RESEARCH PAPER

Time-Driven Activity-Based Costing for Cataract Surgery in Canada: The Case of the Kensington Eye Institute

Méthode des coûts par activités en fonction du temps pour la chirurgie de la cataracte au Canada : le cas du Kensington Eye Institute

HAMID SADRI, PharmD, MSc, MHSC, CHE
Director
Policy Health Economics and Outcomes Research and Health Technology Assessment
Medtronic ULC
Brampton, ON

SARA SINIGALLIA, MSc, CEMS
Product Manager
Medtronic ULC
Brampton, ON

MAHEK SHAH, MD, MBA, MS
Director and Senior Researcher
Harvard School of Public Health
Boston, MA

JASON VANDERHEYDEN, MHCDS
National Director
National Director Value-Based Healthcare
Medtronic ULC
Brampton, ON

BERNARD SOUCHE, MBA, CSAM
Director
Health System Strategy
Medtronic ULC
Brampton, ON

Abstract

Time-driven activity-based costing (TDABC) has received considerable attention globally as a way to measure value in healthcare systems. This study aimed to apply TDABC for cataract surgery at the Kensington Eye Institute (KEI). During a field evaluation, a detailed process map was created for cataract surgery at KEI. The amount of resource use in terms of providers, equipment, space and consumables was calculated to determine the total costs of care. The average patient journey lasted 76 minutes, with 13 minutes of the surgical procedure occurring in the operating room (OR). The average procedure's cost per case was $545.28, which included consumables (34.40%), space and equipment (23.702%), personnel

(11.69%), overhead (30.27%) and OR (57%). KEI cataract operation was at approximately 50% capacity due to funding limits. The TDABC process map and costing allow centres to have data-driven support tools for care redesign and optimization.

Résumé

La méthode des coûts par activités en fonction du temps reçoit beaucoup d'attention à l'échelle mondiale comme moyen de mesurer la valeur dans les systèmes de santé. L'étude visait à appliquer cette méthode à la chirurgie de la cataracte au Kensington Eye Institute. Lors d'une évaluation sur le terrain, une carte détaillée du processus a été créée pour la chirurgie de la cataracte à l'Institut. La quantité de ressources utilisées en matière de fournisseurs, d'équipement, d'espace et de matériel a été calculée afin de déterminer le coût total des soins. Le trajet moyen du patient a duré 76 minutes, dont 13 minutes pour la procédure chirurgicale en salle d'opération. Le coût moyen de la procédure par cas était de 545,28 $, dont 34,40 % pour le matériel, 23,702 % pour l'espace et l'équipement, 11,69 % pour le personnel, 30,27 % pour les frais généraux et 57 % pour la salle d'opération. Les activités d'opération de la cataracte à l'Institut représentaient environ 50 % de la capacité totale, et ce, en raison des limites de financement. La cartographie des processus et la méthode d'établissement des coûts permettent aux centres de disposer d'outils de soutien fondés sur les données, afin de concevoir la refonte et l'optimisation des soins.

Background

Kaplan and Anderson (2004) introduced the time-driven activity-based costing (TDABC) approach as an alternative to the complicated and burdensome activity-based costing (ABC) approach (Cooper 1989). Unlike ABC, which requires subjective interviews, validation and continuous updates, TDABC measures two variables: (1) the unit cost of supplying capacity and (2) the time needed to perform an activity (Kaplan and Anderson 2004). TDABC is a bottom-up approach to costing that estimates costs based on the time for which the particular service has been used. TDABC has been used extensively in manufacturing and service industries, but healthcare organizations have not widely adopted it. In recent years, within the context of value-based healthcare (VBHC) described by Porter and Teisberg (2006), a few healthcare provider organizations used TDABC to define the cost of their services, including computed tomography scan, anticoagulation clinics and emergency departments (Berthelot et al. 2017; Martin et al. 2018; Ying et al. 2016; Yun et al. 2016).

