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SYSTEMS-LEVEL QUALITY IMPROVEMENT

OR Management and Metrics: How It All Fits Together for the Healthcare System

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Abstract
Increased healthcare costs and diminishing returns have prompted healthcare administrators to address budget allocations to alleviate institutional costs. Current economic constraints, such as limited Medicaid and Medicare insurance payments, limit our patients' ability to receive urgent surgical interventions as well as access preventative diagnostic tools. Rather than downsizing the workforce, future sustainability must be derived upon effective cost structures supported by improved quality control measures and increased patient accessibility. Surgeries were performed during 29% of hospitalizations and comprised 48% of the $387 billion in healthcare expenditures in 2011. Further, surgical procedures managed to account for 40–70% of hospital revenues. Effective cost reduction begins at the source and in the case of hospital systems, the operating room (OR). Taking this into consideration, administrators evaluating future revenue streams should look to consider OR-based cost reduction measures as part of their first step approach. Improving OR efficiency through block time and staff optimization remain the premise of today's existing literature on OR management strategies.

Keywords Operating room management · Medicare · Operating room efficiency · Block time · Staff optimization · Cost analysis · Reimbursement · Investment · Return · Scheduling · Sustainability · Administration

Introduction

Increased healthcare costs and diminishing returns have prompted health care administrators to alleviate institutional costs through reductions in budget allocations. In a recent survey by the Advisory Board Company in July 2018, the top two concerns amongst hospital executives had shifted from expanding outpatient access to preparing the enterprise towards sustainable cost control and finding innovative approaches to manage costs. [1] In any business, growth and sustainability are built on effective cost structures that allow for careful control of expenditures while maintaining expansions of core services. A common path towards short-term sustainability, as evidenced by Tenet and Lahey Health in 2017, was the reduction of employees on payroll [2]. From an organizational perspective, this management technique limits the investment necessary for any business to grow and innovate. Management should instead redirect their attention towards creating new revenue streams rather than downsizing their workforce.

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What economic constraints are we facing?

In 2016, the United States spent a staggering $10,000 per person on healthcare expenses – 250% more than the Organizational for Economic Co-operation and Development (OECD) international average [3]. It may seem reassuring to see a government willing to spend so much on the health of its people, but are there enough tangible consumer-side benefits to justify the cost? Consider that the average cost of an MRI was $1119 in the US, $215 in Australia, and $181 in Spain with identical machines and equal staffing resources. Furthermore, this disparity exists across the pricing points amongst different institutions within the US, with the 95th percentile cost of that same MRI nearly tripling the mean at $3031. Using MRI density as an indicator of access to care, the US has the second greatest density of MRI machines in the world and theoretically should have a healthier population compared to most other countries [4]. However, despite unparalleled spending on diagnostic tools, today's US life expectancy - an indicator of overall health - remained lower than countries with comparable spending, ranking below the OECD average behind Costa Rica and Chile [5]. In contrast to the US, Japan has the most MRI machines per capita, but also boasts the highest life expectancy in the world. Japan's universal healthcare system permits high utilization and low per-appointment costs, justifying the increased spending towards facilities and equipment [6]. There is clearly something inherently flawed in the way the US approaches patient care. With these exorbitant pricing schemes, US hospitals must ask themselves: where is this money going?

Government insurance payments through Medicaid and Medicare continue to pale in comparison when it comes to hospital and physician reimbursements. In measuring the commercial to government insurance payment ratios, the America's Health Insurance Plans (AHIP) discovered payments for commercial inpatient stays were higher than Medicare and Medicaid 90% of the time [7]. Selden et al. found these standardized private insurer payments to be 75% higher than Medicaid's over a span of 16 years between 1996–2012. This was a 65% jump in payment disparity when compared to reimbursements between 1996 and 2001 [8]. These declining government reimbursement rates may not only make it harder to maintain current budget allocations, but also anchor future physician reimbursement rates [9].

