, costs taken into account, stakeholder).

TABLE 2

TABLE 3

Finally, in Table 4, the research articles are classified regarding to illness and criteria (bio-medical impact, quality of life, patient preferences, caregiver stress, costs).

TABLE 4

III. MAKING A UNBIASED COMPARAISON BETWEEN HOSPITAL AT HOME AND TRADITIONAL HOSPITALIZATION

Position of the problem

The literature review proves that comparisons between hospital at home and traditional hospitals is well assessed from a clinical point of view. However, economic comparisons are lacking, implying additional investigation. Therefore the question about unbiased comparisons is approached in this article using a formal simulation model as well as a sensivity analysis of initial parameters.

To do so, we chose to describe a generic multisession treatment, which requires various care episodes for patients (such as chemotherapy and blood transfusion for Myelodysplastic syndrome). The proposed model must be generic enough to be applied to a wide range of care. In this case, a treatment is made of a certain number of sessions following a therapeutic plan.

As shown before, comparisons from an economic standpoint are difficult to undertake for three reasons:

1. *Point of view:* Costs and resource consumptions vary depending on the actor. Hospital point of view is often used for cost calculation in the literature (Lanois & Perrocheau 1996, Rischin *et al.* 2000, Oterino-de-la-Fuente *et al*. 1998 and Shepperd *et al*. 1998). Studies from the hospital standpoint can only be used to adjust organizational strategies of hospitals and not healthcare system policies. To develop these policies, society perspective should be preferred because of its higher standpoint; moreover, changes in actor's behaviors and resource consumption in the whole system should be studied.
2. *Costs of resources:* It can be useful to compare structures using resource consumption along with costs. In this case, time horizon must be taken into account (especially in the case of multisession treatments where resources costs can vary) in order to provide an unbiased comparison.
3. *Assignment of patients to structures:* HAH structures and hospitals have different advantages. A structure may be able to provide care for certain illnesses with a lower cost. Thus comparing hospitals and home-based structures without taking into account treatment characteristics and patients assignments can result in a bias for the study. For example, it may be interesting to define different rules to assign patients to HAH structures by using precise parameters such as distance from home to hospital or patient health status.

In order to perform an unbiased comparison between HAH and traditional hospitalization, we propose a new strategy taking into account the aforementioned remarks. A formal modeling using Petri nets (Proth & Xie 1995) is proposed to describe a generic multisession treatment that could be undertaken by HAH structures or hospitals indifferently. A discrete-event simulation model is also proposed to test various bio-medical and organizational scenarios. Discrete-event simulation (DES) is an useful tool to compare different structures without bias, as it will be explained later. This tool has proven to be a successful in healthcare optimization problems(Buthion *et al*. 2010) and especially for multi-session treatments simulation (Santibanez *et al*. 2009) like the reduction of waiting times (Sepúlveda *et al*. 1999); improvement of patients flow (Baesler & Sepúlveda 2002) and planning of activities (Werker *et al*. 2009), increase capacity (Eldabi *et al*. 1999) or as a decision aid tool (Angelis *et al*. 2003).

Assumptions The following assumptions are taken into account:

1. The point of view of the society is preferred, even if impacts of policies on hospitals are important.
2. Main performance indicators are (i) use of resources (cost of human and material resources) and overall costs, that are detailed below.
3. Treatment characteristics are defined for all patients, as well as the structure assignment decision taking into account biomedical parameters.

IV. MULTISESSION TREATMENT MODELLING

Patient health status modeling

Patient's health status is the most important setting of the model considering bio-medical parameters because it determines in a multisession treatment (i) the number of session of each protocol, (ii) the length of sessions, and (iii) it can be used to implement a selection rule (treatment at home or in the hospital). In order to model patient's health status, we choose the Karnofsky Score, defined in Table 5. It will be updated by using Equation (1), where *b* is a parameter that can be adjusted depending on the simulation (as shown in Section VI). Patients will leave the system if (i) the Karnofsky score turns to 100 (full recovery) or 0 (death), (ii) there is a serious incident in a session (patient is transferred to an acute care unit), or (iii) the treatment is finished (protocol complete and no new protocol). If the Karnofsky score decreases drastically, medical activities in the health-care session will be lengthened (patient in a bad condition). The length of sessions is updated with and adjustment time inversely proportional to the Karnofsky score as shown in Equation (2).

