

TDABC: An Efficient System for Calculating the Costs of Health Care Services for Road Accident Victims, Zerka, A.¹, Jawab, F.²

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Abstract :

The present study aims at investigating the potential of the Time-Driven Activity Based Costing (TDABC) system for calculating the costs of health care services for road accident victims (VRA). The latter could be efficient in terms of understanding the process of consumption, the use of resources as well as the accurate evaluation of the cost of care provision with the aim of making appropriate decisions.

To that end, we approached models for calculating the costs of health care services for road accident victims regarding three main dimensions: during transport, in hospital and at home. We conducted a search of scientific articles written in both French and English in Web of Science, PubMed/MEDLINE and Scopus databases.

Ten studies met the inclusion criteria, in various health care-related disciplines such as surgery, home care, general health care services and pre-hospital transport.

This led us to conclude that the capacity of the TDABC method is likely to be applied in the full cycle of health care of motor vehicle accident victims. The purpose of this work is to provide health care organizations and policy makers with an overview of TDABC costing practices associated with the health care cycle of road accidents victims. In this respect, it will also be a question of describing how the said method can be applied in the health care services of road traffic accident victims.

Keywords: health care, home, hospital, road accidents, TDABC, transport, victims.

TDABC: Un système efficace de calcul des coûts des services de santé pour les victimes d'accidents de la route

Résumé :

La présente étude a pour but d'examiner le potentiel du système Time-Driven Activity Based Costing (TDABC) pour le calcul des coûts des services de santé pour les victimes d'accidents de la route (VRA). Ce dernier pourrait être efficace en termes de compréhension du processus de consommation, d'utilisation des ressources ainsi que d'évaluation précise du coût de la prestation de soins dans le but de prendre des décisions appropriées.

Pour ce faire, nous avons approché des modèles de calcul des coûts des services de santé pour les victimes d'accidents de la route selon trois dimensions principales : pendant le transport, à l'hôpital et à domicile. Nous avons effectué une recherche d'articles scientifiques rédigés en français et en anglais dans les bases de données Web of Science, PubMed/MEDLINE et Scopus.

Dix études ont répondu aux critères d'inclusion, dans diverses disciplines liées aux soins de santé telles que la chirurgie, les soins à domicile, les services de soins de santé généraux et le transport préhospitalier.

Cela nous a permis de conclure que la capacité de la méthode TDABC est susceptible d'être appliquée dans le cycle complet des soins de santé des victimes d'accidents de la route. L'objectif de ce travail est de fournir aux organisations de soins de santé et aux décideurs politiques une vue d'ensemble des pratiques de calcul des coûts TDABC associées au cycle de soins de santé des victimes d'accidents de la route. À cet égard, il s'agira également de décrire comment ladite méthode peut être appliquée dans les services de soins de santé des victimes d'accidents de la route.

Mots clés : Soins de santé, domicile, hôpital, accidents de la route, TDABC, transport, victimes.

Introduction:

Road accidents are a serious public health problem around the world. The latter necessitates concerted endeavors for both preventing and reducing their impact. The quick arrival of emergency responders at the scene of the accident, followed by rapid transportation of victims by qualified health care personnel, as well as the provided hospital care can reduce the consequences of road traffic injuries. However, the full course of health care for VRA is a considerable cost to the economies of many countries. Modeling the costs of health care for VRA provides information for a better use of resources on the one hand, and on the other hand, it helps understanding the way in which consumption is carried out. This modeling provides an accurate estimation of the costs of health care services that are valid for effective and appropriate decision-making.

There is no doubt that hospitals around the world, as they seek to meet the needs of an increasingly demanding population (Jawab et al., 2018), are under increasing pressure in terms of cost reduction and better management of their activities. However, improving the financial management of healthcare organizations is a heavy burden because they are part of a complex system composed of many devices, namely patients, family members, and healthcare providers. These organizations require organizational systems to effectively collect relevant information for decision-making. Therefore, it is very important to further improve the performance of hospital financial management and determine the method to better manage this complex environment in the economic system under the premise of high standards of care quality and cost control (Troyer et al., 2005).

In terms of the satisfaction of patients and medical service providers and in compliance with regulations and standards, this quality of care has become a major concern of medical institutions and can help reduce costs and delays (Frichi et al., 2019). Moreover, precise cost calculations and estimation are crucial in determining the effectiveness of economic analysis in the decisionmaking process, because it is necessary to accurately measure the real cost of care providing and establish a pricing system. This area of research uses economic valuation methods to estimate the value of health products and services by comparing costs and outcomes. Though in practice, the importance of precisely modeling the cost of health care services is a challenge, seeing the lack of cost accounting basics, in recent years, researchers have explored and tried systems that can determine health care costs based on specific activities or products, such as a TDABC. It would help managers to know where they are coming from, and to make decisions to better manage and distribute resources within the care service portfolio.

In this contribution, we will first present the general framework of the analysis; then we will explain the research method used; then we will present the studies that aim to model the costs of health care services for victims of road accidents in TDABC; finally, we will describe how the said method (TDABC) can be applied in the care services of these victims.

1. Framework of the Analysis

1.1. Research context

Road traffic injuries place, for both emergency response and medical treatment, a heavy burden on the resources of the medical system. Of course, road traffic accidents have several types of adverse effects. Most importantly, they result not only in loss of life and injury, but they also cause damage to other road users and result in costs for ambulances, medical expenses and home care.

If we refer to the report of the World Health Organization (WHO, 2018) on the situation of public road accidents, we find that traffic accidents cause nearly 1, 3 million deaths every year worldwide. They also cause a considerable number of injuries, in the order of twenty to fifty million. Road accidents cost most countries three per cent of their Gross Domestic Product. These costs are due, among other things, to the cost of medical treatment.

Recall that according to WHO (2018), the death rate, caused by traffic accidents, is, globally, 18.2 per 100,000 population. However, this rate varies depending on the region. It ranges from 9.3 to 26.6 per 100 000 population. Fig 1 shows the rate of traffic fatalities per 100,000 population by WHO region between 2013 and 2016.