In 2016, Merritt Hawkins (MH) sent a survey to 3500 hospital chief financial officers and received less than 100 responses. The information requested was the combined net inpatient and outpatient revenue generated annually for their facility by a single, full-time equivalent (FTE) physician (either employed by the hospital or in independent practice) in a variety of specialties through procedures performed at the hospital, including diagnostic tests and treatments. Despite the small response rate, the data MH has gathered has been consistent over 14 years. Average revenue for all physician specialties has been essentially unchanged over that time period. Primary care physicians represent the best potential return on investment for hospitals, generating 7.5 times the cost of their annual salary (Table 1). However, specialists generate more total revenue for their hospitals compared to their primary care colleagues (Table 1). Additionally, employed primary care physicians may keep patients "in-house" for tests and studies, and under new reimbursement models, this may paradoxically adversely impact hospital revenue. All physicians generate more revenue for hospitals than they cost in salaries or income guarantees. Indeed, with the consolidation of health care systems across the country, hospital leadership holds most of the financial levers.

Surgeries are performed only during 29% of US hospitalizations, yet the costs compromise 48% of the $387 billion in healthcare expenditures in 2011 [10]. Further, surgical procedures managed to account for 40–70% of hospital revenues [11]. Quantifying surgical revenue is a complex process, as hospital-dependent factors play a large role. Analyzing cash flow, the generation of revenue to cover expenditures, is essential to maintaining a system that relies heavily on positive margins to maintain the current quality of care. Revenue generated from hospital services relies on numerous factors such as payer mix, patient mix, length of stay, and procedure type. The ideal revenue-generating group would be patients requiring procedures associated with a short length of stay. Inherent flaws within day-to-day operational decisions may be to blame; however, a thorough analysis of operating room management and surgical output is necessary to bridge the gap between revenue and expenditures.

Effective cost reduction begins at the source and in the case of hospital systems, the operating room. With the growing Baby Boomer population, Medicare has become the largest insurance population in the United States [12]. This has forced OR managers to develop workflows that focus on resource scarcity. Hospitals looking to improve profit margins are incentivized to incorporate physicians whose patient populations are comprised of better payors [13]. These payment models have also resulted in two compensatory operational decisions for surgical suites: (1) increase case volumes to maintain revenue or (2) reevaluate operating room efficiency and day-to-day operating costs without reducing accessibility. In a resource limited environment, the latter is preferred, as adding cases will require additional infrastructure. Changes in anesthesia practices will have to be made to accommodate for reduced compensation from government agencies and to develop new approaches to existing issues.

Management for surgical and procedural cases

Operational efficiency is essential to reduce unnecessary cost drivers within surgical and procedural cases. Fixed costs include supplies, purchased services, leases, utilities, insurance, and travel. These fixed costs represent 62% of all associated costs. Inefficiency, however, is considered to be a variable cost. Variable costs include employee wages and associated

Table 1 Data adapted from Merritt Hawkins [65]

Specialty	Average Salary	Average Revenue	Revenue ÷ Salary
Nephrology	275,000	712,000	2.59
Gastroenterology	455,000	1,422,677	3.13
Otolaryngology	334,000	1,066,221	3.19
Urology	412,000	1,405,659	3.41
Pediatrics	195,000	665,972	3.42
Pulmonology	331,000	1,190,870	3.60
Neurology	277,000	1,025,536	3.70
Ophthalmology	249,000	1,035,577	4.16
Noninvasive Cardiology	291,000	1,260,971	4.33
Neurosurgery	553,000	2,445,810	4.42
Invasive Cardiology	525,000	2,448,136	4.66
Hematology/Oncology	350,000	1,688,056	4.82
Psychiatry	226,000	1,210,568	5.36
Orthopedic Surgery	497,000	2,746,605	5.53
OB/Gyn	276,000	1,583,209	5.74
General Surgery	339,000	2,169,673	6.40
Family Practice	198,000	1,493,518	7.54
Internal Medicine	207,000	1,830,200	8.84

benefits, which change depending on the degree of utilization [14]. Over-utilized and under-utilized time are commonly investigated in the pursuit of OR efficiency, as their associated costs are substantial. Under-utilized time represents block time left in the day that could be used to accommodate another case. Over-utilized time represents time spent beyond allocated block time.