TABLE 5

$$\text{New Karnofksy} = \text{Karnofsky} + \text{TRI}(-b, 0, b) \quad (1)$$

$$\text{Adjustment} = \frac{\text{adjustment time}}{\text{Karnofsky}} \quad (2)$$

In addition, the following assumptions are proposed to stick to the reality:

1. Transportation of patients from home to hospital will be reported to insurance for reimbursement.
2. Delivery services of medicines at home have infinite capacity.
3. Processes inside the pharmacy do not have an impact on the overall cost of system, so it can be neglected in the process modeling.

Process modeling using Petri nets

Petri Nets (PNs) provide a logical representation of the simulation, readers are referred to (Proth & Xie 1995) for introduction and presentation of Petri Nets theory. Figure 1 presents the Petri net modeling of a generic multisession treatment, composed of four main processes: (i) setup treatment (sub-net SN1), (ii) control session (sub-net SN2), (iii) setup session (sub-net SN3), and (iv) the session itself, that can occur at home (sub-net SN4) or at the hospital (sub-net SN5).

A multi-session treatment is characterized by the repetition of an unchanged health-care session. The process starts with the definition of treatment (i.e. main medicine, number of sessions and place of session). Before each session, a control is performed to establish if patient's health status allows the session to continue as planned. Results from this control can trigger a consultation with a specialist where the treatment will be redefined. Finally, the session is realized as planned in the treatment.

[FIGURE 1]

Resources: Four resources are considered in this example: (i) Nurse (Pr3), (ii) Specialist (in case of chemotherapy is oncologist, Pr1 in the petri net model), (iii) Coordination nurse (Pr2) and (iv) Hospital Beds (Pr5). Some coordination activities require a medical expertise, like receiving information from patients and the coordination activities in the setup of the session. These activities are performed by coordination nurses while the medical activities are performed by nurses.

Processes: Setup treatment process starts when a patient arrives to the system. If a patient enters the system when it is closed, he will wait until next day (but this time will not be counted in the waiting time). Since some patients have to come back after sessions, it is difficult to manage daily arrivals in both structures separately. The entity (patients) flow through model is the following: patients arrive to hospital [T0] where treatment is defined by specialists and coordination nurses. After registration [T1] the patient enters in the consultation [T2] with the oncologist [Pr1] where the treatment will be defined. Then, a coordination nurse [Pr2] will gather the relevant information [T3] and a nurse [Pr3] will evaluate the parameters and apply the selection rule [T4]. This selection rule is used to decide if a patient can apply to home-based treatment or not. Since this decision can drastically change the performance of the system, different scenarios will be tested during the simulation. The following transition correspond to coordination activities such as ensure human resources for treatment (assign a responsible or contact the free-lance nurse), ensure material for treatment and ensure support medicaments [T5], all performed by a coordination nurse [Pr2]. After transition [T4], the process of control session begins. Orders of biologic samples will be sent [T6] and two different paths can be taken. If patient's Karnofsky score is below a certain value of parameter *"Karnofsky limit to send a nurse to take biologic samples"* a freelance nurse will be sent at home to take the samples [T7], otherwise it is assumed that patient will do the necessary to procure biologic samples results from a laboratory [T8]. Depending on the results of the biologic samples analysis, the authorization of the session [T9] is given by the specialist [Pr1]. If results of this analysis are bad, a consultation [T10] with this specialist [Pr1] is triggered. These two decisions are controlled by parameters *"green light percentage"* and *"Sessions cancelled after consultation"*. Otherwise the process continues.
If the session is authorized, the process of setup session is triggered. This process starts with three activities of setup, similar to the ones done already for treatment: Ensure the human resource for the session, ensure materials for the session and ensure the session medicines (in the case of chemotherapy, send the chemotherapy order to pharmacy) [T11]. These three activities are performed by the coordination nurse [Pr2]. The session can be held at home or at hospital. Session at home (sub-net 4) begins with the activity of installing patient in bed and performing some control