VBHC links dollars spent to health outcomes that matter to patients, rather than to volumes of services or to specific processes that may or may not achieve those outcomes (Zelmer 2018). However, to date, there is limited experience with TDABC in the Canadian healthcare system. Nevertheless, with the new interest in VBHC, researchers have applied the TDABC process to the clinical procedures in pediatric ophthalmology, sinus surgery and breast cancer screening (Au and Rudmik 2013; Gulati et al. 2018; Nabelsi and Plouffe 2019). In order to further explore the applicability of TDABC in a Canadian setting, this study evaluated cataract surgery – a well-defined procedure – in an ophthalmology integrated practice unit (IPU). The Kensington Eye Institute (KEI) is a not-for-profit specialized healthcare facility affiliated with the Department of Ophthalmology and Vision Sciences, University of Toronto. KEI is licenced under the *Independent Health Facilities Act* (Government of Ontario 1990) and offers cataract, glaucoma and retina surgery as well as corneal transplants (North Toronto Eye Care n.d.). The goal of this study was to implement TDABC for cataract surgery at KEI.

This study will be of interest primarily to healthcare administrators. TDABC provides a less complicated alternative to ABC by allowing centres to directly estimate each procedure's resource demands, even for complex and specialized procedures.

Method

KEI surgeons performed 9,881 cataract procedures in 2019 that constitute 81% of the surgical procedures at KEI (Ontario Ministry of Health and Long-Term Care 2019). The scope of this study was to focus on the surgical procedure for cataract treatment. Accordingly, only activities that were relevant to cataract surgery at KEI were considered. Pre- and post-procedural activities (e.g., outpatient ophthalmology assessment) and possible procedural complications were excluded. The authors conducted an observational field evaluation and several interviews with the KEI clinical team and management. During the field evaluation study, the authors shadowed the KEI staff on a day dedicated to cataract surgery. To develop a detailed process map, authors followed 15 patients, one at a time – from intake to discharge – recording the procedural steps taken by the KEI administrative staff, clinical staff and surgical teams. The time spent at each of the following stages was recorded, starting from the registration/administrative area and activities in the care area – including preoperative (pre-op), transition to the operating room (OR), OR time and post-operative care unit (PACU) – to discharge. The staff activities relevant to the care process and their role in each functional area were identified and listed. KEI has four ORs and one separate laser room. The surgical department and the KEI senior management provided a list and annual cots of the equipment/services and clinical staff including their accreditation and remuneration. This study was approved by the KEI management and was conducted from the KEI perspective; therefore, the physician fees were excluded from the calculations. The study is an observational process evaluation and cost analysis. There was no intervention or interaction with patients, and no patient data were collected or accessed. As such, there was no need for the ethics review board approval.

Calculations and statistical analysis

This study used KEI data to calculate the capacity cost rate (CCR) for resources documented in the process map. CCR is defined as the cost of capacity-supplying resources divided by those resources' actual capacity (Keel et al. 2017). The variables for the CCR were personnel, space and time. To calculate each activity's cost, the CCR was multiplied by the probability-weighted time and probability of space use (e.g., the laser room was used only in 20% of the cases). As mentioned earlier, cataract surgery makes up 81% of the total surgical procedures performed at KEI, which is reflected in the calculations. The only exception was surgical equipment, 100% of which was allocated to the cataract procedure. To calculate space cost, the total annual rent was divided by the total square footage and reallocated to each area used in the care cycle based on the square footage. Capital equipment allocation was based on the location of use, with a five-year amortization rate added to the annual maintenance cost.

The CCR for the care team personnel was calculated by multiplying the annual clinic working days (240 days excluding weekends, holidays, and vacations) by the number of available activity minutes per day (excluding breaks) multiplied by the number of full-time equivalent employees to define the total personnel capacity. For activities that involved multiple care team members, each care team member's role, time spent on a task and the activity's location were used to determine the relevant costs. For activities that did not have personnel involvement (e.g., a patient waiting in the pre-op area), only space and equipment allocation was considered in the calculations. During the time out, several care team members carried out several activities simultaneously, including preparation for the next surgery, scrubbing and cleaning the OR. Hence, time was allocated as total value. Two resources were used throughout the care cycle in all the activities: the surgical chair and the OR manager. The surgical chair cost was calculated by dividing the total annual maintenance and capital cost for in-use chairs divided by the yearly case volume and overall care cycle time and was allocated to each activity on a weighted processing time basis. The OR manager was not directly involved in procedures. However, as an essential care team member, this role's cost was allocated across all activities. The capacity utilization rate was calculated by dividing the time (minutes) demand per year to perform cataract procedures by the total available time.

