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Measuring the cost of care in benign prostatic hyperplasia using time-driven activity-based costing (TDABC)

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ABSTRACT

Background: Determining '"value"' in health care, defined as outcomes per unit cost, depends on accurately measuring cost. We used time-driven activity-based costing (TDABC) to determine the cost of care in men with benign prostatic hyperplasia (BPH) – a common urologic condition.
Methods: We implemented TDABC across the entire care pathway for BPH including primary and specialist care in both inpatient and outpatient settings. A team of expert stakeholders created detailed process maps, determined space and product costs, and calculated personnel capacity cost rates. A model pathway was derived from practice guidelines and calculated costs were applied.
Results: Although listed as 'optional' in practice guidelines, invasive diagnostic testing can increase costs by 150% compared with the standalone urology clinic visit. Of five different surgical options, a 400% cost discrepancy exists between the most and least expensive treatments.
Conclusions: TDABC can be used to measure cost across an entire care pathway in a large academic medical center. Sizable cost variation exists between diagnostic and surgical modalities for men with BPH.
Implications: As financial risk is shifted toward providers, understanding the cost of care will be vital. Future work is needed to determine outcome discrepancy between the diagnostic and surgical modalities in BPH.

1. Introduction

The importance of "value", defined as the health outcomes achieved per dollar spent, is becoming increasingly recognized in American health care.[1,2] Measuring and improving *outcomes* – the numerator in the value equation – has predominated health services research while investigation into cost containment has largely failed to consider the value of care.[3,4] An isolated focus on outcomes without a similarly rigorous approach to understanding costs may fail to "move the needle" in value measurement in health care and warrants further investigation.

Providers are increasingly called upon to enter into alternative payment models, such as bundled payments or participation in accountable care organizations. In these paradigms the clinician's ability to accurately measure and report the value of his/her care will be pivotal to success.[5] Likewise, health care organizations must be able to document the value of their care across care pathways over time. Traditional costing strategies use advanced accounting calculations to allocate resource costs to products based on consumption. This affords managers greater visibility into organizational processes and cost drivers. By knowing the drivers of cost, managers can eliminate costs related to non-value added activities and improve efficiency.[6] These strategies are hospital-based, cumbersome, often breakdown in the face of complex health care encounters, and yield poor approximation of total expenditures.[6,7] To address the limitations of these modalities, health care economists at Harvard Business School developed a novel costing strategy that may more accurately estimate true cost.[6]

Time-driven activity-based costing (TDABC) relies on managerial estimates of resource demands imposed by each encounter, product, or patient.[6] Traditional activity-based costing relies on individual employee surveys and interviews to estimate the

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percentage of time spent on an activity.[6] The excessive cost and time required to conduct repeated interviews and surveys have been a major barrier to widespread adoption in service and health care industries.[6] The novel time estimating equations and managerial input used in TDABC allow for multiple time drivers to be considered, more aptly capturing the complexities of health care. In a 2009 case study describing TDABC implementation in the clinic setting, Demeere and colleagues found that the strategy enlightened managers and department chairs about the cost drivers and inefficiencies in their system which led to process improvement and strategies to reign in cost.[8] TDABC has shown promise across multiple health care settings, including medical, surgical, outpatient clinic and hospital.[3,6] To our knowledge, this methodology has not been used to analyze an entire care pathway within a large health system.

Lower urinary tract symptoms (LUTS) due to benign prostatic hyperplasia (BPH) is one of the commonest diagnoses in adult urology and accounts for a considerable proportion of the cost of urologic care.[9] As a part of a greater effort to improve value at our institution, we implemented TDABC to assess the cost of BPH across the entire care pathway, from initial primary care visit to urologic consultation through surgical intervention. Our ultimate goal is to understand the processes and variation that drive cost in BPH care, which we will couple with rigorous outcomes assessment; thereby achieving a comprehensive value analysis. We hypothesized that implementing the method would be feasible and that we would identify significant cost variation between the different diagnostic and surgical procedures.

