PETIT N., DUCROCQ C., 2017, « Using TDABC to calculate costs in a hospital transport service », *Gestion et Management Public*, vol.5, issue 3, 2017/1, p.59-80 [ISSN: 2111-8865]

Using TDABC to calculate costs in a hospital transport service

Nicolas PETIT[1], Charles DUCROCQ[2]

Résumé

Cet article présente une expérimentation d'application du Time-Driven Activity-Based Costing (TDABC) aux coûts du service transport d'un établissement hospitalier public. La méthode déployée et les résultats obtenus sont décrits, faisant émerger l'intérêt de ce type de démarche pour la gestion opérationnelle de la logistique hospitalière. Les auteurs mettent en avant les intérêts et les limites de la méthode, applicables à d'autres domaines de la gestion publique.

Mots clés : hôpital, transport, coût, TDABC

Using TDABC to calculate costs in a hospital transport service

Abstract: This paper describes the experimentation of the Time-Driven Activity-Based Costing (TDABC) method to model the costs of the transport service of a public hospital. The method and results obtained are described, bringing out the interests for the operational management of the hospital logistics. The authors highlight the interests and limitations of the method, applicable to other areas of public management.

Key-words: hospital, transportation, cost, TDABC

Introduction

The consumption of hospital care in France represents more than 80 billion euros per year, with a rise well above inflation (DREES, 2013). 25% of hospitals have had a deficit for at least three consecutive years, and the context of public expenditure restraint does not allow for an increase in hospital resources. Hospitals face a challenge to develop new and efficient business models.

The actions focused on patient care, with the introduction of a mode of financing of healthcare institutions based on the acts carried out: activity-based pricing.

A number of management studies have investigated the impact of this method of financing healthcare institutions (Krief, 2009, Noguerra and Lartigau 2009, Pouvourville 2009, Guerrin and Husser, 2011). Escaffre (2008) discuss its use as a management tool: its primary nature is to set a financing system based on the activity carried out. Activity pricing may eventually provide objective costs for the care being provided. Halgand and Garrot (2014) confirm the research for efficiency by increasing production and optimizing revenues, and little monitoring of costs.

Within the health institutions, support activities are included in the logistics function, with characteristics specific to hospital organizations (Chow and Heaver, 1994; Beaulieu and Landry, 1999). These support activities are usually evaluated in traditional way in management accounting (catering and its cost of the meal, laundry and its cost of the kilo of linen, cleaning and its cost of m², transportation and its cost of km…). They are allocated to care or distributed via volumetric

[1] Enseignant-Chercheur à l'Institut Franco-Chinois de l'Université Renmin de Chine

[2] Professeur à l'Université Paris Descartes, CEDAG (EA 1516)

distribution keys (number of patient days, number of beds and places...).

We decided to focus on field hospital transport for various reasons:

- In a hospital, transportation is not as repetitive as other programmable and logistics business: apart from collection or distribution of medical products, time demands fluctuate, unlike industrial based activities, such as catering or laundry.
- Calculating the cost of a single kilometre may include disparities related to the type of transport (illness, equipment, analysis, blood, etc.), the autonomy of the patient (patient sitting or lying down), number of paramedics (one or two paramedics in a vehicle), waiting, returning empty, the simultaneous transport of patients and products, etc.
- Volume of activity. This leads to a variety of situations caused by a limited knowledge of the transport industry, an inability to assess or predict specific human resource needs or the need to subcontract with private carriers in the case of more than average activity.
- Official full cost calculation: focusing on care is already a very complex issue. The diversity of the transport business is often not taken into account and the transport business is simply considered part of indirect costs with a too simple method of distribution.
- There is a real need to have a monitoring tool for hospital transport costs.

The French court of auditors (Cour des Comptes, 2012) highlighted a concern about patient transport and its potential : in France, it costs 3.5 billion euros each year to the national health insurance (without taking into account transport carried out by the healthcare institutions themselves), for 65 million journeys made and more than 5 million patients concerned. These transport expenditures have risen sharply (over 60%) over the last decade, even more than the overall increase in health insurance expenditure (40%). Transportation by health care institutions (mainly intra-hospital transport) is not estimated. Nevertheless, the general trend towards groupings of establishments leads to an increase in these transports: transport between two sites is considered, before consolidation, as an inter-hospital transfer, in charge of the national health insurance and becomes, after consolidation, an intra-hospital transfer, and therefore in charge of the hospital. The Cour des Comptes considers that it would be possible to save 450 million euros only by better controlling the services invoiced and the conditions of the transports. This illustrates the potential for future improvement in the field of medical transport and the importance of empowering hospital logisticians to manage the costs of such activities.

Noting that the measurement of volume or cost of transport activity in hospitals is not satisfactory, our research sets out to discover how monitoring of transport activity and the cost of hospital transport can be improved. The TDABC (Time-Driven Activity-Based Costing) method, proposed by Kaplan and Anderson (2004), has aspects that seem to meet our research concerns. It allows hospital transport to be considered as a separate entity, measures the time consumed by an activity, integrates different events (waiting, emergencies) that affect this activity, estimates the normal capacity of each resource group, warns of unused capacity, evaluates the cost per unit of time (minutes) or deducts the total cost of an activity (internal transport of laboratory tests or transferring a lying down patient from hospital A to hospital B).

De La Villarmois, Levant and Zimnovitch (2012) concur; they put forward the idea that the TDABC is particularly adapted to the logistics function, because of its compatibility with unstable environments and the reactivity capabilities allowed. Some activities do not always consume the same amount of resources in all cases. Therefore, rather than defining separate activities for all possible cases, the TDABC approach makes it possible, thanks to the time equations, to take into account the diversity of situations. A US study (Kee, 2012) seems to show that the TDABC reduces the cost of public services, and a more efficient and effective use of resources through process improvement.

Our research consists in experimenting with the TDABC for hospital transport, modelling this activity, that is to say in the sense of Le Moigne (1990) to carry out a purposeful development and construction of a model capable of making understandable a phenomenon, and amplifying the reasoning of the actor, projecting a deliberate intervention within this phenomenon . We adopt a method of field research, qualitative, following a research-action approach (Liu, 1997) in a hospital in particular. This approach allows us to be at the heart of the transportation service, to engage in a reciprocal interaction between the researcher and the environment. The work of Everaert et al. (2008) provides an example of the use of TDABC in this logistical context, with the benefits and limitations to be expected. Other examples in the hotel sector (Dalci et al., 2010, Basuki and Dwiputri, 2014) show the value of this type of approach with TDABC. Our work will make it possible to compare the results obtained with some of the few studies on the TDABC for transport, thus contributing to a better knowledge of its contributions and limitations.

Thus, the contributions of this paper focus on the interest of developing a cost calculation relevant to the support functions of healthcare establishments, its application to a particular logistic activity that is transport, as well as the study of interests and limits of the TDABC. We will analyze these advantages within the framework of the expected purposes of the cost calculation methods and of the TDABC in particular.

A first section presents the theoretical and methodological framework of our research: a presentation and a critical analysis of Time-Driven Activity-Based Costing (TDABC), an overview of the legal characteristics and constraints of hospital transport, how we will associate the two concepts, the TDABC and health transport, by developing our methodology around a research-action approach.

A second section describes our action-research approach for the implementation of TDABC in a health transport service, including time equations, capacity management, taking into account waiting times, transport costs, the management of malfunctions linked to unforeseen events or the recording of time.

A third section aims to enrich the academic knowledge of the TDABC, of which there are few examples of observations. To do this, we will compare the difficulties encountered and the results obtained with the literature on the TDABC, we will evaluate its feasibility and its potential by studying the possible exploitation of this type of approach for a transport service hospital.

