12 Mapping the Service Process to Enhance Healthcare Cost-Effectiveness: Findings from the Time-Driven Activity-Based Costing Application on Orthopaedic Surgery

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Abstract

The main goal for any healthcare delivery system is to improve the value delivered to patients. Particularly, to properly manage value, both outcomes and costs must be measured at the patient level; this requires the engagement of physicians, clinical teams, administrative staff and finance professionals in designing the process maps and estimating the costs involved in treating patients over the care cycle. Moreover, many scholars stated that Activity-Based Costing (ABC) strategies represent valid support in the decision-making process on healthcare management, by fostering corrective actions in the case of an inefficient process or low-quality outcomes. Accordingly, the goal of this work is to demonstrate how mapping processes, using the Time-Driven ABC approach, is a key for the improvement of the value created in health care, both in terms of better outcomes and cost reduction. To achieve this goal, a multi-centre experimental case study has been run on the field of orthopaedic surgery (hip and knee arthroplasty). The case study was designed on empirical observation, data collection and face-to-face interviews within three Italian Hospital Organizations. Findings confirm that mapping the surgery process allows clinical management to understand: (i) the whole clinical pathway (from pre to post patient's surgical path) and the associated resource consumption; (ii) which

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clinical activities require more resources and time; and (iii) how phases of the surgery process could be improved in order to obtain best practice outcomes according to the NHS' necessity to lower costs and increase service quality.

12.1 Introduction

The aim of healthcare delivery in the Value Based Healthcare era is to provide high value to patients. This purpose is what matters to patients and bonds the interests of all system players; patients, payers and providers will all prosper as the healthcare system's economic sustainability improves. In this perspective, the system for performance improvement in health care should be defined by value creation and the best way to drive system change is through rigorous, disciplined assessment and enhancement of value (Porter, 2008). As a result, the healthcare delivery process has changed from quantity-based to value-based efficiency.

Within this system, the use of resources aimed at gathering valuable information for the overall activities performed by healthcare organizations are even more necessary. To this end, managerial accounting tools can be considered useful for information collection in the healthcare context. Several authors have defined Time-Driven Activity-Based Costing (TDABC) as a managerial tool (Kaplan & Porter, 2011) that fosters cooperation between clinicians and clerical staff by mapping the entire value creation process (Baratti et al., 2010; Demeere et al., 2009; Dombrée et al., 2014). Furthermore, because of the higher process standardization, TDABC is especially suitable for the surgical field (Akhavan et al., 2016). TDABC will provide more and better knowledge about timing, procedures and costs. According to (Moffitt & Vasarhelyi, 2013), accounting models should evolve and adapt to focus more on data quality, atomicity and data linkages; as a result, information gathering should shift from a periodic collection of data to a real-time flow.

This advancement in health care would be extremely beneficial for clinical managers (both physicians and administrative staff) in order to rapidly understand the effectiveness of a treatment and its resource consumption.

In the perspective of reorganizing the healthcare delivery process to achieve high value for the patient, through its process, TDABC mapping could generate information about which steps add the highest value and whether waste can be reduced or if resources are being under-utilized. TDABC application in orthopaedic surgery is particularly appropriate, as demonstrated by several authors (DiGioia et al. 2016; Akhavan et al., 2016; Pathak et al., 2019; Blaschke et al., 2020).

The aim of this study is to determine how knowledge obtained from the application of TDABC to the delivery process of two orthopaedic surgeries in separate hospitals can be used to enhance the delivery process. The orthopaedic surgical area was chosen because of its streamlined procedure and significant effect on healthcare system costs. The preference of total hip and knee arthroplasty (THA and TKA) is primarily due to the high frequency and demand for the two surgical procedures (Ministero della Salute, 2019).

Following this introduction, the paper has the following outline: the second section includes the key theoretical background; the third one reports on the method of the study, whilst the fourth section presents the research results. Section five discusses the results obtained and offers some implications on the role of accounting tools in the healthcare delivery process. The concluding section includes final remarks on the work.

12.2 Background

The healthcare sector has undergone significant improvements in the way it provides health care since the turn of the century. For example, rising healthcare costs, technological advances, cultural shifts and increased access to health information through the internet and digital media. These have led health care to a patient-centred approach to health and well-being (Francis, 2010; Frow et al., 2016), which involves new ways to lure patients to access services.