Multiple models exist in which different variables are used to characterize poor utilization; however, it is not clear which variables OR management should focus on. Simply knowing this information may not have direct implications for financial performance. Further, convincing an entire department to reduce a few minutes of over-utilized time per day is a time-consuming process that does not generate the cost savings to build new buildings and necessary OR expansions. For example, first case start delays and turnover delays constitute only small portions of under-utilized block time, whereas downtime, last-minute cancellations, and case-length overestimations are the primary drivers [15]. Each of these events lead not only to over-utilized time, but also to a reduction in throughput that represents the lifeline of the hospital. Presumably, tackling these issues will not only improve scheduling, but also generate much needed profits.

Traditionally, the model equation for inefficient use of OR time has been:

Inefficiency [16, 17] = [(cost per hours of under-utilized OR time) x (hours of under-utilized OR time)] + [(cost per hour of over-utilized OR time) x (hours of over-utilized OR time)].

Previously, small amounts of under-utilized time per day were considered sunk costs because block allocations were pre-allocated. Therefore, the above equation can be remodeled to include only over-utilized time. The variable costs associated with over-utilized time do not represent the majority of total costs. For some hospital systems, the opportunity to actively manage labor sources with hourly employees without shift guarantees remains a viable strategy to maintain profitability, but not necessarily nurture an organization culture. However, the highly political environment within a hospital may hinder optimization. Physicians who refuse to work certain hours of the day limit flexibility of day-to-day scheduling. These time-based management constraints force OR managers to find ways to fill the under-utilized time to minimize losses. As each minute of OR time costs $35.45, two hours of gap time between surgeries results in a net loss of $4254 [14]. With more than 80% of hospital expenses representing fixed costs, this indicates that financial inducements to labor (technicians, nurses, and physicians) may help amortize the costs of healthcare if additional cases may be induced (i.e. later into the evening and on weekends) [14]. Variable compensation schemes to reward utilization in non-peak hours should be evaluated in each institution. Redistribution of normal block allocations to match the schedules of physicians with limited working hours may result in increased cost efficiency and concurrency per anesthesiologist and ancillary staff.

With the recognition that a large proportion of the hospital budget is actually fixed, hospital administrators are increasingly examining methods to exploit the current assets and infrastructure. Here, the perioperative services need not look any farther than the airline industry to better understand the opportunities to minimize sunk costs. For airlines, the most expensive line item is the aircraft. Airline executives understand that higher aircraft utilization spreads the fixed costs across a larger number of passengers, thereby reducing the costs per mile per seat for the company [18]. For large health care systems, the largest expense is the infrastructure and staff. However, by increasing the hours of operations for the operating room, hospital administrators can spread the fixed costs across a larger number of cases. With most cases in the United States continuing to maintain a positive contribution margin, the math is simple. Further, this model coincides with the current dictum in OR management. Dexter et al. have noted that block allocations should be increased (or decreased) as the workload grows (or shrinks) in order to minimize variable costs [19–21]. In other words, hospitals will save money by minimizing over-utilized time and maximizing under-utilized time. This concept extends beyond block allocations. On the Boeing website, a report on airplane utilization states that by "reducing turn-time by 10 minutes with an average trip length of 500 nautical miles improves airplane utilization by 8 percent" [22]. The reader should be cautious in applying the principle to the operating room. For most perioperative services, the constraint is the human resource and extending operating hours may not be sustainable. Ultimately, when it comes higher utilization rates with human systems, perioperative administrators should be concerned about sustainable degradation [23].

OR Management Theories

Although the OR management literature has benefited from statistical rigor and forays from the operations research fields, many theories often fail when transitioning to real life applications. Four widely accepted components regarding OR performance management provide a framework for evaluating current management structures [24].

Improving OR Efficiency

Studies that propose maximal utilization of OR block time strive to generate income by minimizing under-utilized time. Higher levels of utilization may eventually generate scheduling constraints due to a lack of flexibility [25]. For example, Tyler et al. demonstrated that the optimal utilization for an OR system topped out at 85 to 90% [26]. However, maximizing economic throughput through high non-emergent OR utilization can lead to increased wait times for patients with emergencies and urgent clinical diseases. Short delays in urgent cases have also been shown to correlate with significantly higher hospital costs, thus counteracting the prior optimization [27]. Studies on capacity allocation are in favor of overbooking or predicting cancellations based on prior usage patterns to forecast future demand [28–30].