1. Experience of implementing TDABC

The calculation of cost can be seen as having two purposes: firstly, to understand how resources are consumed, but also, to provide information for better use of resources (Mévellec, 1995). But the assessment of the cost of a product is not an easy task. Faced with the difficulty of identifying the resources consumed, different solutions are possible (Bouquin, 2011): limit the analysis to the known operation of the organization by calculating incomplete costs, expand data collection in order to have more information, use distribution key related to resource consumption. It is then down to choosing between the wish to integrate the considered charges and the pitfalls of bias due to the integration of indirect expenses. The calculation of costs in the health sector is particularly affected by the problem of the attribution of indirect costs, and is made difficult by the complexity of the healthcare business in itself (Kaplan and Porter, 2011). Kaplan (2014) states that this difficulty can be overcome by using information technologies generating information for accurate allocation of resources to patients, and using a calculation method (the TDABC) authorizing the consideration of the complexity of the overall care variables.

After reviewing the fundamentals of TDABC, we conduct a literature review to identify the strengths and weaknesses of the method (1.1). Hospital transportation, our field of study, has specific characteristics and legal boundaries we need to explain (1.2), before presenting our methodological approach to test TDABC in hospitals (1.3).

1.1. Time-Driven Activity-Based Costing (TDABC)

Kaplan and Anderson (2004) introduced TDABC to palliate some of the criticisms advanced against the traditional ABC system (Demeestère et al., 2009 ; Gervais, 2009 ; Bouquin, 2011), such as multiplication of activities and integrating complex operations, the need for massive data collection, difficulties of updating, the need for powerful tools for information processing and not taking into account unused capacities. TDABC introduced a less intensive level of analysis and the use of a single inductor. The TDABC method estimates charges for each resource group (function, service, team, etc.) based on theoretical work capacity and standard time for each activity.

The total cost of a cost object (product, customer, etc.) depends on three variables: resource i (commercial, warehouse, etc.), activity j (order, pallet return, etc.), event k (emergency, expectation, novelty, etc.). The cost is written as the sum $\sum i \sum j \sum k$ tjk * ci, with ci the cost per unit of time (minute) of resource i, tjk the time consumed by the event k of activity j.

Time tjk is expressed by an equation like $\beta0 + \beta1*X1 + \beta2*X2 + \beta3*X3*X4$; β0 is the constant time for activity j, regardless of the event k; X1, X2, X3... Xn are the drivers of time necessary for the fulfillment of the event k; β1, β2, β3… βn are the times associated with drivers or combinations of time drivers.

Consider a logistics example for the delivery preparation activity (Everaert et al., 2008a); The total time includes two constants (1 min at the start for printing the delivery note, 2 min for the final check on the dock) and five variables (X1 the number of order lines, X2 the number of packages to be loaded, X3 the number of complete pallets to be loaded, X4 the number of journeys to the dock, X5 the number of pallets to be covered with a packaging film); The equation of preparation time of a delivery becomes (in min): 1 + (0,3 * X1) + (0,1 * X2) + (1,5 * X3) +2.

Kaplan and Anderson (2004) describe a six-step approach for the implementation of the method:

- Identifying the resource groups contributing to the achievement of several activities;
- Estimating the cost of each resource group;
- Normal capacity estimation of each resource group in hours;
- Calculation of unit costs for each resource group by dividing the resources consumed by their normal working capacity;
- Determination of the time consumed by activity based on different time drivers;
- Multiplication of resource group unit costs by the time required for the activities.

The TDABC benefits advanced by the authors include: reduced data collection time compared to ABC, ease of equation implementation and update and the fact that the different variables affecting activity and their interactions are grouped in a single time equation. The method is finally described by its designers as able to deliver quickly at low cost accurate and usable data (Kaplan & Anderson, 2007).

Other researchers confirm the advantages over ABC: TDABC offers assistance in decision-making (Demeere et al., 2009; Campanale et al., 2014), accuracy in the calculation of costs (Everaert et al., 2008; Oker & Adiguzel, 2010; Stouts & Propri, 2011), ease in updating the calculation system (Stouthuysen et al., 2010), a good adaptation to internal benchmarking practices (Pernot et al., 2007) and identification of unused capacity (Tanış & Özyapıcı, 2012).

However, the TDABC method is not free from criticism. A review of the literature uncovers some unresolved issues in the methodological presentation advanced by Kaplan and Anderson. First, the indecision between the use of standard costs or actual costs to determine the cost of resource groups has implications when considering sub-activities (Ratnatunga et al., 2012). Second, the normal level of activity and thus the capacity of resource groups are not easy to define (Tse & Gong, 2009). Third, the recurrent problem of homogeneity already present with the total cost methods. Last, but not least, time measurement is complex and difficult and the data obtained by interviewing employees are often biased (Allain & Gervais, 2008; Cardinaels & Labro, 2008; French et al., 2013.). Oker and Adiguzel (2010) warn of the initial implementation of the method, which can be longer and more costly than implementing the traditional ABC. Finally, the method does not resolve the issue of cost variability: reducing the number of activities or activity time does not reduce costs associated with short-term fixed resources.

In the field of logistics and transport, an example of a Belgian company is several times highlighted (Everaert et al., 2008a, 2008b; Gervais et *al.*, 2010) to show that the monthly monitoring of activity and capacity, as well as taking into account complexity, is not possible with ABC. The main problem is that the variability of the work cannot be represented by a single inductor. The authors also find that there are a multiplicity of activities with the ABC method, compared to TDABC (a ratio of one to three), and a problem of homogeneity. This study lists a series of TDABC benefits compared to ABC:

- Increased involvement of managers in the management of profits;
- Opportunities for internal benchmarking;
- An improvement in capacity management;
- An improvement in profitability management;
- An improvement in making logistical decisions with information from TDABC;
- A more accurate estimate of cost than the one obtained using the traditional ABC model.

Nevertheless, the large number of equations and the need to retain a single time unit cast doubt on the simplicity of application.

We will further discuss advantages and limits of TDABS in the discussion of this paper.

1.2. Specificities of healthcare institutions transport

French health transport is regulated by the Code of Public Health. Transportation must be carried out by state-degree owner paramedics. Seated transport requires the presence of only one ambulance driver. Lying down transport or transport requiring medical supervision must be carried out in an ambulance with a crew of two paramedics. The transport of several patients sitting simultaneously is possible. Lying down patients must be transported alone in an ambulance. The transport of blood for transfusions complies with separate legislation, prohibiting the simultaneous transport with a patient. Elements of laboratories (tests, sampling, etc.) or equipment (sterile bins) can be transported simultaneously to a patient or to blood. Medical transport in France is carried out by ambulances belonging to hospitals, or most often by private companies, combining ambulances and taxis activities. This economic model for land transport was the subject of a ministerial report (Eyssartier, 2010) highlighting the need for reform to be renovated. Tensions have recently arisen in the sector due to rising fuel prices and wage increases due to changes in legislation. Moreover, growth in transport costs is evolving more rapidly than the majority of other expenditure, which has drawn the attention of the public authorities. Today, doctors are prescribers of transport and therefore have an important role in the organization of the activity.

Questions arise as to the cost of these transfers, but also as to which institution should take charge of and bill for the transfer. In the state of the legislation, the support of the transfer by one institution or another depends on the length of stay of the patient within them.

A hospital, even with its own ambulance service, has to outsource some transport to private ambulance attendants for reasons of capacity or schedules. In this case, private ambulance companies charge for the journey to the institution, based on the official tariffs of the national convention of private transporters. The pricing modalities are complex. The price charged depends on the type of vehicle used, but also on the distance or length of the journey.

This complexity raises questions about cost, profitability, and outsourcing of this peripheral activity. Knowing the time devoted to the various tasks of the medical transport before deducting costs incites us to opt for an approach in TDABC.

1.3. Action-research approach to experiment TDABC

We should clarify the context and field of study to justify the methodology.

We conducted our study in a French hospital with a capacity of 600 beds and places, with 15,000 admissions per year and a workforce of 800 employees. The hospital is part of a group of three hospitals (later called A, B, C) that share a common administrative direction, while having separate accounting. Its annual budget is 80 billion euros, transport department budget is 330 000€.