The patient-centred approach to care is a strategy of delivering care that aims to improve the quality of interactions between providers and customer institutions by putting consumers (and their families) at the centre of decisions that impact their well-being. This methodology entails patient involvement and attracting patients to a specific hospital.

Concerning patients' engagement, healthcare providers no longer regard patients solely as patients; they are increasingly regarded as healthcare customers (Levine, 2015). Furthermore, healthcare users are no longer passive recipients of care; rather, they are active participants in the design of their healthcare service experiences (Danaher & Gallan, 2016). In particular, in order to meet and surpass patients' desires and needs in this dynamic healthcare environment with patient consumerism, healthcare providers must consider what patients and families experience in their facilities, how they view healthcare service quality and what influences those expectations (Lee, 2011).

The healthcare industry has acknowledged the significance of servicescape (the organization's physical environment) in defining the service experience of its patients and families. The principle of patient-centred care is also closely related to the concept of service design; creating service encounters that are meaningful, functional and attractive from the client's point of view (Moritz, 2005). Healthcare providers have begun to incorporate critical techniques used in the guest services industry as they continue to emphasize the value of patient-centred care and work to increase the quality of that care (Lee, 2011).

As a consequence, in terms of attracting patients to the hospital, value creation for patients plays a critical role and is also a key for service design.

Porter (2010) defines value in health care as outcome over expense for a particular condition; an equation in which the patient outcomes obtained serve as the numerator and treatment costs serve as the denominator. As a result, in order to be more efficient, it is critical to maximize the quality of the process of healthcare delivery, whilst minimizing the cost expense for them.

Fundamental re-thinking (Clack & Ellison, 2019) of healthcare delivery is needed to increase value development. To provide a full cycle of treatment for a given health condition, care pathways must be reorganized around the patient's medical condition, which necessitates the formation of a dedicated multidisciplinary team that forms a common organizational unit (Porter, 2009).

Rehabilitative care, patient education and collaboration between a physician team leader and a care manager, who monitors each patient's care process and provides outcomes and cost indicators, are also part of the process improvement. Within the value-based healthcare system, healthcare costs are defined as the overall cost of patient care and are determined by the actual usage of resources involved in a patient's care process (personnel, facilities, supplies) (Porter, 2008). Accordingly, the study of the healthcare delivery process is the starting point to improve its process and cost efficiency. The Time-Driven Activity-Based Costing approach, a seven-step method that can be used to estimate the process and the cost of treatment for an individual patient treated along a care continuum for a specific illness, can perfectly respond to this information requirement (Kaplan & Porter, 2011). In this approach, clinical and nonclinical staff contribute to the creation of process maps that detail all of the activities required for a particular service or procedure. Based on surveys or direct observation, the TDABC team estimates the practical capacity (that is, the actual productive time) of each capacity-supplying resource (employee and equipment) and the average time required for each resource operation. It is a "bottom-up" approach that, through process mapping and time equations, captures the true complexity of activities at the patient level, whilst also accounting for the numerous care pathways amongst heterogeneous populations (Pathak et al., 2019). TDABC process maps, according to (Blaschke et al., 2020), provide the visibility needed to reveal high cost drivers, non-value-added measures and unused resource capability, which can then inform decision makers on how to maximize value through the care cycle. One of the model's main strengths is its ability to identify areas of variation or inefficiency in the care pathway by process mapping. The granular calculation of each process phase can then be used to advise strategic resource reallocation and care pathway restructuring to maximize value (Blaschke et al., 2020).

This technique has been used by many scholars in a variety of healthcare settings. (Demeere et al., 2009), for instance, employ the TDABC in an outpatient environment. This experience has enabled the medical directors to recognize the time required to carry out specific activities and analyze them. In particular, this study showed that the times for categorizing patients were twice as high in the Gastroenterology and Urology departments than in the other departments. At this point, managers, with the help of the various subjects involved, analyzed the methods of carrying out these activities and found that inefficiency was represented, in this case, by an incorrect distribution of roles and by a rotation of staff.