2. Methods

To determine BPH costs, we used the TDABC method as described by Kaplan and Anderson[6]: (1) process mapping to define each step in the BPH care pathway including time estimates per step, (2) calculate personnel capacity cost rates, and (3) calculate space and equipment costs. To compare diagnostic and surgical modalities according to cost, we then created a simplified model pathway based on practice guidelines. Calculated costs were then applied to the model for each of the various diagnostic and surgical modalities for comparison.

2.1. TDABC Step 1: Process mapping

Borrowed from industry, process mapping refers to the development of flow charts listing each activity involved in a workflow. In health care quality improvement, process mapping is a methodical and graphical explanation of all the steps in a care pathway (e.g. patient calls clinic to make an appointment). To define the processes in BPH care, we assembled a team of expert stakeholders from the University of California, Los Angeles Health System. The team was comprised of providers involved in each step of the BPH care pathway, including urologists, primary care physicians (PCP), clinic, inpatient, and operative nurse managers, and representatives from patient affairs and scheduling. The care pathway encompassed all patient–health provider interactions from the first onset of BPH symptoms to the last follow-up appointment after surgical treatment. Over the course of three meetings, the team created detailed process maps to account for each potential encounter in the care pathway.

Medical management was defined as treatment by PCP, urologist, or both. Non-invasive diagnostic testing included urinalysis, PSA measurement, uroflowmetry, and post-void residual (PVR) measurement. Invasive diagnostics were defined as cystoscopy, urodynamics (UDS) or transrectal ultrasound (TRUS). Surgical procedures – further stratified as inpatient or outpatient – were transurethral resection of prostate with monopolar current (TURP), electrovaporization of prostate with bipolar current (EVP), photovaporization of prostate with laser (PVP), open simple prostatectomy, and robotic simple prostatectomy.

We identified all personnel, personnel activities, consumable supplies, facility space and equipment that were utilized during BPH patient encounters. After identifying the components of each encounter in the pathway, including the activities involved with each encounter, we defined usual patient flow and time estimates for each activity, e.g. the time a nurse spends cleaning/setting up uroflowmeter or time anesthesiology resident takes to place spinal block prior to TURP. When time estimates differed between providers an average estimate was employed. Using these beginning- and end-points, we created a process map to identify the sequence of events and time for each activity in the BPH care pathway.

2.2. TDABC Step 2: Personnel capacity cost calculation

Capacity cost rates – in dollars per minute – were calculated for all personnel using financial data obtained by departmental human resources. Personnel compensation was adjusted to account for the cost of benefits, administrative support, training and travel, office space, hardware and support, office expenses, and malpractice insurance. *Per Diem* personnel were excluded from all calculations. Urologic personnel included in the analysis were 30 full-time clinical faculty, 18 residents, 10 fellows, 2 nurse practitioners, registered nurses, licensed vocational nurses, medical assistants, technicians, and administrative staff. Capacity estimates incorporate both direct and indirect patient care. Urology attending physicians were estimated to work 10.5 h per day, including work from home. All other personnel were estimated to work 8 h per day. Vacation time, sick and personal leave, weekends/holidays and educational time were accounted for in the analysis. Time spent engaged in clinical activity while physicians were on-call was estimated at 20%.

2.3. TDABC Step 3: Space and product cost calculation

Space costs were calculated by physically measuring the clinic square footage that is devoted to treating BPH patients and allocating a proportionate percentage of the monthly rent. Construction and renovation costs were incorporated as well. Costs for all equipment and materials were obtained from clinic managers, materials management, facilities and operative services. Clinic and hospital space costs (e.g. rent) were obtained from departmental and Health System administration, respectively. Equipment and space costs – in dollars per minute – were determined using capacity cost equations while product costs were by estimated number of items used (e.g. number of disposable surgical instruments used during an operation). Equipment (e.g. office-based ultrasound machine) capacity cost incorporated depreciation, maintenance, and utilities in the equation.