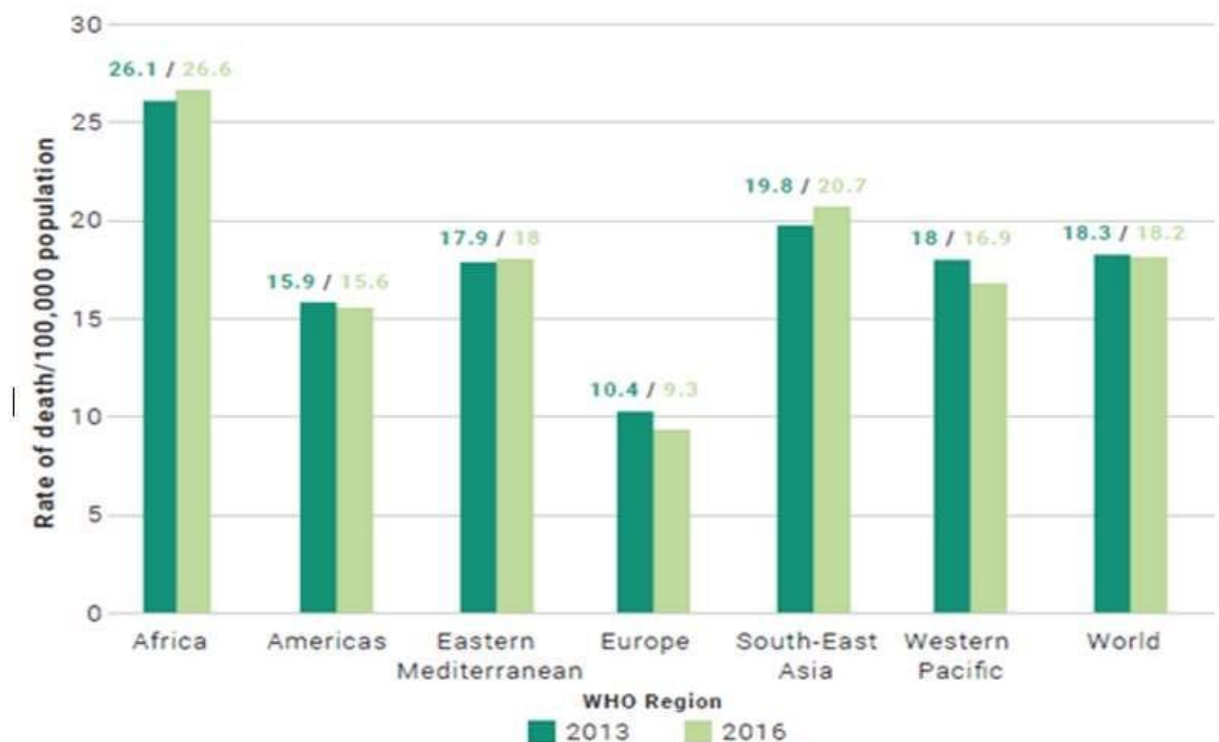


Fig. 1: Rates of road traffic death per 100,000 population by WHO regions (2013, 2016).

The accident rate has clearly changed in a context marked by the massive use of means of transport (Zehmed and Jawab, 2021). Pedestrians, also involved in urban mobility, are highly exposed to traffic accidents (Fallah and Roshani, 2021).

It is true that the impact of road accidents has increased, but it should also be noted that the number of deaths resulting from them has fallen significantly in several developed countries in recent years. Several factors could explain this decrease: among others, the implementation of better medical treatment methods in the victim's care. This improvement is the result of major investments in the adoption of new innovative technologies. Health care for road accident victims requires the use of new technologies and advanced care services, as these are essential to provide added value and high quality care services.

The development of new technologies in the field of health care is one of the main drivers of the increase in health care costs (Lamuraud and Lhuillery, 2016). Being the expenses related to health care, it is essential to perform the financial management of health care institutions and to adopt approaches that guarantee a relevant management of the cost increase. Thus, the empirical application of the cost accounting tool, namely the TDABC method, is presented as the solution to regulate the health care cost crisis (Kaplan and Porter, 2011).

1.2. TDABC: Theoretical notes

1.2.1. TDABC

TDABC has achieved some success in industrial and service production (S. Hoozée and W. Bruggeman, 2010), proposed by Kaplan and Anderson (Kaplan and Anderson, 2004), is a modified version of ABC. TDABC is a process-based micro-cost accounting method that can optimize cost accounting efficiency, thereby overcoming major challenges related to traditional cost accounting methods. It is particularly useful when the cost is mainly determined by employee time, hence the name "time driven" (Kaplan and Anderson, 2004). However, previous attempts have begun to develop process-oriented methods to achieve cost accountability in health care. Here, we give an example to illustrate the activity-based cost accounting (ABC) introduced by Cooper and Kaplan (Cooper and Kaplan, 1991) in the eighties to replace the so-called traditional cost accounting method. Facts have proved that ABC is more useful than the so-called traditional accounting methods (Tang et al., 2010). In this regard, we are referring to its application in service activities, especially in hospitals and medical institutions, which has flourished since the beginning of 1990 (Baker, 1998).

However, it turns out that the implementation of this system (ABC) is very difficult, especially because it entails too many resources in large or complex organizations (Kaplan and Anderson, 2004, 2007), and it is difficult to update and slow to implement. After reaching its peak in the mid-1990s (Udpa, 1996), the subsequent disappearance of ABC (Tang et al., 2010) illustrates the need to strike a balance between the efficiency of cost accounting and the resources spent to achieve efficiency (Lipscomb et al., 2009). To overcome these problems, TDABC has been valued as a costing tool that seeks to strike this balance and capture business processes accurately. Indeed, it is less expensive to update and can be used to design simple cost models as opposed to ABC (Kaplan and Anderson, 2004). On the other hand, according to Öker and Özyapici (Öker and Özyapici, 2019) the two costing systems (ABC and TDABC) have common features: both tools

are activity-based, and it is the two-step costing systems that use the same cost factors from the first step to allocate indirect costs to activities. However, the system (TDABC) has one unique feature.