In the work of (Laviana et al., 2016), this methodology was used, instead, in order to determine the short- and long-term costs of localized prostate cancer. With the support of the TDABC, the delivery process was analyzed and the areas of inefficiency were identified in order to eliminate waste.

Concerning the surgery field, (Au & Rudmik, 2013) and (Akhavan et al., 2016) used the TDABC, respectively, for the cost of endoscopic breast surgery and for the calculation of the cost of arthroplasty surgery. In particular, (Akhavan et al., 2016) defined the entire process of patients undergoing THA and TKA from admission to the operating room to their transfer to the post care unit, distinguishing all the actors involved and time required. This allowed the authors to calculate and compare the cost information from traditional cost accounting with those obtained from the application of the TDABC, noting more accurate information from the use of the activity-based methodology.

All these authors also agree that the Activity-Based methodology is able not only to provide more information, but also to ensure greater detail and greater punctuality of the same, representing valid support to the decision-making process. Furthermore, the application of this methodology reduces the percentage of unspecified allocated overhead costs and, through process mapping, it is possible to effectively manage the entire process, resorting to corrective actions when necessary (Dombrée et al., 2014). In this way, the analysis of the healthcare delivery process is complete and correct as the resources used and the activities carried out are described with precision (Baratti et al., 2010). In addition, the information obtained and the ways in which it is detected, increases transparency in the management of companies and allows, as evidenced by the study by (Demeere et al., 2009), an internal analysis aimed at determining a reference benchmark.

To summarize, the following Fig. 12.1 reports a process map example of all pre-admission steps for a surgical patient within the hospital, according to his/her medical condition and/or situation.

The key to Fig. 12.1 and general roles for designing process maps:

- Rounded rectangles represent the start or the end of the process;
- Rectangles represent the activity performed;
- Arrows show the order of the activities within the process;
- The rhombus is the symbol for “decision turning-points”. It represents where a decision is needed.

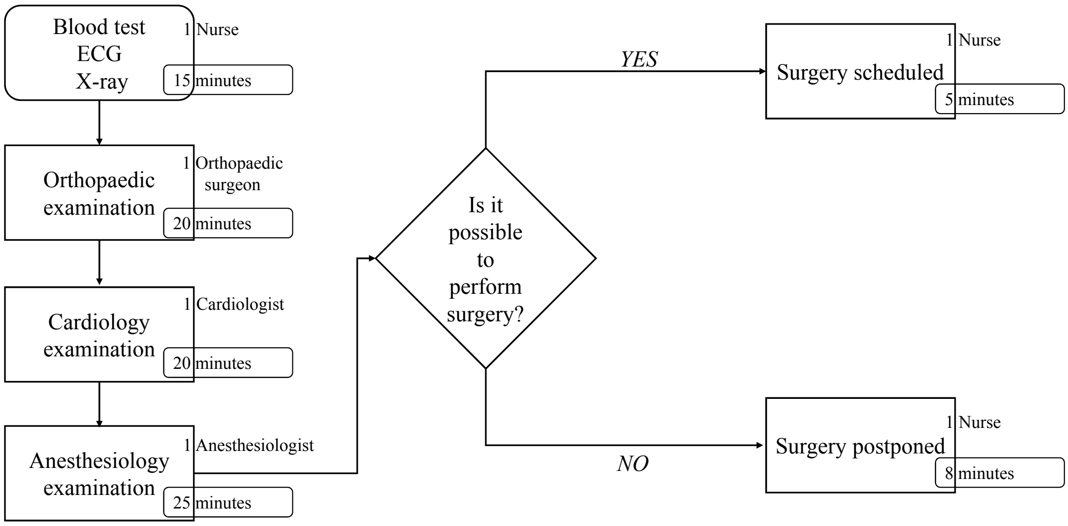

Fig. 12.1 Pre admission screening for patient undergoing elective surgery. *Source* Authors' illustration inspired by DiGioia et al. (2016), Akhavan et al. (2016), Pathak et al. (2019)

12.3 Method

A multi-centre case study (Yin, 2017) has been performed. Built as an experimental case (Scapens, 1990) applied to the service management field, this accounting inquiry has regarded the observation of a surgical team providing THA and TKA in three different hospitals.