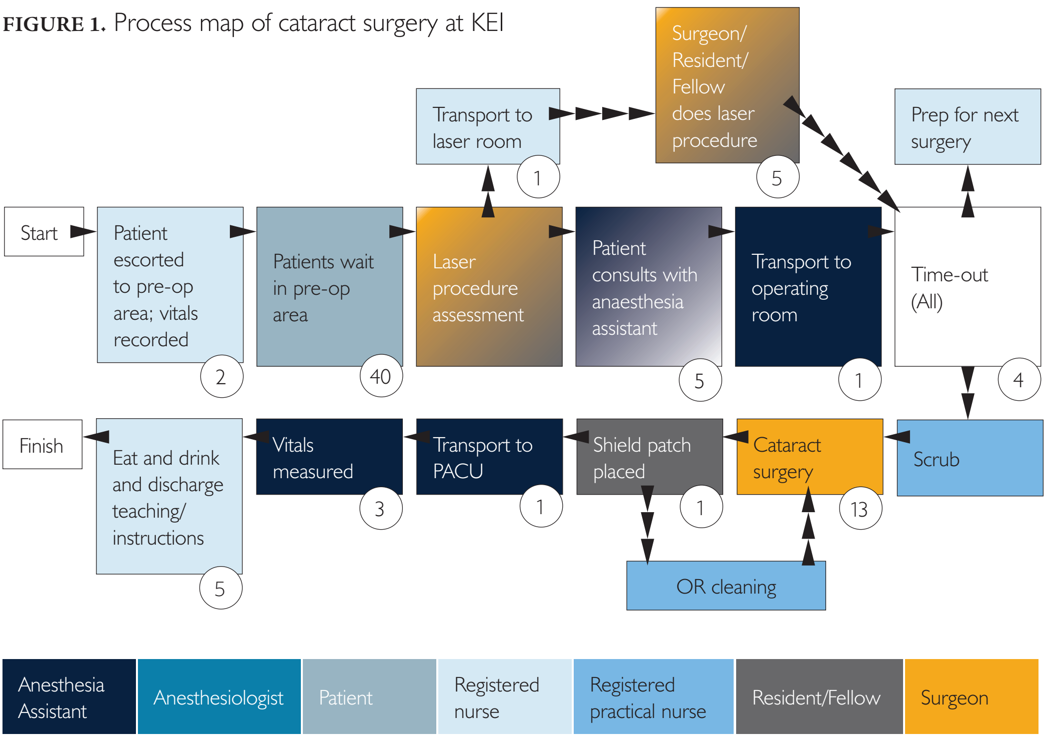
Human, space and capital and consumables resources

The activity cost included three types of salaried personnel: registered nurse (RN), anesthesia assistant (AA) and registered practical nurse (RPN). There were nine full-time RNs, six AAs and nine full-time RPNs active on each operating day. However, the AAs' total personnel cost has been divided by six, as KEI employs only one of the six AAs needed on a regular working day. The care delivery occurred in four main areas that are shown in the process map: pre-op, laser room, OR and PACU. Two additional areas (administration and sterilization process departments) were considered in the overhead expenses. Descriptive statistics were used to define the resource use during the procedure (see Appendix Table A1, available online at longwoods.com/content/26496). All costs are in 2019 Canadian dollars.

Results

Figure 1 illustrates the process map of the cataract surgery procedure at KEI. The process map depicts decision points, location of care, activities and the care team members involved at each step during the care delivery process. Each activity is colour coded, identifying the most responsible individual for each activity. The number in the circles specifies the time (minutes) needed to perform each activity. The laser procedure assessment is the only decision making that occurs during the process, which takes place in the pre-op area. Only 20% of patients undergo a laser procedure. The remaining 80% proceed to consult with the AA. All proper personnel conduct the time out activity, including preparation for the next surgery, scrubbing and OR cleaning, which happens simultaneously between operations. The time for the overall care cycle for cataract surgery lasted 76 minutes. The average wait time in the pre-op area was 40 minutes. However, this step did not use any resources. The procedure time for the cataract surgery was 13 minutes, with the highest number of active personnel.