This system uses time as a second step cost driver. It minimizes the update process by formulating the cost of activities. In addition, this system (TDABC), unlike the ABC system, not only uses the practical capacity, but also determines the unused capacity. In short, these differences confirm that TDABC is a modified version of ABC. This way of calculating costs is therefore different and less complex than the ABC method. Indeed, as explained previously, this method becomes more complex when adding activities to the model. Unlike ABC, the TDABC model assigns a cost per minute to the various groups of resources, so it becomes quite easy to calculate the cost of a new activity. In fact, it is sufficient to estimate the time needed to carry out the activity and to multiply this time by the cost of the resource group involved in this activity. In recent years, the TDABC method has been increasingly used by manufacturing companies and the healthcare sector.

1.2.2. TDABC in health care

Health care in global hospitals requires the use of new technologies and advanced care delivery that are essential to add value and provide skilled care services. The development of the latter is one of the main drivers of the enormous increase in healthcare costs (Lamuraud and Lhuillery, 2016). In view of the jump in healthcare expenditure, it is consequently crucial to better the efficacy of the financial management of healthcare establishments and to define approaches to better manage these increasing costs. The application of the cost accounting tool, in this case the TDABC method, is presented as the solution to the health cost crisis (Kaplan and Porter, 2011). TDABC is a cost accounting tool used by many public and private companies. It has also been introduced to healthcare to accurately measure the costs of curing patients for a specific medical condition over a full longitudinal care cycle. In addition, it offers several possibilities for designing cost models in organizations with complex activities, such as healthcare organizations (Demeere et al., 2009).

TDABC has also been found to be well suited to managing the complex cost assessment of health care facilities (Campanale et al., 2014; Demeere et al., 2009; McLaughlin et al., 2014), allowing health care facilities to compare their costs to reimbursement rates. The main advantage of TDABC in healthcare is its ability to estimate resource use for a particular cycle of care, such as a patient with a humerus fracture (Sabharwal et al. 2016). However, the application of TDABC in health care is relatively new. A recent systematic review on the use of TDABC in general healthcare indicates that 80% of the studies on the subject were published during or after 2013 (Keel et al. 2017). These authors propose that TDABC should be progressively integrated into healthcare systems and easily applicable in hospitals. In fact, we believe that the TDABC tool is the most accurate denominator for assessing the health value of certain medical conditions, such as the health care of VRA.

Based on various researchers (Campanale et al., 2014; Everaert et al., 2008) who have implemented the TDABC model in health care, we have extracted the steps to achieve the TDABC model for health care facilities. These 10 steps are as follows:

- Make a plan for the patient's care process. This plan should include the activities that the patient must go through to complete the care pathway. These activities may include: pre-hospital care, admission, consultation with a medical specialist, various tests to be performed, treatment(s) to be prescribed.
- Break down each activity into tasks or sub-activities. For example, for tests (blood sampling), there is the step of performing the test (nurse who takes the blood sample), followed by the analysis of the test (analysis of the blood sample in the laboratory), and finally, the interpretation of the data by a health professional.
- Estimate the time required to complete each step and enter this time (in minutes) directly into the care pathway plan.
- Identify the different groups of resources needed to carry out each activity. In health care, it is common to group resources according to the different types of personnel involved in care (surgeon, type x nurse, type x technician, etc.).
- Estimate the total cost of the different resource groups.
- Estimate the practical capacity of each resource group or the time to complete the actual activities.
- Calculate the unit cost of each resource group by dividing the total costs by the total practical capacity.
- Multiply the total unit cost of each group of resources by the estimated time for each step that the activities comprise.
- Charge the costs of other human resources not working directly on the care pathways, but necessary to carry out the activities.
- Allocate direct costs, either to each activity or to each care pathway.

1.3. Overview of health care services for VRA and cost modeling in TDABC

Post-crash health care is increasingly essential in saving victims. It has been shown to significantly reduce the number of deaths and serious injuries resulting from motor vehicle crashes. In addition, the speed of rescue, the time factor, emergency care, care delivery, as shown in Fig. 2, the technology used is very important in providing effective care for the injured. First, the nursing system must be activated in the hospital and at home during the transportation process (Zerka and Jawab, 2020).

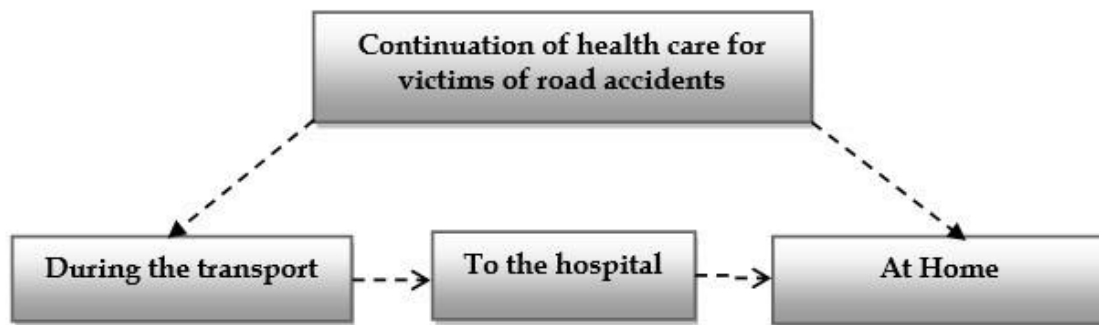


Fig. 2: Health care process for VRA

1- During transport: health care remains the most important link in saving VRA and should be seen as the beginning of a continuum of care that forms a "traumatic chain" (Coats and Davies, 2002), transport is the means of transporting them to nearby hospitals for treatment. Several modes of transportation can be used for victims, including ambulances, helicopters, etc., and differ from situation to situation. However, effective pre-hospital care, prompt rescue and proper transportation of victims by trained health care personnel can reduce the severity of injuries and the number of preventable deaths. Prompt responses are considered one of the most important criteria for the quality of care afforded to trauma patients (Carr et al. 2006). It is vital to note that many trauma experts believe that the first sixty minutes after the onset of injury (called the golden hour) is the most effective time to save lives (Carr et al. 2006). After this period, the risk of death or injury increases dramatically (Carr et al. 2006). Pre-hospital care is an important cost in the entire care process for VRA; they are the source of various costs: ambulances, staff, healthcare, supplies, etc.