Different scenarios of orthopaedic surgery in Italy have been analyzed. In particular, the following have been considered:

- A public hospital
- A university public hospital
- A private hospital

The hospitals are located in Italy, in two different Regions (Abruzzi and Latium).

Ninety procedures amongst the hospitals have been observed in order to map activities and resources involved in the surgeries analyzed. Table 12.1 below reports the detail about the procedures as per each organization participating in the case study.

Table 12.1 Number of observations. *Source* Authors' elaboration (2021)

	THA	TKA
Public hospital	15	15
University public hospital	15	15
Private hospital	15	15
Total number of observations	90	

Each surgery procedure observed corresponds to a patient eligible for THA or TKA. Only patients undergoing planned hip and knee replacement who did not have major comorbidities were included in the study. Consequently, all necessary interventions following traumatic events or in patients whose condition was particularly complex were excluded.

By using the Time-Driven Activity-Based Costing approach (Kaplan & Porter, 2011), built on seven steps of application (Keel et al., 2017), a process map of the whole healthcare services provided in a THA and TKA (from the patient's admission to his/her discharge) has been obtained.

The main activities and time spent on them during the delivery process, as well as the subjects involved, were identified using questionnaires collected through interviews and submitted to health professionals.

Process maps have been built including all the activities carried out and all the consumable goods needed in each phase of the care process.

The physicians', nurses' and technical staff's time spent on the specific procedures has been calculated. Time spent on each activity has been described by sample statistics.

The process maps have been reviewed by the main investigator (Klein et al., 2006) with key experts belonging to the three organizations included in the case study.

12.4 Results

The sequential process map related to THA is shown in Fig. 12.2, and the one related to TKA is shown in Fig. 12.3.

The diagram shows a process map outline of the arthroplasty operating day including anaesthesia preparation, surgical preparation and surgery. The large boxes represent activities with arrows indicating sequence. The colours correspond to different hospitals (see legend) with personnel ID in the upper smaller boxes (see legend). The numbers in the smaller boxes correspond to minutes used per activity.

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Except for the university hospital, every organization analyzed shows the same structure of patient pathway for THA and TKA. Except for the university hospital, where local anesthesia in the PACU is administered only for patients undergoing TKA, the main flows for the two surgical procedures observed are the same.

For both procedures, indeed, the activities regarding the operating room are equal in all the hospitals analyzed. They diverge only for time requirement and personnel involved.