FIGURE 1. Process map of cataract surgery at KEI



Circles define the duration of the steps in minutes.

Table 1 identifies the direct costs and CCR for the cataract procedure. The available time per year for each care team member was 93,600 minutes. The RN's total time capacity was 682,344 minutes per year and the cost for RN services was $760,973, resulting in a CCR of $1.12. The total annual space cost for the laser room was $9,064, with a total of 81.551 minutes per year, resulting in a CCR of $1.04 including the equipment. The CCR for OR space and equipment was $4.63. The RN bears the highest cost per case at $33.68.

The AA cost is considerably lower, given that the KEI covers the cost of one of the six

TABLE 1. CCR for cataract procedure

	Capacity cost rate	Time (minutes)	Cost per case
Personnel			
Registered nurse	$1.12	30	$33.68
Anesthesia assistant	$1.32	27	$5.89
Registered practical nurse	$0.71	17	$12.15
Operating room manager	$0.15	76	$11.72
Space and equipment			
Pre-operative room	$0.46	47	$21.51
Laser room	$1.04	1	$1.04
Operating room	$4.63	18	$83.43
Post-anesthesia care unit	$1.43	9	$12.87
Chair	$0.14	76	$10.39
Not allocated			
Consumables	NA	NA	$187.55

AAs on a regular surgical day. The CCR for the OR manager was $11.72 per case. The OR space and equipment rate was the highest at $83.43, followed by the pre-op and PACU rates. Table 2 demonstrates the space capacity use for patient care areas. The OR and laser room capacity utilization were 55% and 12%, respectively. In comparison, the pre-op area capacity utilization was 498%, mainly due to the 40 minutes waiting time for patients with no additional value-added activities. Similarly, the personnel's capacity utilization (e.g., RN, AA and RPN) was 43%. The total cost of the care cycle per case was $545.28 (Table 3). The cost driver for the cataract surgery procedure was consumables, responsible for 34.4% of the total cost per procedure, followed by space and equipment (23.7%), overhead (18.6%), corporate overhead (11.7%) and personnel (11.6%; $63.44). The rate-limiting area for a potential expansion was the PACU, at 95% capacity use.

TABLE 2. Resource capacity utilization rate and cost

Patient care areas and personnel	Time per care cycle (minute)	Annual case volume	Time per year (minutes)	Capacity utilization rate	Cost of unused capacity
Operating room	18	2,470	44,465	55%	$171,892
Laser room	1	9,881	9,881	12%	$74,621
Pre-operative room	47	9,881	464,407	498%	-$169,899
Post-anesthesia care unit	9	9,881	88,929	95%	$6,110
Registered nurse	30	NA	296,430	43%	$430,385
Registered practical nurse	17	NA	167,977	25%	$367,493
Anesthesia assistant	27	NA	266,787	59%	$248,199

TABLE 3. Total cost per case for cataract surgery

Consumable	Space and equipment	Personnel	KEI overhead	KHC overhead to KEI	Total overhead*	Total cost per case
$187.55	$129.24	$63.44	$101.31	$63.74	$171.54	$545.28
Percentage of total costs						
34.40	23.70	11.63	18.58	11.69	30.27	NA

*Total overhead is the sum of KEI overhead and Kensington Health Centre (KHC) overhead allocated to KEI for cataract procedures.

Secondary Analyses

For benchmarking KEI with other centres, a secondary analysis was conducted to include the cost of the personnel supporting cataract procedures who did not have a KEI contract (e.g., an anesthesiologist and five AAs). In this scenario, the total case cost increased by 9.9% to $599.34. A sensitivity analysis with a 20% and a 30% increase in annual cataract cases demonstrates that the baseline case cost could be reduced by 5.72% ($514.09) and 6.99% ($507.19), respectively, as the overhead cost was diluted. At a 30% increase in annual cases, the OR and personnel capacity utilization was estimated at 76%. The PACU capacity utilization at 95% is a rate-limiting area. However, by increasing the number of PACU operating hours by two, KEI can increase the cataract surgery volumes by 30% with no other incremental investment.