At the time of the study, the transport service had undergone significant changes in its working arrangements, resulting in a sharp reduction in the number of patient transport carried out by the service. To address this decrease, the institution's management decided not to replace the former manager of the service when he retired.

The logistics manager for the group of hospitals wanted to initiate a process of thinking on transport within institutions, the hierarchy lacking visibility on the reality of the transport activity. The reduction of resources on the sole volumetric criterion (reduction in the quantity of transport carried out) seemed to him to be irrelevant and provoked protests from the paramedics of the service, decrying the difference in time between, for example, indoor transport on the site of the hospital and a transport to another establishment distant of several tens of kilometers. The information available to him (the overall service budget, the amount of transport carried out according to his modalities) did not allow him to analyze the activity of the service and led to considering outsourcing as the only way out.

During an interview to present his structure and the management of his service, this manager told us of his desire to find a way to overcome this lack of information and to better understand the characteristics of health transport.

Service ambulance workers were confronted with a context of decreased activity and staff downsizing, generating many concerns about the future of their business with regard to the threat of complete outsourcing.

The challenge we faced was the desire of the head of the transport department to have a tool enabling him to process the volume of activity by a unit of measurement more relevant than the kilometre travelled, in order to be able to assess the overcapacity of which his service seemed guilty. As a follow-up, we were are asked to base our research on full cost. The presentation of the TDABC gave rise to the most encouraging comments, summarized by "this we will be able to do".

The logistics director authorized full access to the data and activity of the service, the researcher was free to retrieve the information. The freedom of judgment of the researcher has been permitted by the absence of a paid relationship between the researcher and the institution and by the absence of an obligation to produce results (the information provided should not justify a particular action by management, but to inform future decisions). Finally, the use of time-based data has made it possible to better measure the observed activities.

Our concern is then to find the most appropriate methodology. The limited data available excludes any quantitative research. Qualitative methods give rise to various assessments. Group discussions and semi-structured individual interviews are abandoned because, while they can give insight into the behavior and perceptions of ambulance attendants, and allow for in-depth study of their opinions, the interviews generate only ideas and with assumptions not allowing us to be able to assess the activity of the service. We decided to opt for case method, research intervention method and more generally the methods of observation to follow the operation in real time, without a posteriori reconstitution, without forgetting anomalies.

The method of research we have chosen is one which combines the idea of intervention and experimentation to observe a phenomenon; It is a research-action, research-intervention or research-experimentation. Although there are several types of action research (Goyette and Lessard, 1987, Liu, 1997, David and al., 2000), a common set of characteristics responds to our concern:

• this approach recognizes action as one component of the research process;

• action research is developed in close relation with beneficiaries who become partners; the reciprocal interaction between researcher and environment allows the device to understand the phenomena in a global way and to understand them better; The researcher temporarily abandons the role of external observer in favor of a participatory attitude;

• Different stages follow: a phase of diagnosis, the choice of a course of action, field intervention (materialized by an organizational change, the implementation of a tool, etc.) the assessment of the consequences of the action.

The definition of problematic and research objectives is not based on preliminary theories or assumptions (even if the intervention is based on a theoretical framework) that it is necessary to confirm but depends on the needs of a concrete social situation and practice (Mayer and al., 2000).

The research-action phase took place after a period of reflection limited to exchanges with the head of the hospital transport service. The TDABC orientation was based on the arguments put forward: the need to assess the capacity of the service other than the overall duration of work, to determine activities, to measure the time taken by an activity, to integrate different events (waiting, urgency ...), to deduce the total cost of a cost object (different types of transport of patients or goods).

Our aim is to transform the way we understand transportation to the hospital by implementing a tool called TDABC. The restitution of our intervention results in the modelling of a hospital transport service through the equations of the TDABC.

The term "modelling" must be understood here in the sense of social construct (Le Moigne, 1990): to carry out an action of conception, construction, implementation of a model, a model that aims to make a phenomenon understandable. The reasoning of the actor projecting a deliberate intervention in this phenomenon is central because the researcher has a role, he is not neutral in modelling, unlike another form of more mathematical modelling where quantitative techniques and automated information systems are widely available. When it comes to a social construct, Lacroux (1999) remarks that its contingency and the fact that it is based on particular projects of the modeller relativize, if not its scope, at least its stability and its universality.

The research-action method itself encounters limits. Nobre (2006) sees two main ones: the cumbersome nature of the research process, which imposes an important presence of the researcher on the ground; the results of the research which remain by nature very contextualized despite the quality of collected informations.

In terms of the cumbersomeness of the research process, this study took place over a one-month period of observations. The time equations are based on the analysis and minute-by-minute recording of more than 75 hours (4532 min precisely) of four ambulance workers, divided into 142 observations. This necessitated the presence of a researcher exclusively devoted to recording the observed times during the opening hours of the service. The use of an external society to carry out this type of work would be totally inequitable with the budget of the concerned department.

In addition, it is important to note that the presence on the ground of a person belonging to another social category, a different culture is already a difficulty in itself: the researcher is placed in front of a group, with which he wants or needs to cooperate in order to make his members aware of certain facts and even to modify their behavior. The study was well accepted, despite the conditions for setting up the TDABC, which could be perceived as surveillance (activity timing), but ambulance attendants did not denigrate thanks to a patient explanation about the nature of the research and its goals. One ambulance driver said, "*I remember that in the hospital where my wife is a nursing assistant, the management had done this: they record time needed to clean a patient, then they told them a cleaning is that many minutes, you must make a certain number of them a day, without taking into account the human aspect and all the little things that one may be led to do, it does not make sense.”*

The favorable reception of the study by the ambulance workers comes from its perception as a means of valorising the activity carried out. A reporting in quantity was perceived by the agents as inaccurate, and a valuation in terms of time actually consumed by the activity was perceived as an improvement of the accounting of the work realized by the service. In addition, all vehicle maintenance activities were until then not recorded.

Concerning the contextualization of the results, we have introduced a precision, choosing to use times based on a timing of the real activity and not just declared times, as advocated by the designers of the TDABC. The observation allowed us to define the activities carried out by the transport service, and to determine the time standards of the various elements constituting these activities, thus structuring time equations corresponding to the consumption of the capacity of the service. These standard times are observed times averages, after removal of aberrant observations due to malfunctions.

2. Presentation of the TDABC experiment within a hospital transport service

The identification of activity variables and the development of time equations are a central element of the TDABC system; we detail the way in which we have conceived the time equations (2.1). Each type of transport (patients, blood, drugs) gives rise to a specific time equation; the regrouping of different types of transport and the pooling of transport between establishments are elements of complexity which allow us to test the model (2.2). The head of the hospital transport service himself tested the model; we will analyze the contributions made in practice (2.3).

2.1. Elaboration of time equations

Our experimentation has seen the first steps of the TDABC proceed according to the guide, to arrive at the estimation of the normal costs and capacities of the resource groups (ambulance and vehicles). On the other hand, it is more difficult to determine the activities carried out and to evaluate their standard time; it was at this stage that theoretical and practical round trips proved to be unavoidable. For example, patient transport take several steps: walking from the ambulance to the room, moving the patient from the bed to a stretcher or moving from the chair to a wheelchair, retrieving the patient file , transfer from the room to the ambulance, cleaning of the stretcher, etc. ; We find again the dilemma evoked by researchers in management accounting: either a multiplication of activities to integrate the complexity of operations, or a limitation of activities for a simplification of calculations. Our orientation was to move towards a regrouping under a single name "embarkation / disembarkation of the patient"; after confrontation of the first measures, it was clear that the single activity was too restrictive, in particular because of a significantly different time between the displacement of a patient with little autonomy that must be stretched on a stretcher and a patient who supports a wheelchair transfer. We have thus decomposed the "paramedics" resource for the "patient transport" activity (then noted X73), in two modalities: the lying down patient (mode X30) or the sitting patient (mode X31).