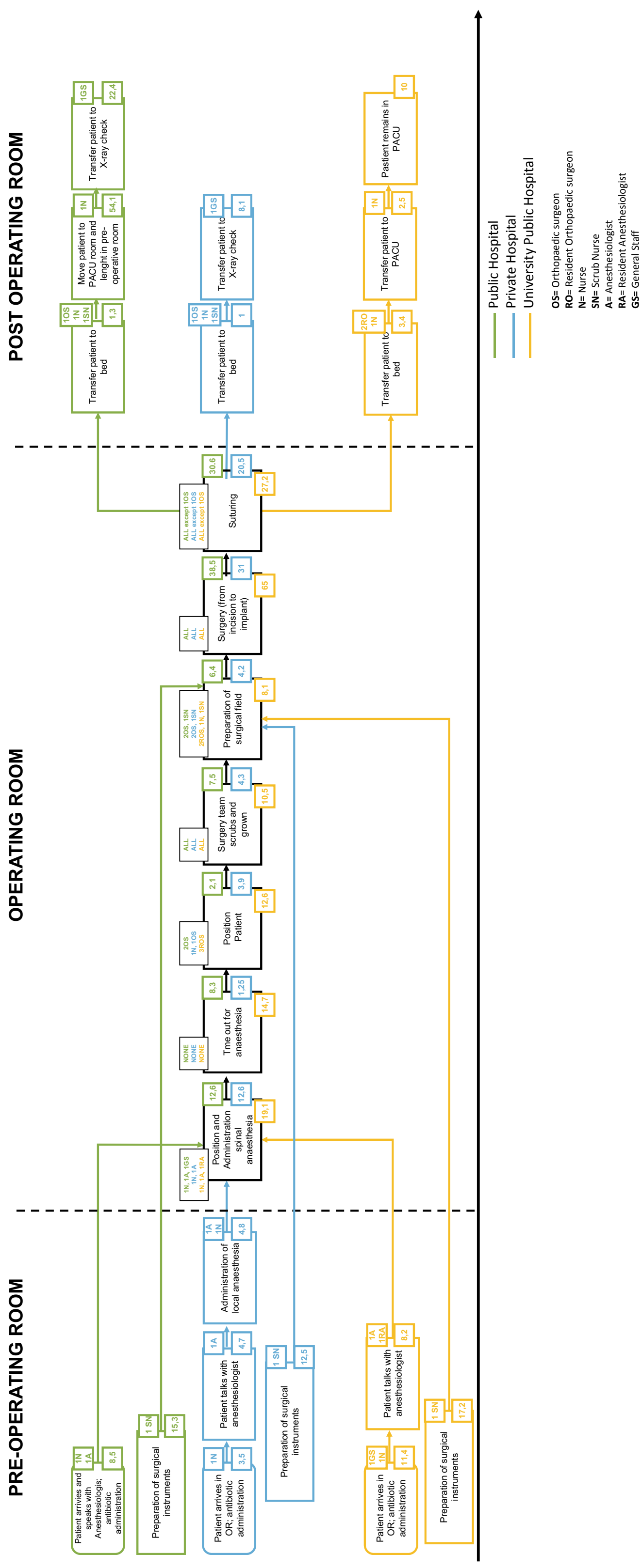

Fig. 12.2 Process map of total hip arthroplasty. OR = operating room; PACU = post anesthesia care unit. *Source* Author's own illustration (2021)