2.4. Cost modeling to compare diagnostic and surgical modalities

The preoperative evaluation for BPH can range from history and physical examination coupled with non-invasive uroflowmetry to invasive procedural testing – cystoscopy, UDS, TRUS. The American Urological Association (AUA) practice guidelines for BPH list these invasive tests as optional.[10] Additionally, there are multiple surgical modalities that exist to treat BPH that has failed medical management. To eliminate unnecessary variation in diagnostic and surgical BPH care, we sought to compare TDABC-derived costs associated with each of the modalities.

A simplified model BPH care pathway was derived from AUA guideline recommendations and represents the “minimalist” approach to the diagnostic workup.[10] Invasive tests that are guideline "optional" were eliminated from the model. The model assumes two primary care visits with no diagnostic testing, two urologic consultations with PSA measurement, urinalysis, uroflowometry and PVR measurement. This "index" care pathway used the least invasive diagnostic modalities and incurred the lowest cost in the preoperative setting. All five surgical modalities were included – TURP, EVP, PVP, open and robotic simple prostatectomy. The model assumes one post-operative visit for catheter removal.

Capacity cost rates for personnel, space, and equipment were multiplied by the time each resource was used during an activity in the care pathway and added to materials costs to obtain a total cost for each component (e.g. setting up for a cystoscopy). Costs were then aggregated to determine the complete cost of each patient–provider encounter in the pathway. All costs from non-surgical patient–provider encounters were aggregated into a minimal BPH care pathway assuming no invasive diagnostic testing. Additional diagnostic testing was calculated as percent-added cost to the minimal BPH pathway. Surgical costs – which incorporate costs for average length of stay (LOS) – were indexed to the lowest-cost surgery, outpatient EVP.

Table 1
Personnel cost calculation for Urology resident.

	Urology resident
Compensation: Salary, and bonus	55,411
Benefits	1662
Supervision	
Assistant/admin support	2998
Training and Travel	487
Office Space	5770
IT (hardware and support)	682
Office expenses	331
Malpractice Insurance	
Total	**$67,340**
Research, education, & administrative time (%)	
Total clinical costs	**$67,340**
Personnel capacity (min)	108,433
Personnel capacity cost rate	**$0.62**

Table 2
Equipment cost calculation for Urodynamics procedure.

Sub process	**Perform urodynamics procedure and interpret results**
Space	Clark Urodynamics Suite
Equipment	Urodynamics machine
Replacement cost	$330,000
Useful life (years)	15
Yearly depreciation ($)	22,000
Yearly maintenance cost (% of replacement cost)	2.7
Yearly maintenance cost ($)	9009
Equipment cost per year ($/yr)	31,009
Availability timeframe	Normal hours
Availability (min)	110,571
Capacity cost rate ($/min)	0.28

3. Results

The results of this work are as follows: (1) an extensive full BPH care pathway, (2) personnel cost, (3) space and equipment cost, (4) the simplified model pathway, and (5) cost comparison between diagnostic and surgical modalities as derived from the model.

The full BPH care pathway, illustrated as a process map, is not shown for simplicity. An example of the personnel cost calculation for a Urology resident is provided in Table 1. An example of the equipment cost calculation for the Urodynamics procedure sub-process is shown in Table 2. Aggregate cost data for a Urology clinic visit is shown in Table 3. Additionally, aggregate cost calculations for an office-based cystoscopy are described below as another illustrative example. The simplified model pathway is illustrated in Fig. 1.

Aggregate cost calculations associated with office-based cystoscopy – a common diagnostic procedure – are described herein. There are 13 "sub-processes" that make-up the cystoscopy episode: referral/authorization, scheduling, chart preparation, patient check-in, vital signs, resident consultation, attending consultation, attending explanation of procedure, cystoscopy, room cleanup, nursing check, patient check out, and schedule follow up. For the room cleanup sub-process, the average LVN at capacity cost rate $0.72/min takes 30 min to clean the room before and after the procedure. Space and equipment for this room run at a capacity cost rate of $0.27. In all, the sub-process of cleaning the room for cystoscopy costs $27. The overall cystoscopy episode costs $349.