operations (such as controlling patient's blood pressure and temperature) [T12]. Then equipment is installed [T13] and the free-lance nurse [Pr4] waits until the end of session [T14] or until an incident occurs. In order to simplify the model we assume that incident arrive only at the end of session time. Since both structures are equivalent from the bio-medical output standpoint, this probability is the same. A real-life example can be found for ambulatory chemotherapy in (Buthion *et al*. 2010), where authors analyzed historical data and found probability close to 0.018%,. In case of incident, patient must be transported to hospital and will exit the process [e1], otherwise start over the control session process [T22].

If session is held at hospital; activities can differ. Patient must register [T15] and wait until a bed [Pr5] is free to be installed [T16] by a nurse [Pr3]. Control operations and the install of patient are done [T17]. A difference with session at home is that while patient is waiting for the session to finish [T18], the nurse is idle to perform other operations. When session time is past, the nurse [Pr3] finish the session (uninstall patient, cleaning material, update patient's file and so on) [t19]. If an incident occurs, patient exits the simulation [e2] otherwise the process of control session (for the next one) is triggered [T21].

In the following section, we describe the data collection performed during a field observation in order to provide relevant inputs to the simulation model.

V. DATA COLLECTION

Data was gathered during three weeks of field-observation in a HAH coordination network and in an outpatient service of a hospital in Lyon (France). The observation was focused on modeling the process including relevant resources, activities and interactions between them. At hospital the process is performed in two units: (i) a coordination unit, where treatment is defined and consultations were held; and (ii) an outpatient unit for the session itself. The coordination unit is composed of specialist and coordination nurses while the outpatient unit of the hospital is composed of beds and nurses. Pharmacy related process is not taken into account in this work, because they have the same behavior at hospital and home-based treatments for the most part.

The HAH structure shares the coordination unit with the hospital but healthcare services are delivered differently: coordination nurses contact free-standing nurses to perform sessions at home. These free-standing nurses are an abundant resource, especially in urban zones. In case of an accident at home, the patient is transported to the hospital by ambulance.

Costs of treatments are calculated taking as an example the ambulatory chemotherapy in France. Obviously, these parameters must be adapted depending on the pathology and the country. Costs are calculated from the insurance point of view. At hospital, the price paid by insurance is the sum of: (i) price for staying in the structure, (ii) price of medicine and (iii) transportation of the patient. Current price for staying at hospital is 379.14 €. Price of patient transportation is equal to 11.48 € + 0.83 €/Km.

Cost of session at home-based structure has a fixed part and a variable part. Fixed part is the sum of 101.01 € for coordination activities, and 23 € for authorization of the doctor. Variable part is the working time of liberal nurse: 47.25 € if the session length is less than 1h30, and 31.5€ + 18.5€/h otherwise. Cost of medicine delivery is 0.7 €/Km.

Due to difficulty of gathering real data (Santibanez *et al*. 2009) some parameters in the model must be calibrated. To do so, a sensitivity analysis is required as presented in Section VI. These special parameters are the (i) the Karnofsky threshold to send a nurse to do the control visit, (take the biologic sample in the example) that is set to 40, (ii) the health factor adjustment (5 min) for changing operations time and (iii) the Karnofsky score change after a session (initially set at 5 Karnofsky units).

Finally, required parameters for the simulation model are listed below. These parameters are used to define simulation scenarios.

1. *Structure selection rule*: this rule is used to send a patient to a home-based treatment or not. Four different rules are tested: (i) when a desired bed load at hospital is reached, the following patients will be sent to the home-based structure; (ii) using a certain percentage threshold (for example 50% of patients are sent to each one); (iii) based on the approved list of medicines. Some legislation forbids delivering some medicines at home. This means that all possible medicines will be delivered at home. (iv) healthy patients will be kept at hospital. Since insurance will pay an average price for treatment, patients consuming fewer resources (in a good health status) will be sent to the structure with higher marginal costs.
2. *Resource amounts*: number of beds at hospital, nurses, coordination nurses and oncologists.