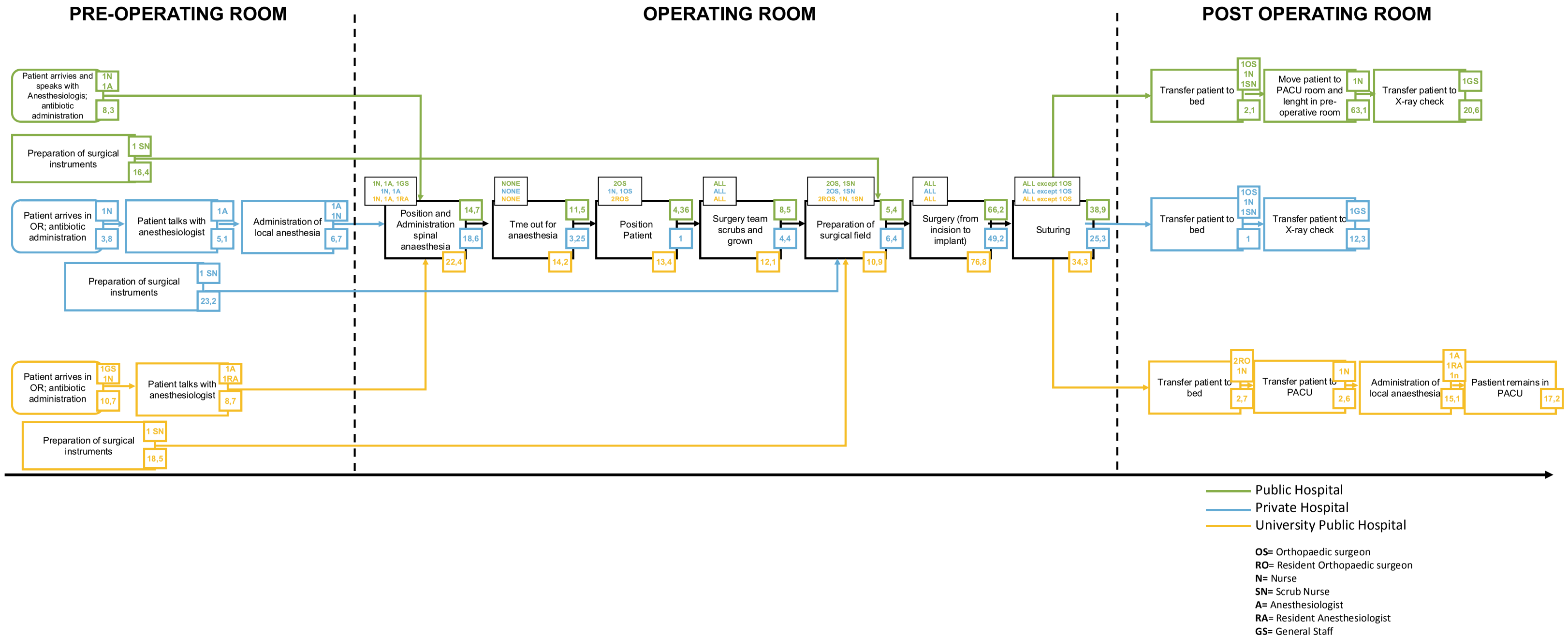

Fig. 12.3 Process map of total knee arthroplasty. OR = operating room; PACU = post anaesthesia care unit. *Source* Author's own illustration (2021)

Table 12.2 lists all the activities and the time required for them in every structure.

As we can note from the table, the main differences in times between the three hospitals, both in THA and TKA, are related to both the pre and post operating room activities. These differences are mainly concerned with the following key points of the surgical services:

Table 12.2 Mean time (minutes) required for all the activities. *Source* Authors' elaboration (2021)

Activity	Public hospital		Private hospital		Public university hospital	
	THA	TKA	THA	TKA	THA	TKA
Patient arrives in room Administer antibiotic	μ = 8,5 σ = 3,9	μ = 8,3 σ = 3,8	μ = 3,5 σ = 0,7	μ = 3,8 σ = 0,8	μ = 11,4 σ = 2,7	μ = 10,7 σ = 2,4
Patient speaks with anaesthesiologist			μ = 4,7 σ = 0,9	μ = 5,1 σ = 1,0	μ = 8,2 σ = 1,6	μ = 8,7 σ = 1,1
Administer local anaesthesia	NP	NP	μ = 4,8 σ = 0,8	μ = 6,7 σ = 1,1	NP	μ = 15,1 σ = 1,4
Preparation of surgical instruments*	μ = 15,3 σ = 5,3	μ = 16,4 σ = 5,7	μ = 12,5 σ = 1,8	μ = 23,2 σ = 3,3	μ = 17,2 σ = 1,3	μ = 18,5 σ = 1,2
Position for spinal or general anaesthesia and administer anaesthesia	μ = 12,6 σ = 6,8	μ = 14,7 σ = 8,0	μ = 12,6 σ = 2,9	μ = 18,6 σ = 4,3	μ = 19,1 σ = 3,3	μ = 22,4 σ = 3,05
Time out for anaesthesia	μ = 8,3 σ = 3,4	μ = 11,5 σ = 4,8	μ = 1,25 σ = 0,5	μ = 3,25 σ = 1,3	μ = 14,7 σ = 0,4	μ = 14,2 σ = 0,9
Position patient	μ = 2,1 σ = 1,3	μ = 4,36 σ = 2,9	μ = 3,9 σ = 0,6	μ = 1 σ = 0,1	μ = 12,6 σ = 2,8	μ = 13,4 σ = 1,4
Surgery team scrubs and gowns	μ = 7,5 σ = 1,7	μ = 8,5 σ = 2,0	μ = 4,3 σ = 0,7	μ = 4,4 σ = 0,7	μ = 10,5 σ = 1,3	μ = 12,1 σ = 1,2
Preparation of surgical field	μ = 6,4 σ = 1,4	μ = 5,4 σ = 1,2	μ = 4,2 σ = 1,0	μ = 6,4 σ = 1,5	μ = 8,1 σ = 0,8	μ = 10,9 σ = 1,2
Surgery (from incision to implant)	μ = 38,5 σ = 12,6	μ = 66,2 σ = 20,0	μ = 31,0 σ = 3,83	μ = 49,2 σ = 6,0	μ = 65 σ = 6,4	μ = 76,8 σ = 5,6
Suturing	μ = 30,6 σ = 7,6	μ = 38,9 σ = 9,4	μ = 20,5 σ = 3,88	μ = 25,3 σ = 6,6	μ = 27,2 σ = 4,1	μ = 34,3 σ = 3,9
Transfer patient to bed	μ = 1,3 σ = 1,27	μ = 2,1 σ = 0,7	μ = 1 σ = /	μ = 1 σ = /	μ = 3,4 σ = 1,1	μ = 2,7 σ = 0,9
Total of time	**131,1**	**176,36**	**104,25**	**147,95**	**197,4**	**239,8**
Move patient to PACU	μ = 3,3 σ = 1,2	μ = 2,2 σ = 1,0	NP	NP	μ = 2,5 σ = 0,9	μ = 2,6 σ = 0,8
Patient stays in PACU	μ = 50,8 σ = 28,8	μ = 60,9 σ = 40,2	NP	NP	μ = 10 σ = 1,2	μ = 17,2 σ = 2,1
X-ray check	μ = 22,4 σ = 2,09	μ = 20,6 σ = 2,3	μ = 8,1 σ = 1,6	μ = 12,3 σ = 2,4	NP	NP
Transfer patient to ward	μ = 6,2 σ = 2,1	μ = 2,9 σ = 1,3	μ = 5,1 σ = 1,8	μ = 5,5 σ = 1,6	μ = 7,1 σ = 1,4	μ = 6,9 σ = 1,2
Total process time	**213,8**	**262,96**	**117,45**	**165,75**	**217**	**266,5**