2- At the hospital: health care is one of the main ways to save victims and reduce the damage that can result. However, the use of health care in the hospital environment varies according to the characteristics of the victims and the type of injuries that must be taken into account in the direct observation or communication with the victims for a better destination to the appropriate health care services. For example, in France, hospitals that care for these victims are required to have an emergency department and a minimum of two operating rooms (Fairhurst, 2005). Treatment teams are led by physicians. These centers must also have sub-specialties to care for the traumatized victim.

Indeed, the treatment plan for VRA in hospitals may involve several hospital departments. Consequently, they are the origin of various costs: emergency, radiotherapy, surgery, medical costs, nursing services, etc. The cost value of these items can be estimated based on the cost of the resources consumed.

3- At home: Patient care and treatment at home have become a more common model for health care organizations in the Western world (Duke and Street, 2003, Magnusson et al. 2003). The objective of this type of care is to prevent the use of long-term hospital services. Technological advances have made it possible to provide more medical treatment in private

homes (WardGriffin and McKeever, 2000). As a result, home care for VRA is seen as a viable solution to victims leaving hospital earlier with health problems and not requiring hospitalization. It is questionable whether home health care is cheaper than the same care provided in hospital (Temmink et al. 2000). Moreover, the technology used, the care personnel involved, drugs and consumables, travel, etc., constitute a significant cost in the complete home health care pathway for VRA.

It is worth noting that conducting a TDABC analysis in the healthcare path of consumables VRA (pre-hospital, in hospital and at home) involves identifying all clinical, administrative, and support resources for the treatment of medical problems. The specific elements to be determined include the administrative activities performed, the types of personnel involved (clinical and non-clinical personnel), and other resources such as equipment and consumables. In this sense, it is necessary to consider related services that generate hidden costs and associate the health care cycle of road accident victims. Table 1 that we have developed gives examples of procedures related to 1) health care services for VRA and 2) support services for the health care of road accident victims". These examples are the most frequently mobilized and used for the medical care of victims injured in motor vehicle accidents. Here, we are referring to the WHO. According to the report, the types and severity of road traffic injuries are different. The data in the report shows that patients who need to be hospitalized include those with fractures, open wounds, and brain injuries (WHO, 2004).

Table 1. Examples of healthcare services provided to victims of road traffic accident.

	Health care for VRA		
	-pre-hospital	-At the hospital	-At home
-Health care services for VRA	- pre-hospital health care	- Surgery for fractures of the spine, hip, knee, ankle, humerus.... - cosmetic surgery	- Home health Care - Services
-support services for the health care of VRA	- pre-hospital transport (ambulance costs),	- Hosting, - Catering,	- Distribution of medicines etc.)

2. Research Method

2.1. Methods

The approach adopted to address the health care costs of road traffic accident victims is based on the use of TDABC costing models through three phases: pre-hospital, in hospital and at home. The use of the models is based on a synthesis of studies to identify TDABC costing models applicable to the health care services of VRA. Subsequently, we have described how this system (TDABC) can be applied in the health care services of road traffic accident victims.

The methodology followed is based on a concise analysis of articles dealing with the following keywords: "Time-Drive Activity-Based Costing", "transport", "emergency", "consultation", "radiology", "treatment" and "victim". We searched these keywords in the Web

of Science, PubMed and Scopus databases for articles published between 2004 and 2022. The whole process was supervised and audited by the second author. The research process ended on June 20th, 2022. Our research strategy is detailed in Fig. 3.

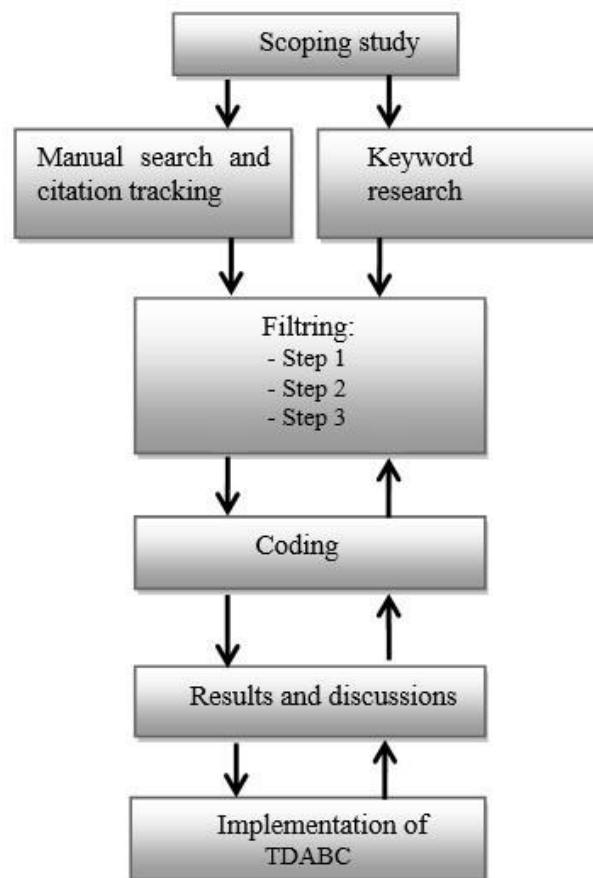


Fig. 3: Study selection method.

Based on a preliminary scoping research, a developed method was used to analyze the content of the basic documents used to calculate the cost of healthcare in TDABC. This initial analysis defines the following analysis steps, for example, specifying the search term and the language used. In addition, the second author set out to improve the search strategy. This allows us to explicitly consider healthcare services for VRA and more practical cost accounting processes, such as TDABC.