Table 3
Aggregate cost data for urology clinic visit.

Sub-process	**Personnel type**	**Space**	**Process time (min)**	**Personnel capacity cost rate ($/min)**	**Allocated personnel cost ($)**	**Space and equipment capacity cost rate ($/min)**	**Allocated space and equipment cost ($)**	**Total costs ($)**
Patient calls to schedule appointment	Call center rep.	Front desk	15	0.72	10.74	0.42	3.14	14
Authorization is obtained	Clinic front desk clerk	Front desk	1	0.72	0.36	0.42	0.10	0.46
Chart is prepared prior to patient's arrival	Clinical assistant	Front desk	10	0.72	7.16	0.42	2.09	9
Patient checks in for appointment	Clinic front desk clerk	Front desk	10	0.72	7.16	0.42	2.09	9
Patient meets with Urologist	Attending physician	Exam room	15	2.95	44.32	0.06	0.47	45
Consent form is prepared	LVN	Exam room	5	0.75	3.76	0.06	0.16	4
Documentation is completed	Attending physician	Exam room	5	2.95	14.77	0.06	0.16	15
Patient checks out	Clinical assistant	Front desk	10	0.72	7.16	0.42	2.09	9
							Total cost	**106**

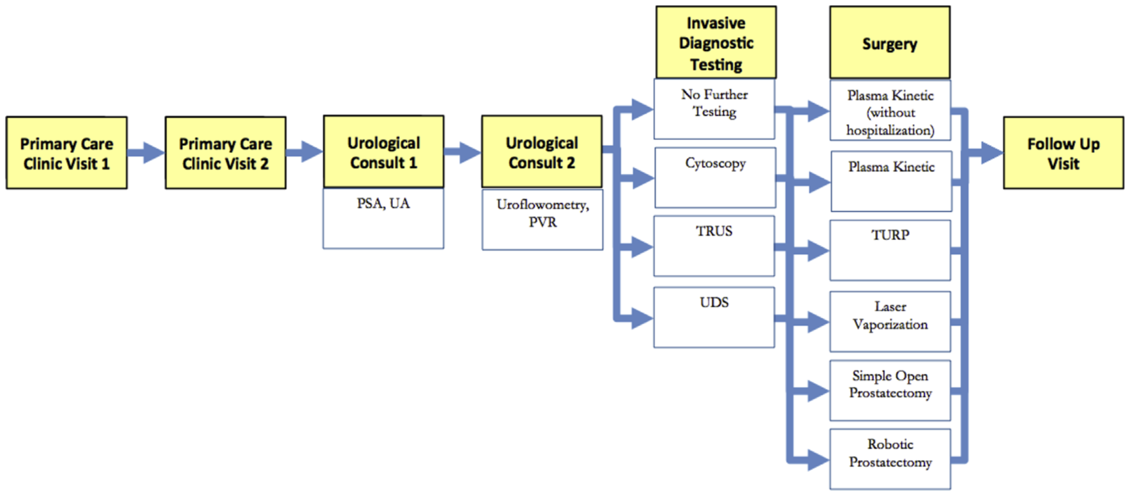

Fig. 1. Model BPH care pathway.

Table 4
Capacity cost rates for select personnel.

Personnel	Capacity cost rate ($/min)
Urology attending	2.95
Urology resident	0.62
Nurse practitioner	1.78
Licensed vocational nurse	0.75
Registered nurse	1.79
Clinical assistant	0.72
Front desk clerk	0.72
Call center representative	0.72

Table 5
Costs of model BPH pathway excluding diagnostics and surgical procedures.