In the following key elements of the simulation model such as parameters, key performance indicators and simulation elements are presented in the following section.

VI. SIMULATION

Model validation and sensivity analysis

A sensitivity analysis of the hypotheses is proposed in order to know their impact on costs, thus eliminate the bias in the comparisons. Hypotheses in the model are modeled using variables (Karnofsky limit to send nurse to take biologic samples, adjustment health factor, Karnofsky change after session, green light percentage, and percentage of cancelled sessions after consultation). Table 6 presents the impacts of the hypotheses as a percentage of costs for the insurance.

TABLE 6

The model was validated by tracking a group of patients through the simulation in various scenarios, including extreme cases (increase of demand), in order to prove that logic behind the model is valid. The model was extensively discussed with health-care professionals and practitioners of a territorial network of healthcare (an example of a home-based structure treated in this article). As presented in Table 6, results are not sensible to most of the hypothesis. The most sensible parameters are the change of the Karnofsky score after the health-care session and the percentage of canceled sessions after consultation. These two parameters were set by trial-and-error until the total number of sessions in the simulation was close to reality.

Simulation results

Various experiments are provided to show how results on economic comparisons can change depending on the parameters of system. The first important question to study is patient triage: which patients should leave hospital to be treated at home? In reality this decision is taken by the doctor responsible of treatment and the patient. However, it is difficult to model such decision because various types of parameters (social, medical, affective) are taken into account. In this first experiment, we model the decision using four different selection rules, based on: (i) a certain percentage of patients, (ii) the occupancy level of outpatient unit, (iii) the approved list of medicines (French legislation forbids to give home-based treatments for some medicines) and (iv) the health condition of patients.

Required number of replications to ensure a confidence of 95% for different measures was 25 (Kelton & Law 2000). These experiments were performed using 1,000 patients arriving in the system with an inter-arrival time following an exponential distribution with a mean of 40 minutes. In order to compare results, a base scenario is simulated. The simulation horizon is 200 days. Hospital is open 10 hours per day; however, if resources are busy after closing time, they must finish their actual task (overtime). This is why reported resource utilization may exceed 100%.

Different hospital configurations were tested by changing the number of available resources (beds, nurses, coordination nurses and oncologists). 10 different configurations constitute the experiments, presented in Table 7. In the base selection rule (BSR), all patients are treated at hospital The index of the scenario is given in the first column; the scenario code *a.b.c.d* stands for: *a* number of beds, *b* number of nurses, *c* number of coordination nurses and *d* number of specialists at hospital. The table presents the total cost for the insurance, the average percentage of utilization for every resource and the number of protocols and sessions. Relevant performance indicators are the different costs for the insurance and the resource utilization for the hospital. In the following, several selection rules will be tested and compared with the «normal» behavior of the hospital.

In Table 8 and Table 9 the mean values (of different configurations) of key performance indicators for each selection rule (SR) are presented. Scenario number 1 of the BSR in Table 7 was used as base scenario tables 8 and 9. In Table 9, columns two to four presents the occupation rate of the respective resource and column six present the average waiting time in minutes.

TABLE 8

TABLE 9

Several facts are shown in these results. For example the changes in resource consumption show us how opening of a home-based structure will change the assignments of resources at the hospital. Bed utilization can be highly reduced (around 55% in pools selection rule) showing how HAH can be used to control both the flow of patients and the consumption of resources at hospital. Obviously, such decrease in bed utilization is counter-balanced by an increase in the utilization of coordination nurses (around 22% in the same SR). This is important because, even if it is not in within the scope of the study, there will also be an increase use of free-standing resources. In this study we suppose that regions where patients live have enough free-standing resources to undertake the demand hospitals will not accept (which is the case in the Lyon region). However, there can be a leak of free-standing resources in low populated territories or high standing cities making the development of HAH difficult.