38 activity variables and 10 sorting variables were used to recreate the complexity of the activity of transportation service (the complete list is presented in the Appendix):

• 11 variables relating to journeys made: X10 (intra hospital A route, between two locations within the hospital A), X11 (round trip to hospital B), X12 (round trip in the city center), etc.

• 13 variables relating to operations realized by paramedics at the origin and destination of the trips: X30 (loading / unloading to elongate transfer), X31 (embarkation / disembarkation for seated / standing transfer), X32 (loading / unloading for extended imaging / consultation), etc.

• 9 variables relating to the activities of the garage: X50 (movement of a vehicle to the cleaning area), etc.

• 5 variables relating to the administration of transportation department activities: X60 (data entry at the end of the day), etc.

• 10 sorting variables: X70 (internal transport), X71 (external transport), X72 (shuttle in the morning), X73 (patient transport), etc.

Each activity variable is assigned a time, in minutes. These times are average time observed, adjusted for non-compliant elements (malfunction-related lost time, waiting time, etc.). We have excluded disruptive or facilitator elements in order to calculate the standard time.

The realization of time equations goes through the design of binomial variables taking a positive value when the variable is present in the tasks to be performed. Giving the variables the value of 1 or 0, we established the equation corresponding to the desired conditions.

Table 1 presents one of the equations corresponding to the transport time of the internal patient, i.e., the transport of patients on site between different buildings. These transports are necessary when there is a patient transfer from one service to another or when there is a need for consultation or imaging performed in another building. These transports are characterized by a short journey time and operations that we call "loading / unloading," corresponding to the care of the patient by paramedics and representing a variable time (due to associated activities varying according to circumstances: journeys on foot, transfer from bed to stretcher or from chair to a wheelchair, file recovery, cleaning the stretcher, etc.). The standard transport includes the route from departure of the transport service to the patient's residence, loading, the route to the destination and the unloading and the return of the ambulance crew to transportation service.

Table 1 : Example of time equation: The internal transport of patients

Transport time = 6*X10*X70 + 27*X30*X73 + 13*X31*X73 + 16*X32*X73 + 12*X33*X73 + 2*X34*X73 + 5*X35*X73

The first part of the equation (6*X10*X70) is composed of a time (6 minutes) associated with a variable (X10 - transport inside hospital A) and the sort of variable (X70 - internal transport). 6 minutes is credited for travel between buildings, i.e., internal transportation-related time.

The following two items (27*X30*X73 and 13*X31*X73) correspond to the same sort of variable (X73 - patient transport) under different conditions (X30 - Embarkation /

disembarkation for lying down transfer, or X31 - embarkation / disembarkation for seated / standing transfer). We observe that the average time varies from one to two depending on the patient's ability to stand or not: 13 or 27 minutes.

If there is no patient transfer, but simple transport to imaging / consultation, times are associated with other variables (16 minutes for a lying-down patient - X32, or 12 minutes for a patient in a sitting position - X33). If there is need of oxygenation for the patient (X34), 2 minutes are added. In addition, a need for sanitary isolation (X35) corresponds to 5 more minutes.

Patient transport is not the only paramedic resource group activity. Transportation of laboratory tests, medications, test results, blood and some paperwork are activities that generate other time equations, using the human potential of the service.

The whole activity of the service is thus modelled according to the variables identified as explanatory of the times consumed. The formation of resource groups then allows us to associate a cost to the different journeys according to their time. But the interaction of the 48 variables leads to sometimes more complex time equations.

2.2. Consideration of complexification elements

The use of opportunities, such as transport combinations and wait time management, provide an interesting use of TDABC within CH A (2.2.1). In addition to the optimization of intra-institutional travel, we can analyze transport combinations with other establishments: for example, the CH B carries out a daily shuttle service similar to the CH A noon shuttle; we study the potential interest of combining these two paths (2.2.2).

2.2.1. Exploitation of transport combination opportunities and waiting times optimization

Sometimes transports follow one another, starting and arriving at the same geographic locations. Thus, in each case, by slightly shifting schedules when possible paramedics are able to combine different transports (two patients together, a patient and administration files, etc.) to reduce empty trips.

The phenomenon is common, but it is neither systematic nor documented. It is hardly conceivable that one can integrate combinations of transport in time equations. However, these combinations are performance gains. Using these potential combinations, the service can save time and reduce costs associated with trips. Moreover, the independent external carriers usually charge for their services for each trip and have no interest in carrying out combined trips. Combinations of transport are opportunities for hospital ambulance services to improve their performance rather than outsourcing.

30% of trips observed included a combination of transport. The phenomenon is recurrent. Only some combinations shows a real time saving.

From the time equations, it is possible to simulate various transports, including combinations (table 2), to calculate the wage cost of the ambulance and thus measure the interest of promoting or not combinations of transport.

Table 2 : Examples of combinations associated with transportation savings

Types of combined trips	Separately trips costs	Combined trips costs	% savings achieved
Internal transport of sitting patient + internal transport of laboratory tests	$15.36	$10.32	33 %
Internal transport of a sitting patient + internal transport of a second patient sitting	$18.00	$11.64	35 %
Transfer of lying down patient + transport of laboratory tests from hospital A to hospital B	$134.85	$97.50	28 %
Transfer of an lying down patient from hospital A to hospital B + transfer of another lying down patient from hospital B to hospital A	$186.50	$113.65	39 %

The importance of savings suggests that the transport service must be encouraged to seize the opportunity for combinations as much as possible. This phenomenon was not quantifiable before cost modelling; managers did not realize its importance. Decisions based on data can now be taken to optimize transport management.

Others optimization opportunities exist : sometimes it is worth waiting for a patient to complete a consultation or medical imaging, rather than make the trip back and return later. Again, TDABC modelling allows us to analyze in which case it is worth waiting.

Take the example of a patient to be transported from hospital A to hospital B for a thorough examination with a waiting time, lying down and needing the presence of two paramedics. Is it better that paramedics go back to hospital A after dropping off the patient and take the opportunity to make another run in the interim or is it better that the paramedics wait at hospital B? Table 3 gives us some answers.

Table 3 : Cost comparison with different waiting times

Type of transport	Transport without waiting for the patient (twice the distance)	Transport with patient wait of 45 min.	Transport with patient wait of 60 min.	Transport with patient wait of 90 min.
Time excluding waiting time	172 min. (a)	112 min.	112 min.	112 min.
Total time	172 min.	157 min.	172 min.	202 min.
Cost excluding waiting linked cost	$167.80	$106.00	$106.00	$106.00
Waiting cost	$0	$38.25	$51.00	$76.50
Total cost	$167.80	$144.20	$157.00	$182.50

(a) = 2 times 60 minutes for two round trips between hospitals A and B, plus 52 minutes loading / unloading the patient and administrative record.

Waiting costs calculated here consist of the cost of immobilized resources during this waiting period (idle crew, immobilized vehicle). These do not include the possible outsourcing of transportation not performed by a waiting ambulance. It is impossible without a level of complexity prohibiting any relevant calculation to take into account all the transportation options that could take place during this waiting period. It is then at the discretion of the manager on duty whether it is more advantageous to outsource or to return his crew depending on the type of need and the expected waiting time (which depends on the type of examination, imaging, etc.). These cost calculations decisions can be based on data.

We find that the wait can be profitable up to a certain time. In this example, the 60 minute wait is still economically attractive; however, at 90 minutes it is no longer. This example tells us that for each transport and each destination, wait times are cost effective or not depending on the service activity. TDABC allows us to perform these calculations.

2.2.2. Opportunities of pooling of transport between institutions

Hospitals A and B send transport to the regional capital, the seat of certain essential health sites such as the university hospital, the center of blood supply and the regional hospital logistics center. Part of the travel is done in a section common to both hospitals. Paramedics are already used to meeting occasionally at the common section to deliver laboratory tests from hospital A to be analyzed at hospital B because of the specialization of the institution.