	Percent total cost
Initial PCP visit	18.72
Follow-up PCP visit	18.72
Initial urologic consult	23.83
Follow-up urology visit	21.88
Postoperative follow-up	16.84
Total	100

Urology residents accounted for the lowest capacity cost rate at $0.62/min while faculty accounted for the highest at $2.95/min (Table 4). Excluding surgical cost, the urologic consultation constituted 46% of total cost compared to 38% cost spent in the primary care space (Table 5). Performing a cystoscopy added 60% to the total cost of non-operative care while UDS added 80.3% (Fig. 2). Of the invasive diagnostic modalities – listed as "optional" by AUA guidelines – TRUS added the least percent cost (12.9%) to the work-up. Surgical cost – which incorporates average LOS in our institution – are shown in Fig. 3. Average LOS for TURP, EVP, PVP, robotic and open prostatectomy were 1.5, 1.6, 1.4, 1.0, and 5.4 days respectively. Costs are reported as relative cost to the index, outpatient EVP as this was the lowest cost modality.

4. Discussion

In the 1920s, Dr. Hugh Hampton Young, the father of modern American urology, agreed to perform a prostatectomy for a fixed

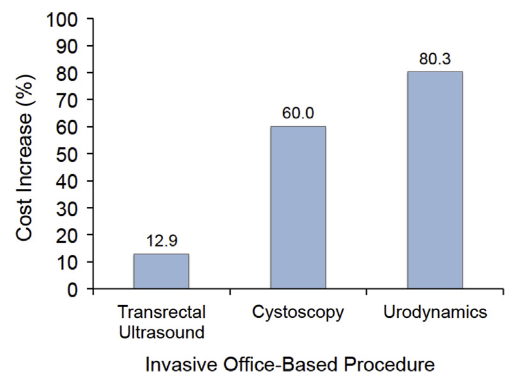

Fig. 2. Added cost (%) of invasive office-based diagnostic testing.

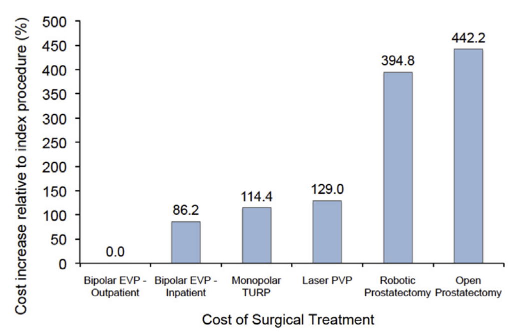

Fig. 3. Cost increase relative to index surgical procedure – outpatient electrovaporization of prostate (EVP). Cost estimates incorporate average length of stay.

fee of $500, on the assumption that his patient would have a 3-week hospital stay. Surgical complications resulted in a prolonged stay and Young had to spend his entire fee as well as an additional $350 to pay off the hospital bill.[11] Nearly a century later, payer–provider dynamics are radically different but the struggle to estimate cost in clinical practice remains.

Recent legislation promotes value-based purchasing of health services by payers. Policy analysts, health care economists, and health services researchers alike encourage a shift towards rewarding value in health care.[2,12–14] For clinicians – whether in academic medical centers, accountable care organizations, or group practice – being able to determine the value of care will be an essential step toward fruitful provider–payer negotiations and patient accrual.[5] We describe our experience with measuring the cost of comprehensive BPH care using a novel costing strategy, TDABC. Our study has several important findings.

First, we were able to describe the cost of care across the spectrum of disease, from diagnosis to surgical treatment. While measuring the cost of particular related services within an enterprise seems elementary, the task is novel in health care. TDABC has been implemented and reported in the literature in the outpatient clinic setting,[8] for a specific surgery,[15,16] in a single department,[17] and in a private hospital.[18] This is the first report of implementation across an entire care pathway that encompasses PCPs, surgical subspecialists, medical and operative care, in both the inpatient and outpatient settings. The dynamic nature of BPH care, along with provider variation in work-up and operative approach, makes this an ideal "proof-of-concept" condition for TDABC implementation. We feel that demonstrating feasibility in this setting augurs well for translation to most other conditions treated within urology and serves as a framework to begin systematic cost investigation.