2.2. Criteria for the selection of studies

On the basis of the subject matter of the research, to guide our inclusion/exclusion decisions, the extracted studies were subjected to three rounds of filtering. However, the search using the above keywords was interpreted in such a way that the main study aimed at including only those articles that explicitly addressed the application of the TDABC method for the modeling of costs of health care services for VRA and for related pre-hospital services, in hospital and at home. Titles and abstracts were made visible in the search browser. This exhaustively includes any wording, abbreviations or other forms that signify Time-Driven Activity-Based Costing. Only articles in French and English could be included in the analysis.

In the first step, we removed duplicates. In the second step, based on a thorough reading of the titles and abstracts, we eliminated studies that were not closely related to our research area.

In this step, we also excluded documents that were in the form of abstracts and commentaries. In the last step, we read the selected studies in their entirety. The only articles that were retained were those that presented health care cases similar to those of car accident patients. Sometimes databases provide non-specific information on modelling the costs of health care benefits in TDABC of various diseases.

2.3. Data search and retrieval

The collection of potential studies is based on searches of the online databases mentioned in Table 2. Based on the research purpose described earlier, we constructed a search string. However, our preliminary research shows that choosing keywords accurately is tricky. We cannot use specific words to express cost modeling. Therefore, we only include: time-driven activitybased costing, transportation, emergency, consultation, radiology, treatment and victim in the keyword search, thereby increasing the manual filtering workload in the following steps. These keywords provide a comprehensive overview of all the research dedicated to modeling TDABC expenses, which are used for the medical care of VRA and pre-hospital services generated to the hospital and home.

Table 2: Databases and number of articles found.

-Sources	-Number of articles
-Scopus	830
-PubMed	167
-WOS	132
Total	1129

After designing the research to be reviewed, the data is extracted and classified in a standardized manner according to the general characteristics of the research. Tabulating the data: care pathway, field, year of publication, author, type of care service, health care department studied, and country of origin. The data is stored in Microsoft Excel 2010.

2.4. Methodological limitations

We did not evaluate the scientific quality of the study, because the purpose of this study was to extract and analyze the work of using the TDABC method to calculate the cost of medical services for victims of motor vehicle collisions, not to model the results of the interventions. Therefore, there is an opportunity to include some papers with insufficient methodology and/or inaccurate results. These papers are part of a comparative study or analysis of medical interventions and propose a model for calculating costs in TDABC.

3. Results and Discussions

3.1. Results

3.1.1. Selected articles

A number of 1129 articles were obtained after the search strategies were executed. Fig. 4 illustrates the process we used to select the studies. Once the duplicates were removed (378), there were 751 papers remaining, 655 of which were excluded because they did not meet the inclusion criteria after a thorough reading of the titles and abstracts. In the end, 96 articles were selected for the final review. Then, a total of ten articles were included in the analysis after 86 papers were excluded after reading the full text.

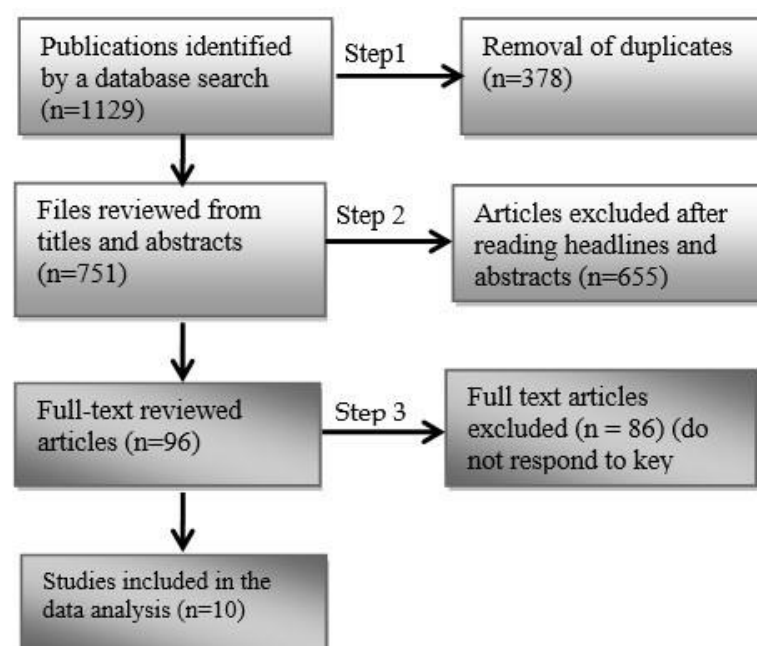


Fig. 4: Study review process.

3.1.2. Principal Characteristics of the selected articles

Among the ten reviewed papers, the number of studies from the United States was the largest ($n = 6$), and the number of publications from Portugal, Italy, Denmark and Morocco ($n = 1$ each). Most research is mainly conducted in developed countries because these countries have highcapacity data processing systems and can use advanced cost accounting methods. It should be noted in this regard that TDABC was developed at Harvard University. In developing countries, in view of the scarcity of health care resources and insufficient investment in health information systems, it is necessary to solve this problem to improve several management areas, including financial and accounting management.

Most of the articles ($n=4$) generally describe applications related to health care services that can benefit VRA. Three searches were conducted in surgical services and ($n=1$ each) focused on pharmaceutical services home care and pre-hospital transport (Table 3).

Table 3: Selected articles for the examination.