Each hospital sends a noon shuttle to the regional capital. Let us consider the possibility of pooling these two routes. It would be necessary that a hospital A paramedic meet the hospital B shuttle during its trip to the regional capital. They would intersect again when the shuttle goes back. The layout of roads between institutions allows us to find a rallying point and seems to favor the opportunity studied. The observations we made cover this type of journey and so we have a basis for what would be the combination of the two noon shuttles.

Thus, the journey for a hospital A ambulance to the place of appointment takes 15 minutes, 30 for a round trip. We can evaluate (Table 4) what would be the rest of the activities necessary for this combination of trips for A and B hospital ambulances, based on the current execution elements.

Table 4 : Impact of trips combination between hospitals A and B

Types of travel	**Current route for hospital A**	**Combined journey – Impact on hospital A**	**Combined journey – Impact on hospital B**
Required time	140 min.	84 min.	
Time difference compared to the actual situation		- 56 min.	+ 14 min.
Associated cost	$77,80	$47,74	
Cost difference compared to the actual situation		- $30,06 (-39 %)	+ $6,16 (a)

(a) Additional costs for hospital B evaluated according to the operating conditions of hospital A

The savings are significant for hospital A. In addition, the removal of a long journey strongly impacts the ability of the service around noon, enabling it to add an additional consumer transport (lying down patient transport) which is currently outsourced.

Similarly, we can imagine that the routes between institutions (e.g. transport of a patient from hospital A to hospital B) can be considered in an overall consideration, in particular if there is another transport planned from hospital B to hospital A in the day so that it is the same team that performs both transports.

Here we see the potential of sharing transport organization among several institutions. In organizing transport from a network of institutions, potential performance gain is possible by ensuring optimization of routes taken by each institution and implementing a fair billing system between institutions. Our time equations and our valuations make pooling a viable option which could be brought to the attention of the general management of the different hospitals.

2.3. Contributions for a hospital transport service

The logistics director was seduced by the understanding of the activity carried out. To obtain the details of the journeys, the explanatory variables of the times, the distribution of the resources by types of journeys, made it possible to pinpoint precisely what was the transport activity within the establishment. The TDABC served as a tool for identifying the various aspects of the activity.

More precisely, we highlight a detailed knowledge of the costs (2.3.1), a measure of used and unused capacity (2.3.2), a decision support in the choice of partnership, outsourcing or pooling (2.3 .3).

2.3.1. Detailed knowledge of the costs

The head of department was able to evaluate the consequences of the changes in the journeys made, based on elements more precise than the single criterion of the quantity of trips made (confirming the lack of relevance of this criterion, the observed transports ranging from 6 minutes to more than 3 hours).

The allocation of resources to the different types of journeys carried out made it possible to identify those which are particularly costly. The head of department deduced an structural reorganization that saved the presence of a crew on weekends, moving weekly trips (including trips involving medical products or supplies) or outsourcing.

2.3.2. An evaluation of unused capacity

The available capacity is determined on the basis of budgetary data and internal documents (number of ambulance workers and working hours, number of vehicles and availability time).

The capacity used is based on internal reporting documents. The transport service keeps a file listing all the trips carried out in the year according to the type of journey and its destination. Using the time equations, we estimated the standard capacity required for the activity. This estimation makes it possible to observe the distribution of resources according to the different types of journey: transport of patients, transport of tests to the laboratory, transport of blood products. In the same way, it is possible to distinguish between the resources used for transports on site and transports to other institutions.

A comparison of the capacity used (determined from our time standards) with the available capacity allowed us to observe excess capacity.

The head of department appreciates that it is possible to study the use of the human and material resources available; it is nevertheless surprised by the magnitude of overcapacity for ambulance workers (31%); it highlights waiting times for emergencies, weekend care, 24/24 availability. Due to the absence of a measure of forced inactivity, TDABC modelling does not seem to be in line with the feeling in the service: "*the need to have available capacity in order to respond to emergency transport demands does not correspond to what is usually understood by overcapacity*". After integration of the emergency management, the unallocated capacity is 20% of the total. This unoccupied time does not correspond to the available time because the calculations are made on the basis of the actual working time; it is recognized that breaks, formal and informal meetings, delays related to unexpected events represent at least 10% of the time spent in attendance. With this in mind, the communication was based on an overcapacity of less than 10%, which corresponds substantially to the perceptions in the service that there are no extra staff.

On the other hand, in terms of equipment, observation of the capacities used made it possible to start thinking about the number of vehicles available; the service showing overcapacity, it was envisaged not to renew all the vehicles available.

2.3.3. Outsourcing or pooling opportunities

The costs obtained from the TDABC equations have suggested choices in terms of behavior in terms of crew waitings, or outsourcing of transport. The head of the service can make a quick comparison of the cost of journeys made by his service and those given to private ambulances, using the standard time equations. The observation of the results teaches him in which situations outsourcing is interesting. This has made it possible to make decisions on the transport to be outsourced as a priority in order to reduce the associated expenses, even if it means abandoning totally the realization of certain types of journeys. It also allowed to see for which transport it was very economical to use the ambulance workers of the hospital, compared to the official pricing of the national health insurance.

The simulations carried out on the possibilities of pooling transport between the different hospitals of the group made it possible to measure the impact of combinations of journeys by ambulance workers. The quantified argument of the prospects for pooling of transport involves strategic decisions for the three institution of the consortium: "*The ultimate consequences can only be a merger of the three transport services in order to benefit from the effects of networking and combinations journeys ".*

The attractiveness of this new tool for monitoring the activity and the costs of the transport service is indisputable, especially since it starts from a rudimentary situation. Nevertheless, it is necessary to go beyond this stage, opening the discussion of the critical aspects.

3. Discussion and conclusion

The modelling of the transport activity in TDABC presents difficulties of implementation: the development of the standard times requires neutral behavior on the part of those concerned whose activity is measured; even if time overruns are inevitable, since adjustment is made for a better service or to compensate for a failure. More or less dysfunctions, generating hidden costs, make its implementation complex (3.1).

In parallel with the stabilization of the calculation, it is important to consider the contributions made at the theoretical level. In public organizations, where the human resources are important, we believe that the TDABC is adapted. More specifically, the TDABC allowed us to model a complex logistic activity that other types of calculations, with inductors that are not representative of the multiplicity of tasks and the conditions of realizations, could not represent. Few case studies exist on the TDABC, and comparison with existing work, constitutes an interesting exercise of reflection on its contributions (3.2).

The limitations of our research and the prospects that could be revealed by further studies in different contexts complement our analysis (3.3)

3.1. Observation of malfunctions during the implementation of TDABC

We observed two types of dysfunction in this study, which should be monitored and discussed: the presence of time overruns compared to those used in our equations, generating additional costs (3.1.1), and non-natural behaviour when recording time (3.1.2).

3.1.1. Exceeding of time generating additional costs

The activity of the health transport service is not as standardized as the equations developed. Its realization encounters a certain number of dysfunctions. Hidden costs related to dysfunctions have been widely studied in work on socio-economic performance (Savall and Zardet, 2010). If the inclusion of these elements in the model is complex, we can nevertheless try to understand their impact on the realization of the everyday activity.

Our observations allowed us to note the presence of anomalies in a majority of the transports carried out. These dysfunctions are irregular and can involve many elements of a journey: the patient is not ready, the documents are not filled, the information given to the paramedics is not correct, the personal belongings of the patient are not grouped, the doctor is absent, the use of a lying down transport with two paramedics is scheduled while a seated transport with a single ambulance driver would have been possible, seated transport is requested but the patient cannot get up and a change of vehicle is necessary, etc. An error in the information transmitted or the lack of preparation of the patient are often the cause of these dysfunctions.

The majority of these malfunctions result in a loss of time related to the waiting of ambulance attendants. Sometimes the consequence is more serious: ambulance attendants have to carry out an extra run (to retrieve forgotten documents), have to change vehicles (patients lying down when they are supposed to be seated) or must come back at another time (information error, patient not ready, etc.).

These dysfunctions do not occur in a recurring way, thus cannot be integrated into the standard, but nevertheless the appearance of at least one dysfunction during a transport is quite frequent.