The main difference between SR(i) and SR(ii) lies in the fact that in SR(i), specialists must only know the percentage of the patients that he has already sent in each structure without taking into account levels of activities. In SR(ii), specialists must know the current level of activity of the fixed and home-based structures. Such results compound with the findings of (Armstrong *et al.* 2008), where authors showed that a lack of "pressure" on oncologist was the main explanation of a low activity level in the home-based structures.

In France, legislation forbids the delivery of certain types of chemotherapy at home. This type of decision can be adapted to the multi-session treatment studied in this article. Every year a new list of authorized chemotherapy molecules is available. SR(iii) delivers the treatment at home every time that the specialist has prescribed an authorized medicine, otherwise the patient will be treated at the hospital. The results of SR(iii) are similar to SR(ii). These results are highly dependent on the probability of choosing authorized treatments. In this case specialists are critical actors since they will define the behavior of the system.

Another important issue that can affect the results on economic comparisons is the cost of free-standing resources. This cost change often in reality. In some low density regions or high standing cities, free-standing resources are expensive. In other regions they can refuse to deliver high technical care, leading to the need of using additional and costly resources. Economic comparisons cannot neglect the possible change in free-standing costs.

Discussion

It may be difficult to control the patient flow at hospital using only one selection rule. In reality, decision makers will use a mix of selection rules depending on features of the structures, nature of the territory and other information. **If decision makers are interested in marginal costs, they might prefer the pool selection rule** since it gives priority to structure that have expensive fixed costs. To the contrary, **if decision makers are concerned about coverage of hospital, they may choose one based on authorized medicines and encourage sending patients to HAH**, leaving space at hospital for other types of treatments. It is difficult to give a "golden rule" for selection of treatment location.

Results on economic comparisons can change if parameters of the system change. Discrete-event simulation is a powerful tool to overcome these changes giving the decision maker the opportunity to test different scenarios before taking decisions. Introduction of health status and geographical distribution of patients in the simulation let us know the importance to treat the question about the economic pertinence by specific scenarios and avoiding universal conclusions. These aid-decision tool can be used to explore different possibilities about the system (concurrent hospitals, urban-rural geographical distributions) about the treatments (changes in incident probabilities and operational times) and about the structures (available resources, resources schedules and capacities).

VII. Conclusion and perspectives

Economic comparisons of structures are difficult to make because of various aspects involving the stability of conclusions and results in time. One of the main reasons is the difficulty to make a neutral comparison taking into account the original purpose of structure and environmental conditions. In order to overcome these difficulties an approach that takes into account both health status of the patient and demographic information was proposed. This approach lets us compare and study different structures for delivering a multi-session treatment at hospital and/or at home. Four selection rules have been tested in order to study the possible behavior of the system when offering home based services and its impacts inside hospitals.

It is important to consider also the role of specialists, even if a coordination cell exists to decide the location of treatments: specialists can prescribe a medicine that is not included in the authorization list and patient will not even be considered for a HAH. A lack of "pressure" or motivation to send patient to HAH structures can be an important factor of the economic failure of these structures (even if their utilization would result in a better global economic performance). This is why it is very important to give them high quality information about the actual state of the hospital (level of activity, use of critical resources and economic strategies) at the right time.

As it can be seen, HAHS can be used to control and improve patients flow on hospitals. Decisions about offering a multi-session treatment at home must be taken, not only because of economic impacts on hospitals, but also because it follows strategic goals of the organization. This decision must be issued following a strategic analysis. Some important questions are: How newly available beds should be used in the hospital? Which territories will be covered? What is the best logistic strategy for delivering the medicines?

The next step of this study consists in introducing more elements of decision like the localization of the hospital (rural or urban), potential new treatments at hospital, professionals skills and additional activities like routes planning. New selection rules may be designed to take into account information about geographical position of patients of patients, or economic status of hospitals. Another perspective may lead us to consider pharmacy activities and liberal nurses conditions (capacity and probabilities to refuse some patients). These activities can be critical in other HAHS.

Finally, it may be interesting to introduce elements regarding production and distribution of medicines. Some important question that may be studied in the following are: Which is the impact of the pharmacy operations in economic performance of structures? Which is the impact of geographical distribution of these pharmacies? What are the impacts inside structures caused by changes in geographical distribution?