Care pathway	Domain	Year of Publication	Author	Categories of Care Services	Health care sector studied	Country
During the transport	Services related to the health care of VRA	(2022)	Zerka & Jawab	- Pre-hospital transport	Transport	Morocco
At the hospital	Care Health Services for VRA	(2016)	Sabharwal et al.	- humerus fracture surgery	Surgical	USA
		(2016)	Resnick et al.	-Surgical planning with 3D and manual splints for orthognathic surgery	General health care sector	USA
		(2017)	Robert et al.	-Spinal Care Service	-General health care sector	USA
		(2018)	Dylan McCreary et al.	-Surgical service for ankle fractures	-Surgical	USA
		(2018)	Husted et al.	-Hip and Knee Surgery Department	-Surgical	Denmark
		(2020)	Hauser et al.	-Radiology Department	-General health care sector	USA
	Services related to the health care of VRA	(2019)	Heaton et al.	-Emergency scribe services	-General health care sector	USA
Care pathway	Domain	Year of Publication	Author	Categories of Care Services	Health care sector studied	Country
At home	Health Care Services for VRA	(2016)	Ippolito et al.	-Home Health Care Services	-Medical	Italy
	Services related to the health care of VRA	(2016)	João Gregório et al.	-Drug distribution. -Drug Utilization -Review Services. -Advice on medication. -Victim Management Services.	Pharmaceuticals	Portugal

3.2. Discussions

3.2.1. General observations

Most of the studies identified were almost exclusively research papers modeling the costs in TDABC of health care services in general. They can be applied to a multitude of disease cases. Although they provided models for a variety of cases in the hospital setting, by virtue of their focus on health care, they remain applicable to health care services for victims of RTA.

There is only one article that directly addresses the problems associated with hospitalization of motor vehicle accident patients, particularly the pre-hospital transport service. In addition, the challenges identified in our research indicate that there is a deficiency of information on TDABC

cost modeling throughout the entire process of providing continuous care for motor vehicle crashes victims.

3.2.2. Synthesis and implications

Most of the studies reviewed here have focused on health care services for VRA (n = 8) and related services (n = 2) for VRA. We noted the absence of a specific definition and studies commonly associated with hospital care services for victims of road accidents. For this reason, most of the studies retrieved in our review discuss a multitude of settings: surgery (n=3), pharmacy (n=1), home care (n=1), and services that generate costs in the general health care field (n=4). Despite their diversity, they are related to the care cycle of VRA. Our research shows that using TDABC can not only measure the cost of providing care, but also assess remaining capacity and hidden costs.

Costing based on time-driven activities is a costing tool used by many listed and private companies. It has also been found to be very suitable for managing complex cost assessments in health care facilities (Campanale et al., 2014; Demeere et al., 2009; McLaughlin et al., 2014). However, the implementation of TDABC in the general medical care field, especially in the field of VRA is relatively novel, and it should be progressively included in the medical care system. However, the results of this review show that research on the above topics has been published in 2016 or later, showing that the method can be largely used in different healthcare fields, such as surgery, home care, and healthcare services. Actually, we believe that the TDABC system is the most precise denominator for measuring the costs and resources required to manage target patient groups (such as VRA).

4. Framework for the Implementation of TDABC in the Health Care of VRA

4.1. Steps for Calculating the Costs of TDABC in the Health Care of VRA

TDABC analysis can be applicable to the whole healthcare steps related to VRA. The purpose of this analysis is to create value for the victims. It allows you to have a more comprehensive understanding of the cost of the implementation process, and can more accurately measure the actual cost of providing medical services. However, using TDABC can not only measure the cost of medical services, but also evaluate support services and hidden costs. Specific strategies to solve these problems can be developed. The conclusive aim is to reveal to healthcare organizations and policy-makers that medical care for VRA is a cost-conscious process. To calculate health care costs using TDABC, several basic steps are necessary:

- Define the health status of the victim: for the transport phase, it is important to consider all costs associated with this phase from start to finish, from the care episode to transport. For hospital care, it is necessary to define the cycle of care at the level of each procedure, such as a department or individual units, in order to choose a standard and comparable condition. For home care, it makes sense to define the cycle of care as a period of time, such as one hour, and to examine all costs associated with this phase.

- Create a detailed process map: for the transport phase, it is useful to develop a process map for the provision of care to victims, documenting the different personnel and materials directly involved with the victim and the means of transport.

For hospital care, it is essential to indicate the main activities related to the care of a victim suffering from a medical problem following a road accident, as well as the places where they take place. The team develops a process map for each procedure in a victim's cycle of care, Record the various stakeholders who interact directly with the victim in each procedure as well as the material resources required to carry out each activity. The team works together to capture all possible activities in the cycle. However, the victim's treatment plan may involve multiple hospital departments. Therefore, the organization chart can be mapped by department (for example, department or individual program). For the home health care phase, the process map for the complete care pathway should be drawn up, indicating the material resources and personnel (doctors, nurses, etc.) involved.

Many methods were used to obtain information for the process, including direct observation, interviews with relevant personnel, review of administrative data, review of records of injured victims and direct data entry from electronic records.

- Obtain time estimates: once a detailed process map has been developed of the victim's care pathway (pre-hospital, in hospital and at home), it is necessary to calculate how long each resource (personnel, materials, etc.) will be used. The process mapping team can make estimates, based on experience or on the times recorded by staff. When it comes to high consumption processes, it is essential to measure time accurately. When it comes to consistent resources, a standard time can be allocated. However, in some cases, many staff members may be required to contribute resources. In order to give an accurate time, it is wise to separate these resources.
- Estimate the cost of providing victim care resources by estimating the direct costs of each resource involved in each procedure: pre-hospital, in hospital and at home. Direct costs include the remuneration of the personnel involved, depreciation or rental of equipment, supplies used or other operating expenses, as well as for the support resources (indirect costs) needed to provide the primary resources that provide care to victims. These data are collected from the accounting information system and other computer systems.
- Calculate the capacity cost rate: In this step, the objective is to calculate the unit cost. In the set of care procedures in each phase (pre-hospital, in hospital and at home), the cost of the resource (staff, equipment, etc.) is divided by the duration of use of this resource. For example, in the case of staff, a clinician's salary is divided by the number of minutes that person spends providing care to victims. In the case of equipment or materials, the cost of the machine is divided by the number of minutes the machine is used.
- Calculate the total cost of care procedures independently in each phase. Start by simply multiplying the capacity cost rates (including associated support costs) for each resource used

in each victim treatment process, based on the amount of time the victim spent with the resource. Next, add up all the costs of all processes used during the full cycle of victim care to obtain the total cost of care for the victim. For example, if a provider sees a victim for a 10-minute visit, his or her capacity cost rate (i.e., unit cost) is multiplied by 10 minutes. This can give the cost of the provider's visit. The costs of all equipment, staff, and facilities are then added together to obtain the total cost of victim care.