From the observations made, we can try to analyze these dysfunctions. On the basis of the TDABC model, we can measure the time consumed by these dysfunctions, which allows us to highlight the hidden costs. For the transport of patients, half of the journeys are overrun by at least 5 minutes compared to the standards used for the time equations; the additional cost is 9%. Note however that the quest for performance gain is not necessarily possible without generating other costs of reorganization nor desirable because it can put unbearable pressure on agents.

Beyond this statistic, we question the possibility of integrating one or more variables related to these occurrences of dysfunctions in the equations. Differences in the variety of observed dysfunctions prevent them from being treated as a block, the mathematical tool reaches its limit where complexity makes it unusable. Even in the absence of integration in the equations of this type of event, this study has had the virtue of revealing these wasted time. Although the quantitative tool represented by the TDABC model appears to be able to reflect these dysfunctions only in a complex way, the observation of the task times associated with it may be an interesting starting point for an improvement process focusing on the most obvious dysfunctions.

3.1.2. Exaggerated execution times

One possible behavior that we could envisage encountering was an exaggeration of the time spent by the paramedics to carry out the activities, in order to show an overflowing occupation and the limited resources available, thus protecting their employment and service, in a context where the financial management of the institution wishes to monitor the resources allocated to the transport service. This was noticeably not the case: ambulance attendants were anxious to show that they were able to carry out their activity in a timely manner without wasting time. An illustration is given by the following example: when collecting a service document listing the various vehicle maintenance to be carried out, the ambulance attendant voluntarily pronounced himself on the document to indicate that certain tasks that were indicated were not carried out because they no longer correspond to the organization of the service; by doing so, it actually knowingly decreased the measured activity of the service.

This type of behavior is related in particular to the context of the study and the perception of the employees concerned as to its convergence with their interests. Compared to a practice of time reporting by employees, our direct observation of activities and our time measurements of the paramedics activity limit this type of dysfunction related to the excessive time spent carrying out the activities.

It seems for us therefore particularly important to implement the TDABC model to be particularly vigilant about the context and, in particular, the appropriation of the tool by the operational staff, which is necessary for its proper functioning. It is easy, in particular when using declared time, to obtain distorted times, voluntarily or otherwise, thus making the subsequent calculations lose value.

3.2. Reflection on the contributions of the TDABC

The evaluation of logistics costs has already resulted in publications, be it an adaptation of the Activity Based Costing to this activity (Pohlen and La Londe, 1994; Bokor, 2008), or the TDABC. Everaert et al. (2008) show the TDABC's ability to model complex logistics activities; they succeed through their research to bring out costs that could not be obtained with a traditional ABC, because too expensive, lacking in flexibility and using inductors that do not correspond to the reality of the activity. Our research reinforces this approach and shows that by acting on a part of the organization, we have been able to achieve this type of result without setting up a complex and global costing mechanism for all the hospital organization. These results confirm certain expectations of the TDABC: a precise cost; improved decision-making, profitability management and capacity management; the possibility of internal and external benchmarking; better involvement of managers in the management of profits.

We will add to these elements two points that emerged during our experimentation:

• The ability to simulate changes in the organization by varying parameters within the equations from test observations. This makes it possible to envisage different hypotheses and possibilities and to help decision-making when reorganizing an activity;

• The possibility of highlighting the observed dysfunctions, generating differences in production times and evaluating their cost. This type of contribution, however, requires a real observation of the activity to form the equations of time and not to rely on times declared by the staff.

In public organizations, where the human resources are important, we believe that the TDABC can be adapted to make an interesting contribution in several ways:

• Different levels of service quality lead to the integration of more or less events for the performance of an activity; The global time equation of the activity can thus contain ... + $\beta a * Xb * Xc$ + ..., in which Xb is a sorting variable corresponding to the presence or not (Xb = 1 or 0) of the variable Xc which consumes βa minutes ; After valuation, different costs in terms of the quality of service performed may be proposed;

• the implementation of a public service mission, such as a 24-hour presence, may result in the introduction of a standby variable, the availability of certain categories of personnel without event to be measured, the theoretical capacity exceeding more or less widely the sum of the times that can be obtained from the time equations; the ability to remain available is valued and integrated into the financial effort to be accepted, unless the optimization of resources leads to reasoning in aggregate and to generating a long queue at certain times (criticism often directed to medical emergency services);

• a number of missions that become transverse, specific, such as project management, to reorganize an activity, to introduce new equipment, etc., the TDABC makes it possible to accumulate and value the time spent by different actors from different departments; the recurring missions, internal, specific to a department, are no longer the only ones to be followed.

In spite of these apparent advantages, it seems important not to overshadow the time necessary to build the TDABC model, in particular the recording of the times of the different journeys. A service with an annual budget of € 300,000, with five employees, required almost two months of full-time work. We can then question one of the major strengths of the TDABC as announced by Kaplan and Anderson (2004), namely, its ease of implementation. Declared times do not require significant field work, but generate drifts that are identified (Allain and Gervais, 2008). If we are concerned with the use of precise and representative times, it is then necessary to deploy a consistent task of observation. It thus seems very complex and costly to implement the model at the level of the hospital as a whole.

Finally, it is the cost of the gain of performance obtained by the application of the TDABC which questions us. It seems necessary to compare the advantages obtained with the complexity of implementation, with the acceptance by the staff of a timing method, etc. In the context of a public service institution, these elements are a source of questions about the maintenance of quality of service, the responses to the needs of the populations, while the weight of the temporal dimension associated with the method risks prevails. The reflection on the reorganization of certain activities, based on the identification of the tasks associated with variables triggering a high consumption of resources, must be done bearing in mind this relationship with the quality of the service provided in return for time allowed. Depending on the level of quality of the support, an agent will be required to spend more minutes on a task, thus changing the time associated with the corresponding variable.

Human relationships are precisely an unavoidable part, to the point that organizational changes are not always in line with the expected potential. At the end of our experimentation, this is precisely what emerges. From a managerial point of view, the transport service has begun to introduce changes suggested during the action-research process, while focusing attention on avoiding full outsourcing by developing an ability to take over TDABC formulas for subsequent periods to justify from an organizational point of view that there is not really any unused capacity. As for practices towards groupings and other efficient actions, they are done at "reasonable" speed; unless under pressure, a head of department will not hustle his team to go too fast; it is a margin of manoeuvre usable over time. The interest is not only at the operational level, but also in relations with head management: the logistics manager can now discuss with the management committee the opportunities for pooling between hospitals on a quantitative basis rather than on feelings.

3.3. Prospects and limits

The hospital logistics sector is generally not satisfied with the possibilities of comparisons available. The information provided by the Base of Angers study or the national cost study are not very precise averages, disregarding the context and the specificities of the institutions, thus providing data that can not be exploited for the operational management of services according to the logistical and administrative officials encountered. It would then be interesting to deploy the TDABC in other institutions in order to make such comparisons. The particular context of the study within an institution included in a group also allows us to consider with interest the networking of the transport of patients between different institutions or actors, in a cooperation approach within the care cycle (Halgand and Garrot, 2014). Moisdon (2000) explained that the generation of information triggered the linking and cooperation of actors from different institutions. In addition, it enables the development of transport activity within the care cycle, whereas this activity is totally absent from today activity pricing. It would be particularly interesting to be able to quantify the gains made by this type of approach, and to detect if there is a hospitals-operable performance deposit, in a particularly difficult budgetary context, in order to motivate efforts toward cooperation.

The TDABC remains a recent method of calculation and we have few examples of it in the literature; the observation of additional implementations will allow to better observe its interests and limitations. Beyond the hospital environment, additional studies in the continuation of the work of Demeere et al. (2009), Öker and Adigüzel (2010), Stouts and Propri (2011), etc., on the impact of TDABC on the performance of the company and the type of decisions resulting from it, would enrich our knowledge on the interests of its application. We were also confronted in this study with problems of homogeneity of resource groups linked to differences in the rate of consumption of resources, difficulties that are not developed in the current literature and which deserve to be studied further. Studies on the circumstances of implementation (Gosselin and Mévellec, 2003) and adaptation to the context (Fladkjær and Jensen, 2011) also seem necessary.