VIII. Acknowledgements

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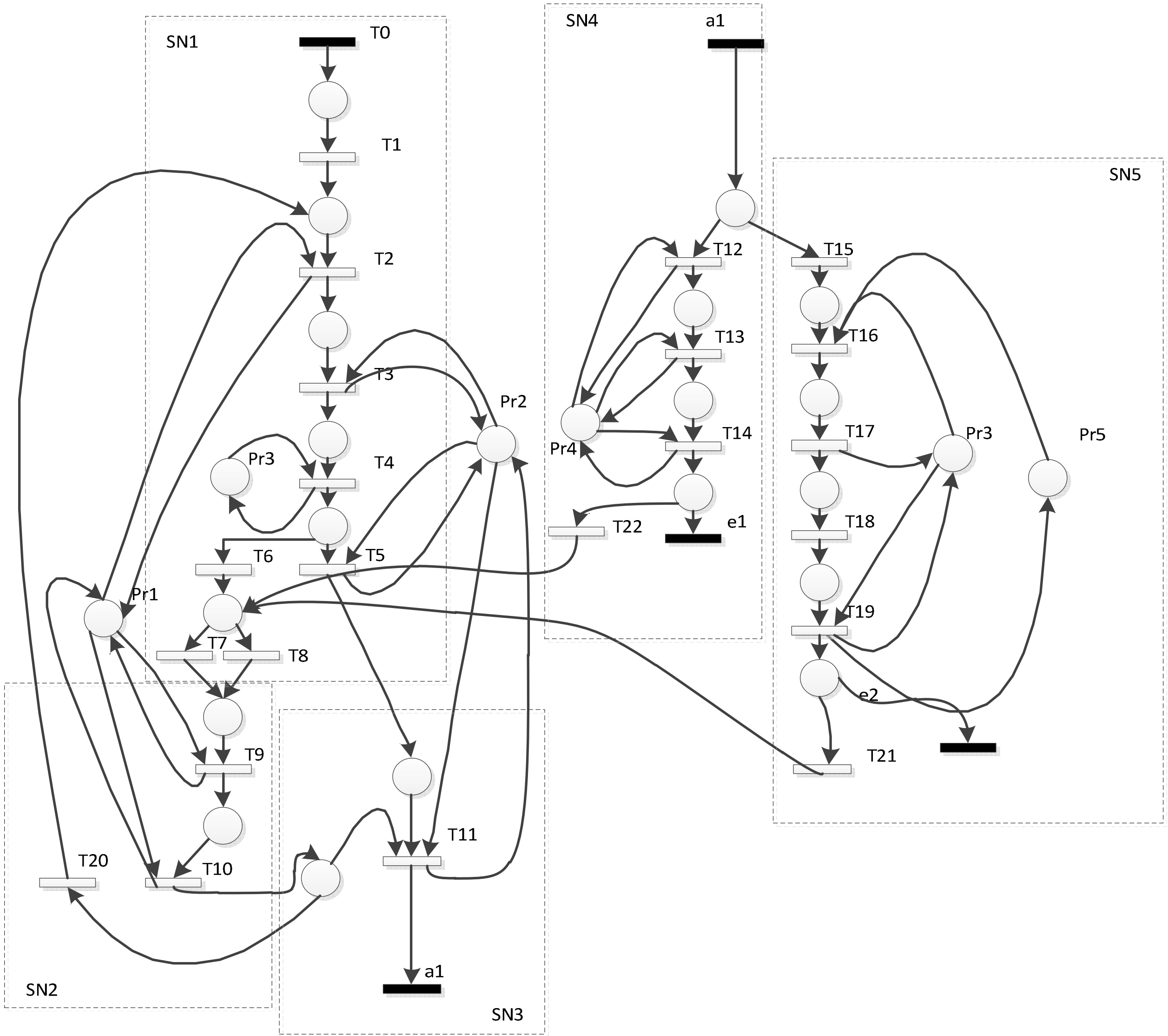

Figure 1: PN model for NBNN

TABLE7

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