Discussion

There are numerous ways in which hospitals can perform service line costing. The cost-to-charge ratio, relative value unit and return on investment are conventional cost-accounting approaches (Phillips and Phillips 2007; Shwartz et al. 1995). While these costing methodologies are essential and useful, they do not always provide the granularity required to correctly attribute a cost to a particular service or activity at the patient level (Gapenski 2016). However, TDABC can provide detailed costing at the patient level for a given service or therapy. There have been limited examples of the application of TDABC in the Canadian healthcare system (Au and Rudmik 2013; Gulati et al. 2018; Nabelsi and Plouffe 2019). Accurate, patient-level costing can enable providers, administrators and policy makers to make informed investment decisions.

In Canada, costing based on the case mix grouping (CMG) model was the first attempt to better understand the costs of hospital procedures (Pink and Bolley 1994). However, as a medical model, CMG does not consider critical resources such as nursing intensity; instead, it uses a per diem approach to nursing (Cockerill et al. 1993). In order to overcome the deficiencies in the CMG approach, the case-cost approach has been used in Ontario, mainly built on the Canadian Institute for Health Information Management Information Systems (MIS) (CIHI 2019; Ministry of Health and Long-Term Care 2010).

However, case costing requires additional data collection that can be linked to an individual case (CIHI 2019). The additional data include workload statistics, supply/service and intermediate products (e.g., specific tests or procedures). Each activity under the MIS is measured through the national workload measurement systems that quantify activities in a standardized unit of time, including the nursing workload measurement (e.g., time spent for patient assessment). This addresses the shortcomings in the CMG approach (Ministry of Health and Long-Term Care 2010).

While case costing as a refined ABC for healthcare systems can provide a relatively accurate cost estimate for a condition, it is often onerous, complicated and dependent on multiple variables, which can distort the data (HMF 2016). Advantages of TDABC over the traditional costing methodologies include the prevention of cost distortions, and simplicity – the unit cost of supplying capacity and the time needed to perform an activity are the only two factors considered by the system (Öker and Özyapici 2013). Furthermore, this system determines unused capacity by considering practical capacity. TDABC is less sensitive to the overhead cost, and in organizations with substantial overhead (e.g., hospitals), TDABC will provide more accurate costing compared to ABC (Tarzibashi and Ozyapici 2019).

This study examined the TDABC methodology's viability in a Canadian independent health facility (IHF) with an integrated practice unit model predominantly in ophthalmology. The study showed that the average cost of a cataract procedure, excluding physician payment, was between $545.28 and $599.34. In contrast, the average total cost of cataract surgery in Ontario across all providers was $720.00 (*SD* =± $399) (Ontario Ministry of Health and Long-Term Care 2019). The *Ontario Quality-Based Procedures Clinical Handbook for Cataract Day Surgery* used the CMG and resource weight factor to estimate the cost of cataract procedure. Interestingly, the average OR time reported in the handbook was 14 minutes for routine unilateral cataract surgery (Ontario Ministry of Health and Long-Term Care 2018). The authors excluded the physician fees to evaluate the procedure cost similar to the hospital system. When physicians' fees were added (Ontario Schedule of Benefits Codes E140 and E950 at $397.75 and $92.50, respectively), the final cost case increased further by 81.8% to $1,089.59 (Ontario Ministry of Health 2020).

KEI has created an optimized process for cataract surgery through an efficient workflow. This finding aligns with a recent US-based study that examined the process efficiency in high-volume cataract surgery (Van Vliet et al. 2011). From a broader viewpoint, this study reflects focused factory principles to address the productivity crisis due to conflicting goals (Skinner 1974). The same concept can be generalized to include large hospitals that deliver a broad range of services with contradictory goals at the operational level, often resulting in suboptimal health outcomes at a high cost. In large hospitals, virtually every department acts independently, without any consideration for other departments. The hospitals could potentially create "focused healthcare services" by carving out small units of hospital operations that can create independent, planned, repetitive and predictable activities with optimal results (Bredenhoff et al. 2010). IPU efficiency has been demonstrated in various cataract surgery and hernia repair studies (Davidow and Uttal 1989).