*Not included in estimation; μ = mean, σ = standard deviation, NP = not performed

Table 12.3 Device and asset used in the three different structures

	Device	Asset	Public hospital	Private hospital	Public university hospital
Catheter	Yes	No	No	No	Yes
Echograph	No	Yes	No	Yes	Yes
Intraoperative x-ray	No	Yes	No	No	Yes
Post anaesthesia care unit	No	Yes	Yes	No	Yes

Source Authors' elaboration

- the steps performed by the patient;
- the device utilization; and
- the asset involved.

The different steps performed by patients have been shown by Figs. 12.2 and 12.3. The differences in asset and device utilization are reported in Table 12.3; in particular, private and university hospitals use the echograph for the administration of local anesthesia, specifically the first one in the pre operating room and the second one in the post operating room, whereas the public hospital requires the patient to be catheterized, which the other two structures do not.

12.5 Discussion

According to (Creswell & Clark, 2017), mapping the clinical pathway allows for the comprehension of connections between activities, actors, roles and responsibility of the service delivery process; additionally, the use of the Time-Driven Activity-Based Costing Method (TDABC) allows for the estimation of time consumed by various staff members involved in patient treatment during THA and TKA. It is fundamental to emphasize that as described by (Laberge et al., 2019), elective hip and knee surgeries are highly standardized procedures with identical clinical paths. Although these surgeries necessitate different materials and patient preparation, the processes are the same. This is confirmed by the findings of this study; therefore, both processes can be discussed as a whole.

The analysis of the process map discloses three main differences between the TKA and THA delivery processes between the three hospitals, in particular:

- Time required;
- Activity performed in pre and post operating room;
- Assets and devices involved.

The time required for the healthcare delivery process is higher for both procedures in university hospitals.

This could be mostly attributed to the “teaching” hospital’s context, which requires residents’ participation in the entire procedure; within this kind of hospital, it should also be noted that there are various levels of expertise in various fields, such as student nurses, radiologist technicians and residents of various medical fields (e.g., anesthesiology, orthopaedics). Thus, residents’ involvement in several steps of the healthcare value chain is generally associated with greater, longer surgical time in total joint arthroplasties (Pugely et al., 2014).

The other explanation for the higher time required by university hospitals is the employment of a device (catheter) and assets (x-ray check in the OR) not found in the other structures.

The difference in activity performed in the pre and post operating room might be related to the different organization of the three structures. According to (Bhattacharjee & Ray, 2014), patient flow is influenced by seasonal and local variables, as well as the location of hospitals and the types of services provided.

Furthermore, within the context of the Italian National Health System, both public and private hospitals are structured in Operating Units or wards, clustered per specializations (e.g. Orthopaedics). The head of department is responsible for delivering organizational resources to ward staff as well as establishing a certain organizational climate, which includes unique policies (guidelines), processes and practices that may differ depending on the manager (Ancarani et al., 2019). Furthermore, clinical decisions addressing surgical strategies can be steered by the clinical staff background (e.g. current practices or specialist school legacy) and/or operating team adherence to scientific literature (e.g. evidence-based medicine or medical guidelines). This may explain why there is a different approach to using devices (e.g. catheter), assets (e.g. x-ray in OR) and activities performed pre and post operating theatre.