It seems to us that the context of the organization is of particular importance in the success of the implementation of the tool. We know that the management tools constitute in the hospital "*a meeting points of multiple forces whose result is not easy to foresee*" (Moisdon, 2007). A great operational proximity, and thus the adherence of the actors, is necessary when designing and revising the time equations, in order to be sure of capturing the reality of the activity represented. Demeestère et al. (2009) clarified this prevalence of the operational environment: *"the information required to build and then update a detailed ABC model can only be provided by the operational ones*" and that such approaches "*can only live if they are appropriate by operational and can only be appropriated by the operational staff if they give them significant services for the management of their own performance* ". These elements also seem to us to be valid for the TDABC. The support given by the ambulance team to the project was thus based on the interest of seeing their activity valued within the hospital organization by a different means than a simple volumetric indicator of which they complained and by the information that were provided to them on the operational management of their journeys.

Finally, if the particular context of our study allowed a good acceptance of the approach by employees despite a strongly unionized hospital sector, we can question the reception of this type of approach in the absence of these particular conditions, limiting the possibilities of using the TDABC. This is an element that may seem trivial, but the risk of deception over time weighs heavily on any TDABC analysis. The implementation of such a calculation requires that a thorough reflection and a particular approach are put in place on the acceptance by staff of the phenomenon of timed recording of the activity. A study on these conditions of implantation would allow to better understand the requirements of adaptation necessary to the environment.

Beyond the TDABC, this work in itself is not without limits. The hours we have timed do not make it possible to have a statistical representativeness of each task, certain conditions of realization being uncommon. It would then be necessary to record over a long period of time in an automated manner, only a global and sustainable implementation process, requiring daily monitoring and information of the database of the tasks carried out, would make it possible to arrive at such means. The repetitiveness of the tasks taken independently and the low dispersion of the recorded times without dysfunction nevertheless make it possible to relativize this limit for our case. A study on the sensitivity of the costs calculated in TDABC to time errors seems to us an interesting track of research for who would like to deepen this complex but nevertheless central element of the TDABC, which is the relation with the time. Similarly, a study on the conditions for time revisions would be necessary to ensure that relevance is maintained over time.

The universality of the results obtained is limited by the very specific context of the hospital. These are certainly extensible to hospitals of similar sizes with the same problems (the existence of crews specific to the hospital and the use of private ambulance drivers simultaneously).

Some conditions seem necessary to achieve similar results: the complexity of the activity must make it pertinent to use dozens of variables in the time equations, compared to the use of simple inducers; a more "simple" full cost could then be more appropriate, which leads us to wonder about the particular conditions that may justify the use of the TDABC. For this purpose additional studies are needed, focusing on multiple topics such as observation over the duration of use and fate of TDABC; the impact on the performance of the service or organization more generally; a better allocation of resources by going further in the knowledge of the causes of consumption; the form that Time-Driven Activity-Based Management takes.

References

ALLAIN, E., GERVAIS, M. (2008). La fiabilité de l'inducteur temps de travail dans les activités de service : un test sur un centre d'appels téléphoniques d'une société d'assurances. *Comptabilité Contrôle Audit* 14 (1) : 119-144.

ANGELE-HALGAND, N, GARROT, T. (2014). Les biens communs à l'hôpital : de la T2A à la tarification au cycle de soins. *Comptabilité Contrôle Audit* 20 (3) : 15-41.

BASUKI, B., RIEDIANSYAF, M. D. (2014). The Application of Time Driven Activity-Based Costing In the Hospitality Industry: An Exploratory Case Study. *Journal of Applied Management Accounting Research* : 1-20.

BEAULIEU, M., LANDRY, S. (1999). Evolution de la fonction approvisionnement dans le secteur de la santé : synthèse de la littérature. Cahier de recherche du groupe CHAINE, n°99-02.

BOKOR, Z. (2008). Activity Based Costing in Logistics. *Acta Technica Jaurinensis Series Logistica* 1 (2): 229-236.

BOUQUIN, H. (2011). *Comptabilité de Gestion*. 6e éd., Paris : Economica.

CAMPANALE, C., CINQUINI, L., TENUCCI, A. (2014). Time-driven activity-based costing to improve transparency and decision making in healthcare. A case study. *Qualitative Research in Accounting & Management*: 165-186.

CARDINAELS, E., LABRO, E. (2008). On the Determinants of Measurement Error in Time-Driven Costing. *The Accounting Review* 83 (3): 735-756.

CHOW, G., HEAVER, T.D. (1994). Logistics in the Canadian health care industry. *Canadian Logistics Journal* 1 (1): 29-73.

Cour des comptes (2012). *Rapport sur l'application des lois de financement de la sécurité sociale.* 576 p.

DALCI, I., VEYIS T., LEVENT K. (2010). "Customer profitability analysis with time-driven activity-based costing: a case study in a hotel." *International Journal of Contemporary Hospitality Management* 22.5: 609-637.

DAVID, A., HATCHUEL, A., LAUFER, R. (2000). *Les nouvelles fondations des sciences de gestion*. Paris : Vuibert.

DE LA VILLARMOIS, O., LEVANT, Y., ZIMNOVITCH, H. (2012). Evaluation de coûts complets : un compromis entre précision et complexité In *Contrôle de gestion, Comptabilité, Stratégie. Mélanges en l'honneur de Michel Gervais* (Eds, Ducrocq, C., Levant, Y.). Paris: Economica, 31-48.

Demeere, N., Stouthuysen, K., Roodhooft, F. (2009). Time-driven activity-based costing in an outpatient clinic environment: Development, relevance and managerial impact. *Health Policy* 92: 296-304.

DEMEESTERE, R., LORINO, P., MOTTIS, N. (2009). *Contrôle de gestion et pilotage de l'entreprise*. 5[e] éd., Paris : Dunod.

DE POUVOURVILLE, G. (2009). Le financement des hôpitaux. In *Traité d'économie et de gestion de la santé* (P.-L. Bras et *al.*). Paris : Presses de Sciences Po « Hors collection », 269-274.

Direction de la recherche, des études, de l'évaluation et des statistiques (DREES) (2013). *Les comptes nationaux de la santé en 2012*. 246 p.

ESCAFFRE, J.-P. (2008). *Le contrôle de gestion des unités de soins hospitaliers.* Paris : Economica.

EVERAERT, P., BRUGGEMAN, W., DE CREUS, G. (2008a). Sanac Inc.: From ABC to time-driven ABC (TDABC) – An instructional case. *Journal of Accounting Education* 26: 118-154.

EVERAERT, P., BRUGGEMAN, W., SARENS, G., ANDERSON, S.R., LEVANT, Y. (2008b). Cost modeling in logistics using time-driven ABC: experiences from a wholesaler. *International Journal of Physical Distribution and Logistics Management* 38 (3): 172-191.

EYSSARTIER, D. (2010). *Rénovation du modèle économique pour le transport sanitaire terrestre*. Rapport ministériel. 106 p.

FLADKJÆR H., JENSEN E. (2011). The ABC-Paradox : is Time Driven ABC Relevant for Small and Medium Sized Enterprises (SME)? *Working paper series of the Aalborg University 2*, 23 p.

FRENCH, K.E., ALBRIGHT, H.W., FRENZEL, J.C., INCALCATERRA, J.R., RUBIO, A.C., JONES, J.F., FEELEY, T.W. (2013). Measuring the Value of Process Improvement Initiatives in a Preoperative Assessment Center Using Time-Driven Activity-Based Costing. *Healthcare* 1 : 236-142.

GERVAIS, M. (2009). *Contrôle de Gestion*. 9e éd., Paris : Economica.