Yield management studies provide a framework to maximize capacity-constrained services in ways that increase reliability through historical utilization. Kimes has refined these concepts into the management of the four C's: calendar (how far in advance reservations are made), clock (the time of day the service is offered), capacity (the inventory of service resources), and cost (the price of the service) to manage customer demand [31–33]. By analyzing prior trends in each of these categories, implementation of multi-objective models that can utilize predictive behaviors to drive growth will improve utilization without changing current block allocations [31–34]. However, perioperative managers should recognize that the airline and hotel industries are willing to tolerate a higher level of no-shows. Hospitals that go down the road of overbooking should recognize that this strategy runs the risk of creating more over-utilized time or lower patient satisfaction.

Block Optimization

As patient populations continue to grow, the prior optimizations put into place will have to change to meet incoming demand. These changes may increase the case load for some services over others, resulting in changes to previous block time allocations. Utilization also differs between hospitals due to prioritization of certain operational characteristics. Hospitals with high volumes of emergent traumas may decide to implement 24-h staffed ORs. Increasing emergent block time for capacity-based services may not generate a steady income stream as consistent patient volumes are not guaranteed. Additionally, allocating for emergent utilization may result in worsening of preexisting waiting lists for elective cases. Hospital systems dealing with resource scarcity may prioritize cost efficiency and utilize 10-h block allocations that result in varying degrees of utilization. However, hospital administrators and physician leaders who decide to establish emergency services should be cognizant that OR management metrics do not apply to capacity-based services. The denominator in under-utilized and over-utilized time is total block time. For most ORs, the block allocations are 8-, 10-, or 12-h. However, acute care surgical and orthopedic trauma services are 24-h service lines and traditional OR metrics will therefore underestimate productivity and efficiency [35, 36].

Staff Optimization

Although physicians and nurses both work towards improving the quality of patient care, Arakelian et al. used a specific, in-depth methodology called phenomenography to demonstrate that surgical team members may have very different understandings of what the term "operating room efficiency" actually means. Phenomenography conducts in-depth interviews with subjects to discern how they see the world, focusing on the relationships between people and the phenomenon under investigation. By surveying nurse anesthetists, operating room nurses, anesthesiologists and operating room supervisors with varying years of experience, Arakelian et al. developed the following two broad categories of efficiency:

I. Individual Efficiency

A) Doing one's best from one's prerequisites.
B) Enjoying work and adjusting energy to the situation.
C) An interacting group performing parallel tasks.
II. Efficiency in the Organization.
A) Desired results with the least resources.
B) Fast work with preserved quality.
C) Long-term effects for the patients [37].

In short, the key concept is simple: efficiency differs from person to person. These very different perspectives concerning operating room efficiency between staff members depended on the length of training, experience, role, and status they had in the operating room team [37, 38]. To establish better workplace practices, efficiency must be redefined in a way that all staff members share a common goal [37]. This goal may differ depending on hospital setting as those with preset budget allocations, such as the Veterans Affairs Health Care Systems, may see cases as expenses and therefore value quality over speed to avoid the additional expenses associated with follow-up appointments [39]. Large academic medical centers without hard financial constraints may instead strive to accommodate higher patient volumes within block time allocations as each patient can be considered an income generating unit. Of note, working fast while maintaining quality - a characteristic associated with high reliability organizations (HROs) - was found to be only one of seven ways of understanding operating room efficiency as noted above. Much work needs to be done in moving healthcare organizations along the continuum toward becoming HROs [40–42]. Unless every person on the team has the same concept and understanding of what exactly "operating room efficiency" actually means, there will be no shared vocabulary and progress and improvement will be impossible.

