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***JACC* REVIEW TOPIC OF THE WEEK**

Effective Operational Management in the Cardiac Catheterization Laboratory

JACC Review Topic of the Week

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ABSTRACT

Operational efficiency is a core business principle in which organizations strive to deliver high-quality goods or services in a cost-effective manner. This concept has become increasingly relevant to cardiac catheterization laboratories, as insurers move away from fee-for-service reimbursement and toward payment determined by quality measures bundled per episode of care. Accordingly, this review provides a framework for optimizing efficiency in the cardiac cath lab. The authors outline a management method based on the Nadler-Tushman Congruence Model, a commonly used business tool by which a company can assess whether its key elements are aligned with its strategy. Standardized metrics of cath lab efficiency are proposed, which can be used in public reports on this topic moving forward. Attention is paid to understanding balance sheets to track the financial health of the cath lab. Specific cost-saving measures are described, and examples of strategies used to save supply expenses are provided. (J Am Coll Cardiol 2018;72:2507–17) © 2018 by the American College of Cardiology Foundation.

In the context of a business, operational efficiency relates to the ability to deliver a good or service in a cost-effective manner while maintaining high-quality production. Maximum efficiency is a core competency of any high-functioning enterprise, yet is challenging to achieve and poorly defined in the cardiac catheterization laboratory (cath lab) (1–4). The importance of achieving efficiency is paramount in the current environment of rapidly increasing health care expenditures, as private insurers and government payers have placed heightened emphasis on quality over quantity of care, reducing procedural volumes, and limiting expenses. Although quality has emerged as an important metric by which to determine reimbursement, equally as important to the financial sustainability of providers are considerations of cost. Though not a focus of current guidelines, economic realities underlie the ability of every cath lab to care for its patients, and many institutions are desperate for guidance on how to provide high-quality care efficiently.

Accordingly, it is the aim of this paper to demonstrate the importance of operational efficiency to cath lab sustainability, approaching the topic from a business perspective. We provide a framework for improving efficiency based on the Nadler-Tushman congruence model, a commonly used tool to design and align organizational management (5–7). Particular emphasis is placed on the importance of effective leadership. We propose standardized metrics of lab efficiency and demonstrate the utility of specific accounting tools to track financial balance sheets longitudinally. Real-world examples of tactics used to save time and reduce supply expenses are provided to disseminate knowledge of strategies that have been successful in realizing efficiency in our cath lab. Although the current review focuses on cath lab operations, these principles may be applied to many

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ABBREVIATIONS AND ACRONYMS

A-APM = Advanced Alternative Payment Model

ACC = American College of Cardiology

AHA = American Heart Association

EBITDA = earnings before interest, taxes, depreciation, and amortization

FTE = full-time employee

MACRA = Medicare Access and CHIP Reauthorization Act

MIPS = Merit-Based Incentive Payment System

NCDR = National Cardiovascular Data Registry

PCI = percutaneous coronary intervention

QPP = Quality Payment Program

SCAI = Society of Coronary Angiography and Interventions

aspects of cardiology service delivery, especially electrophysiology labs, hybrid operating rooms, and the echocardiography suite.

CHANGES IN REIMBURSEMENT

In 2015, the U.S. Congress passed the Medicare Access and CHIP Reauthorization Act (MACRA), which repealed the Sustained Growth Rate Medicare payment formula (8,9). The primary aims of MACRA are to reward care based on quality and move away from fee-for-service reimbursement. Though beyond the scope of this review, a basic understanding of MACRA illustrates the central role that maximizing efficiency can play in cath lab financial sustainability.

MACRA is the catalyst for dramatic changes in cath lab reimbursement for Medicare Part B (physician services). The "heart" of MACRA as it relates to physician payments is the Quality Payment Program. Under the auspices of Centers for Medicare & Medicaid Services, the Quality Payment Program requires providers to participate in either the Merit-Based Incentive Payment System (MIPS), or an Advanced Alternative Payment Model (A-APM), with limited exceptions.

MIPS AND CATH LAB EFFICIENCY. MIPS is effectively the "new default" for Medicare Part B participants. MIPS will start affecting reimbursement in 2019 on the basis of 2017 data. Payments can be adjusted a maximum of ±4% in 2019, gradually increasing to ±9% in 2022 onward. These adjustments will be made to Medicare Part B reimbursement based on a composite performance score that factors in 4 weighted performance categories (10). These include quality, advancing care information, improvement activities, and cost (11).

The cost category considers claims-based Medicare spending per beneficiary and Medicare spending per capita, adjusted for subspecialty and patient risk. The cost category will be incorporated first in the 2018 performance year with a 10% weight, though Centers for Medicare & Medicaid Services is required by law to weight cost at 30% for the 2019 performance year. In light of this, it will be paramount for institutions to prioritize cost control, and those that embrace and attempt to optimize operational efficiency will benefit financially in this environment.