4.2. Challenges and prospects

It is clear that the application of the TDABC system to health care services for victims of road traffic accidents faces several pitfalls. The most significant of these is the lack of highly standardized procedures, characterized by iterative care and the complexity of providing care to victims with different risk signs. However, the treatment plan for a road traffic accident victim may incorporate many hospital services such as transport, emergency department, radiology, surgery, etc.

Therefore, current cost assessment mechanisms (TDABC) often focus on assessing and measuring costs for small units, such as individual services or procedures (Oklu et al. 2015). Another problem, no less important than the previous one, is the non-repetitive provision of services for many other situations under the same conditions in the victim care cycle. Despite this, the TDABC approach is organized for use within the hospital. One of its benefits is that clinicians can see the difference in cost between similar providers and the difference between different care paths for the same medical service (Oklu et al. 2015). In addition, this model offers more benefits than costs. Therefore, decision-makers can increase organizational effectiveness by using TDABC, which can be considered an efficient and accurate system and will empower managers to design and implement best practices to reduce overall costs and improve the value of a patient population, such as VRA.

Conclusion and prospects:

In this paper, to highlight the potential for modelling TDABC costs in the context of health care for victims of motor vehicle accidents, we reviewed scientific research on modelling TDABC costs in the health care of victims of motor vehicle accidents. This research focused on the pre-hospital care pathway, hospital treatment and home care. Ten articles were found that described and reported the results of cost modelling in TDABC.

However, the results of this review indicate that the data relevant to our topic is derived from research that focuses on modelling TDABC costs of health care services in general. The data presented could be applied to a variety of diseases. Most of the studies identified were almost exclusively Time-Driven Activity-Based Costing research papers on health care services in general. They can be applied to a multitude of disease cases. Although they provided models on various cases in the hospital environment, by their very nature of healthcare, they are still applicable to the healthcare services of motor vehicle accident victims. There is only one article that directly

addresses the problems associated with hospitalization of motor vehicle accident patients, particularly the pre-hospital transport service.

The integration of the application of TDABC in the field of health care services for victims of road traffic accidents needs to be implemented gradually. Thus, it is important to build on the guidance provided in the literature. The aim is to equip health care facilities with reliable cost accounting practices.

The steps in implementing Time-Driven Activity-Based Costing to health care services for victims of motor vehicle crashes can serve as a starting point for future research on the costing of health care for these victims. To this end, we will propose case studies of Time-Driven ActivityBased Costing modeling of health care in hospital and during transportation to address the limitations of the work done on this issue.

References:

BAKER, J. J., 1998. Activity-Based Costing and Activity-Based Management for Health Care. Jones & Bartlett Learning.

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*, 11, 165–186. <https://doi.org/10.1108/QRAM04-2014-0036>

CARR B.G., J.M. CAPLAN, J.P. PRYOR and C.C., 2006. Branas, “A meta-analysis of prehospital care times for trauma”. *Prehospital Emergency Care*, 10(2), 198-206,.

COATS, T. J., DAVIES, G., 2002. Prehospital care for road traffic casualties. *BMJ*, 324, 1135–1138. <https://doi.org/10.1136/bmj.324.7346.1135>

COOPER R and R. S. KAPLAN., 1991 "Profit priorities from activity-based costing." *Harvard business review* 69.3 : 130-135.

DEMEERE N., K. STOUTHUYSEN and F. ROODHOOFT,. 2009., “Time-driven activity-based costing in an outpatient clinic environment: development, relevance and managerial impact”, *Health policy*, 92(2-3), 296-304,

DUKE M. and A. STREET, 2003., “Hospital in the home: constructions of the nursing role– a literature review”, *Journal of Clinical Nursing*, 12(6), 852-859,.

DYLAN McCREARY D.L., M. WHITE, S. VANG, B. PLOWMAN and B.P. CUNNINGHAM, 2018. “Time-driven activity-based costing in fracture care: is this a more accurate way to prepare for alternative payment models?”, *Journal of orthopaedic trauma*, 32(7), 344348,.

EVERAERT, P., BRUGGEMAN, W., SARENS, G., ANDERSON, S. R., LEVANT, Y., 2018. Cost modeling in logistics using time-driven ABC experiences from a wholesaler. *International*

Journal of Physical Distribution & Logistics Management, 38, 172–191.
<https://doi.org/10.1108/09600030810866977>

FAIRHURST R. 2005., "Pre Hospital Care in Europe". Disaster Medicine Lippincott Ed . 2007:137–138, November.

FALLAH TAFTI, M., & ROSHANI, R. 2021. Development of models to study traffic accidents on the final sections of access roads to the cities: a case study of three major Iranian cities. Archives of Transport, 59.

FRICHI; F. JAWAB, AND S. BOUTAHARI, 2019. 'The mixed-method 5W2D approach for health system stakeholders analysis in quality of care: an application to the Moroccan context', International journal of environmental research and public health, 16(16), 2899,.

GREGÓRIO J., G. RUSSO, L. V. LAPÃO ,2016.; "Pharmaceutical Services Cost Analysis Using Time-Driven Activity Based Costing: A Contribution to Improve Community Pharmacies' Management"; 12(3):475-85, May-Jun

HAUSER C., C.M. HAWKINS, F.F. DE QUEIROGA AND A. PRATER, 2020., "An Application of Time-Driven Activity-Based Costing in an Interventional Radiology Practice", Journal of the American College of Radiology, 17(8), 1029-1033,.

HEATON H.A., D.M. NESTLER, W.J. BARRY, R.A. HELMERS, M.Y. SIR, D.G. GOYAL AND A.T. SADOSTY,2019. "A time-driven activity-based costing analysis of emergency department scribes", Mayo Clinic Proceedings: Innovations, Quality & Outcomes, 3(1), 30-34,.