While this analysis looked only at an IHF and a single service line, there is an opportunity to bring TDABC at scale to the Canadian hospital sector. The balance between service demand and managing cost has been the focus of Canadian and global healthcare systems (Bohmer 2009; Christensen et al. 2017; Porter and Teisberg 2006). Consequently, hospital administrators are trying to make funding decisions to provide optimal service outcomes. TDABC can shed light on hospital operations in different ways:

Firstly, it can reveal which service lines are feasible and potentially cost-saving (Hennrikus et al. 2012). Hospitals may choose to invest further in these service lines and use those saved dollars to reinvest in other areas essential to their communities. Conversely, it can provide new insights into service lines that may be underperforming, and this can only be achieved appropriately through TDABC. In addition, the process maps developed for TDABC allow hospitals to understand their workflow, which would facilitate procedural improvements.

Secondly, adopting a standard and accurate costing methodology for hospitals can also help hospital administrators and clinicians better understand how they perform against their peers. Over time, this could help all hospitals improve healthcare delivery efficiency across several service lines. Generally, the data favour a focused approach versus general service hospitals in both cost and quality. However, public hospitals may have unintended consequences such as labour disruption or community backlash if multiple procedures are taken out of general hospitals (Kruse et al. 2019).

Implementing a standardized costing approach, which has been undertaken in some provinces in Canada (e.g., Ontario), is an excellent first step. However, to make informed policy and expenditure decisions, the costing methodology needs to be standardized and accurate. Applying TDABC across hospitals and service lines would lead to a greater understanding of the cost at the service or procedure level. It would also help administrators better understand health human resource utilization as every input in the process is tracked and converted into associated costs. Accurate costing can facilitate informed policy decisions, such as allocating procedural volumes to the most cost-effective settings, and lead to the creation of centres of excellence or focused factory models in which hospitals specialize in certain areas. While we recognize that cost is not the only factor in decision making, this approach could inform policy makers on which procedures may be better delivered in alternative (i.e., non-hospital based) care settings, which is challenging due to the inaccuracies with current costing methodologies. Given the limitations in the digital capabilities and available resources at many healthcare institutions in Canada, implementing TDABC can be challenging and require investment in technology and data collection capabilities. However, if health system administrators would like to better understand how funds are being utilized and inform better decision making, TDABC could be beneficial.

Limitations

This study examined the application of TDABC in the context of an IHF that is subject to certain policy exemptions. IHFs can be for profit or not-for-profit and can offer a variety of therapeutic and diagnostic services. Many hospitals and other providers around the world have used TDABC. One of the limitations of this study is the setting. KEI being a cataract surgery IPU, defining the procedure steps, resources used and costs for the procedure were practicable. To implement the same methodology in other settings, one must first map the processes and overcome the limitations associated with complex interconnected operations. As such, the feasibility of a similar analysis in the Canadian hospital sector is unclear due to interdepartmental dynamics, as care may be provided by separate departments. Another major hurdle would be disseminating a new cost-accounting methodology and the required change management. While TDABC does provide an accurate estimate of the actual costs associated with a service, it can be time-consuming and requires additional resources and training. This analysis was conducted on unilateral cataract surgery without major complications. Therefore, the cost estimates may not extrapolate to complex or bilateral cataract surgery or other sophisticated techniques such as laser surgery. Finally, this analysis took place in Canada, and therefore, the estimated cost excludes physician payment because the physician directly bills the provincial ministry of health.

Conclusion

TDABC can accurately calculate the cost of care in a Canadian setting, enabling informed decision making. Through workflow and resource use optimization and reducing the cost of care without impacting the clinical outcomes, TDABC can drive data-driven policy decisions resulting in an effective and efficient healthcare system.

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Correspondence may be directed to: Hamid Sadri, Director, Medtronic ULC, 99 Hereford St., Brampton, ON L6Y0R3. He can be reached by e-mail at hamid.sadri@medtronic.com.

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