Instead, the activities performed in the operating room are equal in all the structures analyzed because, according to (Laberge et al., 2019), standardization of the prosthesis process was employed as a method for improving efficiency; i.e. patient safety. According to the author, this method allowed for the simplification of the supply procedure and the reduction of the strain on physicians to arrange for the proper materials for each surgery. Indeed, regardless of facility or surgeon volume, standardization is associated with improved processes and results for patients having THA or TKA (Bozic et al., 2010). It can also help to improve procedures, which increases productivity and the number of hip and knee replacement surgeries performed per operating room (Attarian et al., 2013).

From the mentioned findings, we can argue that the main differences in THA and TKA performed by the three organizations analyzed follow some organizational features that act as a “conditioning variable” for specific activities in the service processes.

Accordingly, Table 12.4 reports the activities that most differ in terms of time consumed between the three structures.

Table 12.4 The different activities and their conditioning variable. *Source* Authors' elaboration (2021)

	Activities	"Conditioning variable"
Operating room	Position patient	Different clinical approach
	Surgery	Surgeon's expertise
	Suturing	
Pre/post operating room	Length of stay in PACU	Organizational structure

Concerning the activity performed in pre and post operating room, they can diverge according to organizational structure; as shown in Table 12.4, the activity related to surgery can vary depending on the surgeon's expertise and background or training.

Accordingly, in order to define a benchmark of which clinical pathway of THA and TKA may be most suitable, university hospitals are excluded from the benchmark. These structures, in fact, perform teaching activity involving residents in all the delivery processes in order to improve their skills (Chung, 2005), probably extending the time required for the procedures (Tseng et al., 2011).

Performing joint replacement surgery necessitates several resources (operating input), which may be divided into two categories: equipment and labour. According to (Laberge et al., 2019), this research confirms that in order to increase the efficiency of joint arthroplasty, it is fundamental to monitor and measure: (i) the quantity of resources employed; and (ii) the mix of resources employed. Thus, this allows clinical management to manage performance obtained by the operating inputs involved in the clinical pathway.

As a consequence, the use of TDABC and the process map analyses are able to show the weak and strong points of various clinical pathways (Kaplan & Porter, 2011) related to THA and TKA; these points are compared to create a benchmark for patient satisfaction and cost reduction based on the time and personnel required for each activity.

12.6 Conclusion

This paper addresses the theme of the healthcare delivery process and how to increase its cost-effectiveness. Precisely, the work aims at understanding if and how the process mapping due to the application of TDABC can improve value creation and efficiency. Particularly, within the surgical sphere, the healthcare delivery process of knee and hip arthroplasty has been analyzed. To achieve the goal of this study, TDABC approach was employed in different hospitals in order to map the delivery process in different contexts.

The results allowed for:

- understanding the standard clinical pathway for patients undergoing THA and TKA;
- estimating the mean time required for each step of each activity, and so the mean cost too;
- confirming that the surgical process is a high-standard procedure and the patient pathway in THA and TKA differs only in pre and post operating room activities.

These findings seem particularly suitable for practitioners because they allow users to design an efficient surgical procedure. Particularly, the study shows a practical example of a useful process map that formalizes all the activities and resources required in providing surgery. Moreover, process mapping and time detection provide healthcare managers with a comparison between the planned performance and the actual one, according to their own business structure.

Accordingly, this is fundamental for the measurement of the efficiency in providing THA and TKA, by allowing comparisons with other providers' standards and with current practice achievements.

Furthermore, the findings show that the main operating differences in THA and TKA processes are not attributable to hospital ownership (private and public hospitals behave in the same way), but to the feature of being a teaching or non-teaching hospital. University hospitals, due to their institutional function, result in higher charges both for time and resource consumption in comparison with general hospitals.

The study confirms that by comparing standardized processes from different sources, it would be possible to design an optimal pathway for THA and TKA by keeping the best practices from each process analyzed. It would also be suitable for creating a standard process and related costs.

This is relevant also for scholars involved in Managerial Control tools applied in the Public Management field. Accordingly, the study could foster debate about the application of accounting tools, both for cost analyses and process design, following the new requirements of the NHS to increase access to services and quality together with reducing spending.

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