While accurate cost measurement in health care can be elusive, Rosenthal et al.[19] illustrated the related struggle providers have with price – charges incurred by the patient and/or payer – as well. They contacted over 100 hospitals that perform total hip arthroplasty and experienced difficulty in obtaining price information, noted tremendous variation in quoted prices, and found overall poor financial transparency. The ability to determine one's own cost of a particular service allows providers to take the first steps toward increased price transparency, which may increase access to patients in new delivery paradigms.

Second, invasive diagnostic testing prior to BPH surgery adds significant expenditure to the cost of care. AUA guidelines list these procedures as "optional" components of the diagnostic work-up in men with BPH.[9] In cases where both UDS and cystoscopy are employed, the cost of the work-up in men with BPH increases by 140%. In a fee-for-service payment model, there is no financial incentive to curb additional testing whereas in a value-based purchasing model, invasive diagnostics would come under careful scrutiny.

Practice pattern variation in health care is prevalent[20,21] and "discretionary" surgical procedures in particular exhibit considerable geographic variation.[20] In an assessment of urologists' compliance with AUA guidelines for BPH, Strope et al.[22] found that use of cystoscopy, TRUS, uroflowmetry and PVR were associated with low guideline compliance. Because our analysis assesses only cost – rather than the relationship between costs and outcomes – the value of these diagnostic tools cannot yet be determined. Given the significant increase in cost for which cystoscopy, UDS, and TRUS are responsible, further investigation into the value of these tests is warranted.

Finally, our findings regarding the cost of care for BPH are hypothesis-generating and can be used to guide further work on value assessment within a department or practice. Our own departmental value based care redesign effort incorporates cost assessment as described in this study as well as near real-time collection of outcomes data captured from an electronic medical record. Based on the data described here, we are planning further prospective work to determine the marginal value of each diagnostic modality for BPH prior to surgery. Additionally, we identified marked differences in capacity cost rates for personnel and plan to further scrutinize these data to ensure personnel are functioning at their highest professional capability to maximize workforce value. Finally, we plan to work with health system leadership and local payers to explore financial incentives – vis-à-vis shared savings – for physicians maximizing value in clinical practice.

These data and the methodology herein described must be interpreted acknowledging certain limitations. First, TDABC relies on managerial estimates of the time it takes to complete certain activities. Additionally, the time and thereby cost to perform any activity (e.g. a nurse placing a urinary catheter in clinic) is subject to wide variation based on operator skill, patient factors, etc. To control for inaccurate managerial estimates we designed our stakeholder team to include nursing and other staff from various areas in clinical care. To address the issue of varying time estimates, we used the average of reported time estimates; although few such discrepancies existed. Second, this micro-costing schema fails to capture opportunity cost, namely patients' time, lost wages, lost work productivity.[23] TDABC measures cost to the system but fails to account for patient-incurred costs (e.g. outpatient medications and co-payments) or opportunity cost, perhaps a limitation of the strategy. Finally, to speak of "value", outcomes and quality of care need to be part of the discussion. While the scope of this study was limited to the feasibility of cost-determination across a disease state, outcome data – particularly patient-reported outcomes – must continue to take a lead in the value conversation.

5. Conclusions

As a part of a greater effort to improve value in clinical care, we implemented a novel and robust costing strategy, TDABC, to measure the cost of comprehensive BPH care in a large academic medical center. We identified sizeable cost variation between guideline-recommended and guideline-optional diagnostics as well as surgical modalities. TDABC is a useful tool to measure cost, and thereby value, in clinical care. As financial risk is shifted toward providers, knowing the cost of care will be crucial for clinicians. Further efforts toward cost measurement, coupled with outcome measurement, are needed to define value in BPH care.

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