GERVAIS, M., LEVANT, Y., DUCROCQ, C. (2010). Time Driven Activity Based Costing (TDABC): An Initial Appraisal through a Longitudinal Case Study. *Journal of Applied Management Accounting Research* 8 (2): 1-20.

GOSSELIN M., MÉVELLEC P. (2003). Plaidoyer pour la prise en compte des paramètres de conception dans la recherche sur les innovations en comptabilité de gestion. *Comptabilité Contrôle Audit* numéro spécial : 87-109.

GOYETTE, G., LESSARD-HEBERT, M. (1987). *La recherche-action : ses fonctions, ses fondements et son instrumentation*. Presses de l'université du Québec.

GUERIN, O., HUSSER, J. (2011). Les effets incitatifs de la T2A pour les établissements de soins : vers une nouvelle répartition des actes chirurgicaux. *Vie & Sciences de l'entreprise* 189 (3): 12-22.

KAPLAN, R.S., ANDERSON, S.R. (2004). Time-Driven Activity Based Costing. *Harvard Business Review* 82 (11):131-138.

KAPLAN, R.S., ANDERSON, S.R. (2007). *Time-Driven Activity-Based Costing*. Boston, Harvard Business School Press.

KAPLAN, R.S, PORTER, M.E. (2011). How to solve the cost crisis in health care. *Harvard Business Review* 89 (9): 47-64.

KAPLAN, R.S (2014). Improving value with TDABC. *Healthcare financial management* 68 (6): 76-83.

KEE, R. C. (2012). Measuring and managing the cost of governmental services: a case for time-driven activity-based costing. *Journal of Government Financial management* 61 (3): 38-41.

KRIEF, N. (2009). La réforme de la tarification à l'activité à l'hôpital : une lecture de l'impact sur le lien social. *Gestion 2000* 24 (5): 83-106.

LACROUX, F. (1999). La modélisation dans le contrôle de gestion. In *Faire de la recherche en contrôle de gestion ?* (Dupuy, Y.). Paris : Vuibert. Chap. 2, 21-29.

LE MOIGNE, J.-L. (1990), *La modélisation des systèmes complexes*. Paris : Dunod.

LIU, M. (1997), *Fondements et pratiques de la recherche-action*, L'Harmattan.

MAYER, R., OUELLET, F., SAINT-JACQUES M.-C., TURCOTTE D. (2000). *Méthodes de recherche en intervention sociale*. Montréal : Gaëtan Morin éditeur. Chap. 2 : La recherche-action, 101-153.

MEVELLEC, P. (1995). *Le calcul de coût dans les organisations.* Paris, La Découverte.

MOISDON, J.-C. (2000). Quelle est la valeur de ton point ISA ? Nouveaux outils de gestion et de régulation dans le système hospitalier français. *Sociologie du travail* 42 : 31-49.

MOISDON, J.-C. (2007). De la difficulté de prévoir la trajectoire d'un outil de gestion. *Sciences de Gestion* n°64 : 405-419.

NOBRE, T. (2006). Pour une lecture en hypertexte des organisations par la recherche-action : le cas du changement à l'hôpital. *Finance Contrôle Stratégie* 9 (4) : 143-168.

NOGUERA, F., LARTIGAU, J. (2009). De la prospective à la gestion prévisionnelle des métiers et des compétences dans la fonction publique hospitalière : enjeux et perspectives. *Management & Avenir* 25 (5): 290-314.

ÖKER, F., ADIGÜZEL, H. (2010). Time-Driven Activity-Based Costing: an implementation in a manufacturing company. *The Journal of Corporate Accounting & Finance* 22 (1): 75-92.

PERNOT, E., ROODHOOFT, F., VAN DEN ABBEELE, A. (2007). Time-Driven Activity-Based Costing for inter-library services: a case study in a University. *Journal of Academic Librarianship* 33 (5): 551-560.

POHLEN, T.L., LA LONDE, B.J. (1994). Implementing Activity-Based Costing in Logistics. *Journal of Business Logistics* 15 (2): 1-23.

RATNATUNGA, J., TSE, M.S.C., BALACHANDRAN, K.R. (2012). Cost Management in Sri Lanka : a Case Study on Volume, Activity and Time as Cost Drivers. *The International Journal of Accounting* 47: 281-301.

SAVALL, H., ZARDET, V. (2010). *Maîtriser les Coûts et les Performances Cachés*. 5e éd., Paris, Économica.

STOUTHUYSEN, K., SWIGGERS, M., REHEU, A-M., ROODHOOFT, F. (2010). Time-driven activity-based costing for a library acquisition process: a case study in a Belgian University. *Library collections, acquisitions & technical services* 34: 83-91.

STOUTS, D.E., PROPRI, J.M. (2011). Implementing Time-Driven Activity-Based Costing at a medium-sized electronics company. *Management Accounting Quarterly* 12 (3): 1-11.

TANIŞ, V.N, ÖZYAPICI, H. (2012). The measurement and management of unused capacity in a Time-Driven Activity-Based Costing system. *Journal of Applied Management Accounting Research* 10 (2): 43-55.

TSE, M.S.C, GONG, M.Z. (2009). Recognition of Idle Resources in Time-Driven Activity-Based Costing and Resource Consumption Accounting Models. *Journal of Applied Management Accounting Research* 7 (2): 41-54.

Appendix: List of 48 variables of time equations

VARIABLES RELATING TO PATHS
X10: Journey within CH A.
X11: Return trip to CHB.
X12: Travel to and from the city center.
X13: Return trip to CHRU.
X14: Return trip to the SSR clinic.
X15: Drive to the warehouse and pick up equipment on the morning shuttle.
X16: Travel to and from the retirement home in town.
X17: Transfer to and from the Pharmaceutical Cooperative (CERP).
X18: Trajectory between CH B and CH C.
X19: Trajectory between CH A and CH C.
X20: Travel to reprography and retrieval of documents during the morning shuttle.

VARIABLES RELATING TO TASKS AT THE START / DESTINATION
X30: Embarkation / disembarkation for lying down transfer.
X31: Embarkation / disembarkation for seated / standing transfer.
X32: Embarkation / disembarkation for lying down imagery / consultation.
X33: Embarkation / disembarkation for seated / standing imaging / consultation.
X34: Oxygenation of the patient.
X35: Sanitary isolation.
X36: Procedure for admission of the patient.
X37: Recovery and deposit of equipment (laboratory tests, sterile tests, etc.)
X38: Recovery of blood products for transfusions.
X39: Additional time related to the reception related to the morning shuttle.
X40: Additional time related to the blood collection during the lunch shuttle.
X41: Extra time related to recovery of documents during the lunch shuttle.
X42: Overtime associated with mail recovery.

VARIABLES RELATING TO MECHANICAL TASKS
X50: Route of a vehicle parked outside the garage to the cleaning area.
X51: Route of a vehicle parked inside the garage to the cleaning area.
X52: Interior cleaning of the vehicle.
X53: External cleaning of the vehicle.
X54: Internal disinfection of sanitary vehicles.
X55: Checking vehicle fluid levels, tire pressure.
X56: gasoline filling of vehicle.
X57: Deposit of the vehicle at the garage.
X58: Light disinfection of the contact areas of all sanitary vehicles.

VARIABLES RELATING TO ADMINISTRATIVE / VARIOUS TASKS
X60: Enter information about the activity of the service at the end of the day.
X61: Call to private ambulance company when it is necessary to outsource transportation.
X62: Receive a transport request.
X63: Call of the requesting service when there is an emergency or problem in the information provided.
X64: Cleaning and storage of the transport service.

SORTING VARIABLES
X70: Internal transport.
X71: External transport.
X72: Morning shuttle.
X73: Patient transport.
X74: Transport of equipment.
X75: Stop by the CH B withoutstop by the CH C during the shuttle of the morning.
X76: Stop by the CH B and the CH C without return by the CH B during the shuttle of the morning.
X77: Stop by the CH B and the CH C with return by CH B during the morning shuttle.
X78: Noon shuttle
X79: Morning and evening tour.