Transitioning from a volume-based care model towards a value-based care model requires remodeling of existing frameworks to accommodate physician quality measures. Variability in opinions regarding quality metrics amongst providers has focused attention towards standardizing care between physicians. To accomplish this goal objective, trackable metrics and uphold mutual accountability for outcomes [43]. First, however, "quality" must be defined. In a classic example from the industrial literature, the sand cone model, quality is the base of a narrowing pyramid, topped by dependability, speed and finally cost-efficiency [44]. Quality undergirds the entire process. In medicine, the Agency for Healthcare Research and Quality (AHRQ) defines quality as, "doing the right thing, at the right time, in the right way, for the right person, and achieving the best possible results" [45]. Similarly, the World Health Organization (WHO) considers a health system to have the fundamental elements of quality if it is effective, efficient, accessible, acceptable, patient-centered, equitable and safe [46].

Industry has proven that focusing on quality can lead to cost efficiency. The best example of this is the Toyota Production System [47]. One of the best direct translations of this manufacturing paradigm to healthcare has been implement in the Virginia Mason Production System [48]. Following implementation of this model, the Virginia Mason Medical Center had significantly increased patient satisfaction scores, an improved financial picture, lower inventory and labor costs, lower cost and higher quality evidenced by a decrease in professional liability premiums of 56%.

More specific quality measures for anesthesia practice have been developed with the impetus originating from the Centers for Medicare and Medicaid Services (CMS) [49]. Furthermore, the Anesthesia Quality Institute (AQI) and the National Anesthesia Clinical Outcomes Registry (NACOR) of the AQI both have measures accepted by both the American Society of Anesthesiologists (ASA) and CMS. More local date can also be generated. Peccora et al. developed an online reporting tool that can be customized to individual anesthesia providers. This system extracts data that is frequently updated to inform providers as to their performance in comparison to not only their peers, but also to national standards [50]. Gabriel et.al. expanded upon this concept by presenting an electronic score card with common operational metrics such as cancelled cases, average turnover time, and average extubation time [51]. In a workplace with differing perspectives regarding standards of care, the introduction of a report card system may allow OR personnel to compose a unified agenda based on unbiased criteria [50–54]. Finally, the implementation of patient-centered, integrated practice units may allow for further refinement of quality measures that drive efficiencies while meeting the needs of the community [24, 55–57].

Cost Analysis

Resource allocation needs to be catered to the organizational needs for each individual hospital department. The traditional top-down cost-based accounting model utilizes billing codes to assign values to each task within the hospital. Value units are used to determine the appropriate resource allocation for each unit (operating room, ICU, etc.). This model is superior for smaller departments that have simple billing codes that rarely change in value [58]. However, the assignment of billing codes and associated values becomes more complex when scaling up to larger departments and across time. Problems in static billing practices present when cases take longer than expected. Despite the increased expenditures, each case is still billed at the originally coded value and changes in the value of each code cannot be immediately accounted for without a robust IT team.

Time-Derived Activity Based Costing (TDABC) is an alternative strategy in which each activity process is studied and mapped across the entire care process. After mapping, each process is given a cost rate per unit time based on resource expenditure which can then be multiplied by process times to determine cost. This model is advantageous for complex systems as it allows for greater accountability for changes in process time and resource values. The issue with implementing TDABC presents as a higher initial startup cost due to the nature of implementing a bottom-up approach [59–61].

Conclusion

Hospital managers must acknowledge early budget constraints in the face of resource scarcity and continually decreasing reimbursements. Hospitals are complex systems and OR management is focused on cost reduction and generating efficiencies. In an era of value-based care, establishment of quality control measures will help bolster efficiencies and improve patient access to core services. Limitations such as unpredictable variability and task ambiguity due to the nature of disease processes will continue to pose challenges in the foreseeable future. Regardless of any optimization made, there is no purpose if no tangible consumer-side benefits accompany the change. Human-centered design that caters towards the needs of the sick and injured should always remain the end goal [62–64].

Compliance with Ethical Standards

Conflict of interest Steven D. Boggs declares he has no conflict of interest. Derek W. Tan declares he has no conflict of interest. Caleb L. Watkins declares he has no conflict of interest. Mitchell H. Tsai declares he has no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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