HOOZÉE AND W. BRUGGEMAN, "Identifying operational improvements during the design process of a time-driven ABC system: The role of collective worker participation and leadership style", Management accounting research, 21(3), 185-198, 2010

HUSTED H., B.B. KRISTENSEN, S.E. ANDREASEN, C. SKOVGAARD NIELSEN, A. TROELSEN, AND K. GROMOV, 2018. "Time-driven activity-based cost of outpatient total hip and knee arthroplasty in different set-ups", Acta orthopaedica, 89(5), 515-521,.

IPPOLITO A., S. BONI, E. CINQUE, A. GRECO AND S. SALIS, "Using time-driven activitybased costing to establish a tariff system for home health care services", Journal of Healthcare Management, 61(6), 436-447, 2016.

JAWAB, F., FRICHI, Y., BOUTAHARI, S., 2018. Hospital Logistics Activities. International Conference on Industrial Engineering and Operations Management, 3228–3237.

KAPLAN R. S., H. DEREK 2017., "Defining, measuring, and improving value in spine care", November.

KAPLAN, R. S., ANDERSON, S. R., 2004. Time-driven activity-based costing. Harvard Business School Press.

KAPLAN, R. S., ANDERSON, S. R., 2007. time-driven activity-based costing: a simpler and more powerful path to higher profits. Harvard Business School Press.

KAPLAN, R. S., PORTER, M. E., 2011. How to solve the cost crisis in health care. Harvard Business Review, 89, 56–61.

KEEL, G. C. SAVAGE, M. RAFIQ AND P. MAZZOCATO, 2017., “Time-driven activity-based costing in health care: a systematic review of the literature”, Health Policy, 121(7), 755763,

LAMURAUD, K., LHUILLERY, S., 2016. Endogenous technology adoption and medical costs. Health Economics, 25, 1123–1147. <https://doi.org/10.1002/hec.3361>

LIPSCOMB, J., YABROFF, K. R., BROWN, M. L., LAWRENCE, W., BARNETT, P. G., 2009. Health care costing: data, methods, current applications. Medical Care, 47. <https://doi.org/10.1097/MLR.0b013e3181a7e401>

MAGNUSSON A., E. SEVERINSSON, AND K. LÜTZEN, 2003. “Reconstructing mental health nursing in home care”. Journal of Advanced Nursing, 43(4), 351-359,.

MCLAUGHLIN N., M.A. BURKE, N.P. SETLUR, D.R. NIEDZWIECKI, A.L. KAPLAN, C. SAIGAL AND R.S. KAPLAN, 2014. “Time-driven activity-based costing: a driver for provider engagement in costing activities and redesign initiatives”, Neurosurgical focus, 37(5), E3,.

ÖKER . F. AND H. ÖZYAPICI, 2013. “A new costing model in hospital management: timedriven activity-based costing system”, The health care manager, 32(1), 23-36,.

OKLU R., D. HAAS, R.S. KAPLAN, K.N. BRINEGAR, N. BASSOFF, H.B. HARVEY, AND A.M. PRABHAKAR, 2015. “Time-driven activity-based costing in IR. Journal of vascular and interventional radiology” , JVIR, 26(12), 1827-1831,.

RESNICK C.M., G. INVERSO, M. WRZOSEK, B.L. PADWA, L.B. KABAN AND Z.S. PEACOCK, 2016. “Is there a difference in cost between standard and virtual surgical planning for orthognathic surgery?”. Journal of Oral and Maxillofacial Surgery, 74(9), 1827-1833,.

SABHARWAL, S. .A.W. CARTER, A. RASHID, A. DARZI, P. REILLY AND C.M. GUPTE, 2016. “Cost analysis of the surgical treatment of fractures of the proximal humerus: an evaluation of the determinants of cost and comparison of the institutional cost of treatment with the national tariff”, The bone & joint journal, 98(2), 249-259,.

TANG, D., LOZE, M. T., ZEH, H. J., KANG, R., 2010. The redox protein HMGB1 regulates cell death and survival in cancer treatment. Autophagy, 6, 1181–1183. <https://doi.org/10.4161/auto.6.8.13367>

TEMMINK D., A.L. FRANCKE, J.B. HUTTEN, J. VAN DER ZEE, AND H.H. ABU-SAAD, 2000. “Innovations in the nursing care of the chronically ill: a literature review from an international perspective”, Journal of Advanced Nursing, 31(6), 1449-1458,.

TROYER, G. T., BRASHEAR, A. D., GREEN, K. J., 2005. Managing corporate governance risks in a nonprofit health care organization. *Journal of Healthcare Risk Management*, 25, 29– 34. <https://doi.org/10.1002/jhrm.5600250309>.

UDPA, S., 1996. Activity-based costing for hospitals. *Health Care Management Review*, 21, 83–96.

WARD-GRIFFIN C. AND P. MCKEEVER, 2000. "Relationships between nurses and family caregivers: partners in care?", *Advances in Nursing Science*, 22(3), 89-103,.

WORLD HEALTH ORGANIZATION, 2004, "World Report on Road Traffic Injury Prevention".

WORLD HEALTH ORGANIZATION, 2018."Global Status Report on Road Safety".

ZEHMED, K., JAWAB, F., 2021. The performance of tramway service from the users' viewpoint: A comparative analysis between two Moroccan cities. *Archives of Transport*, 60, 7–21. <https://doi.org/10.5604/01.3001.0015.5223>

ZERKA, A., & JAWAB, F. (2022). Modelling the costs of pre-hospital transport service for victims of road accidents in TDABC. *Archives of transport*, 61(1), 89-101.

ZERKA, A., JAWAB, F., 2020. Calculation of the costs of health care services for road accident victims in TDABC: a systematic review of the literature. *International Colloquium of Logistics and Supply Chain Management*, 1–7. <https://doi.org/10.1109/LOGISTIQUA49782.2020.9353894>