A-APMS, BUNDLED PAYMENTS, AND CATH LAB EFFICIENCY. The alternative to MIPS is participating in an A-APM, of which there are several varieties, and all move away from the fee-for-service model and toward quality-based reimbursement. One popular A-APM reimburses care in a capitated, "bundled" payment linked to the index episode of care (most for 90 days afterwards). Proposed diagnoses in this "Bundled Payments for Care Improvement (BPCI)-Advanced" A-APM could include admission for acute myocardial infarction or percutaneous coronary intervention (PCI). In a bundled payments environment, the hospital and provider must use a fixed amount of resources to complete a given case. Reducing costs and utilizing resources as efficiently as possible will be essential, because labs cannot expect to be reimbursed for the volume of procedures performed.

UNDERSTANDING THE DIFFERENCE BETWEEN QUALITY AND EFFICIENCY

ESTABLISHING STANDARD DEFINITIONS. With an appreciation of its importance, one can move toward studying cath lab efficiency in a systematic manner. Evaluating productivity, cost, efficiency, and quality is complicated by these terms' unique meanings and interaction with one another in the cath lab. For consistency, we promote using the following definitions, provided in **Table 1**.

UNDERSTANDING CATH LAB QUALITY. As opposed to efficiency, quality of care in the cath lab is well defined by several guideline and consensus statements. Providing quality care should be the overarching goal of every cath lab and should never be compromised for the sake of saving time or reducing cost. The task at hand is maintaining optimal quality while streamlining care delivery, rather than cutting corners at the expense of patient care. Accordingly, understanding how quality is measured is the foundation upon which addressing cath lab efficiency should be built.

The American College of Cardiology (ACC), American Heart Association (AHA), and Society of Cardiovascular Angiography and Interventions (SCAI) guidelines describe clinical practices intended to serve as the standard of care. Cath lab quality is formally assessed by metrics of adherence to these guidelines and is tracked by the ACC National Cardiovascular Data Registry (NCDR) suite of registries, including CathPCI, the STS/ACC TVT registry, and ACTION registry (among others) (12). These registries promote established standards on clinical competency (13), and performance measures for providers performing coronary, structural, and peripheral vascular interventional procedures (14). In addition, an expert consensus document from the ACC/SCAI establishes specific standards by which cath labs should be expected to operate (15). Although the importance of quality improvement initiatives is discussed in these documents, none provide sufficient guidance on how to run a cost-effective, efficient cath lab.

PUBLIC REPORTING OF CATH LAB OUTCOMES REFLECTS QUALITY, NOT EFFICIENCY. The ACC encourages hospitals to report their NCDR outcomes, which allows institutions to showcase their commitment to transparency and continuous quality improvement (16). Institutions receive quality performance scores (or "P scores"), which are standardized percentages of how often a specific NCDR quality metric is met. Hospitals are assigned a "star rating" of 1 to 4 stars based on their P score in relation to established NCDR performance cutoffs that should be achieved to merit the rating (17). In a related but different program, hospitals can seek accreditation as an ACC/AHA Cardiovascular Center of Excellence (18). Separate from this, SCAI offers a Cardiovascular Laboratory Survey Program consultation service that provides an independent review of cath lab operations focused on improving performance and quality (19).

Although the star rating program and accreditation as an ACC/AHA Cardiovascular Center of Excellence allow for a comparison of quality of care, they do not provide meaningful data on cath lab operations or capacity to innovate. As such, efficiency cannot be inferred from these resources.

A FRAMEWORK FOR CATH LAB MANAGEMENT: THE CONGRUENCE MODEL

We highlight a simple and well-tested business management strategy using the Nadler-Tushman congruence model as a framework for improving cath lab efficiency. We demonstrate the principles of this methodology using a simple example of a congruence model in action (2).

OVERVIEW OF THE CONGRUENCE MODEL. A congruence model examines the performance of an organization through the lens of several elements that encompass all aspects of a company's operations and are considered interconnected to one another. These elements include executive leadership, strategy, critical tasks, formal organization, people, and culture. The first step in forming a congruence model is to study these elements, the interrelationships between elements, and diagram them (**Figure 1**). When considering root causes for an inefficiency, one should categorize each as a misalignment (or incongruence) in one of these elements. The greater alignment between elements, the greater the cath lab performance and efficiency (5–7). Patients undergoing catheterization are considered input, and output is defined by quality and efficiency measures.

TABLE 1 Definitions of Productivity, Cost, Efficiency, Quality, and Value as They Relate to Cath Lab Operations

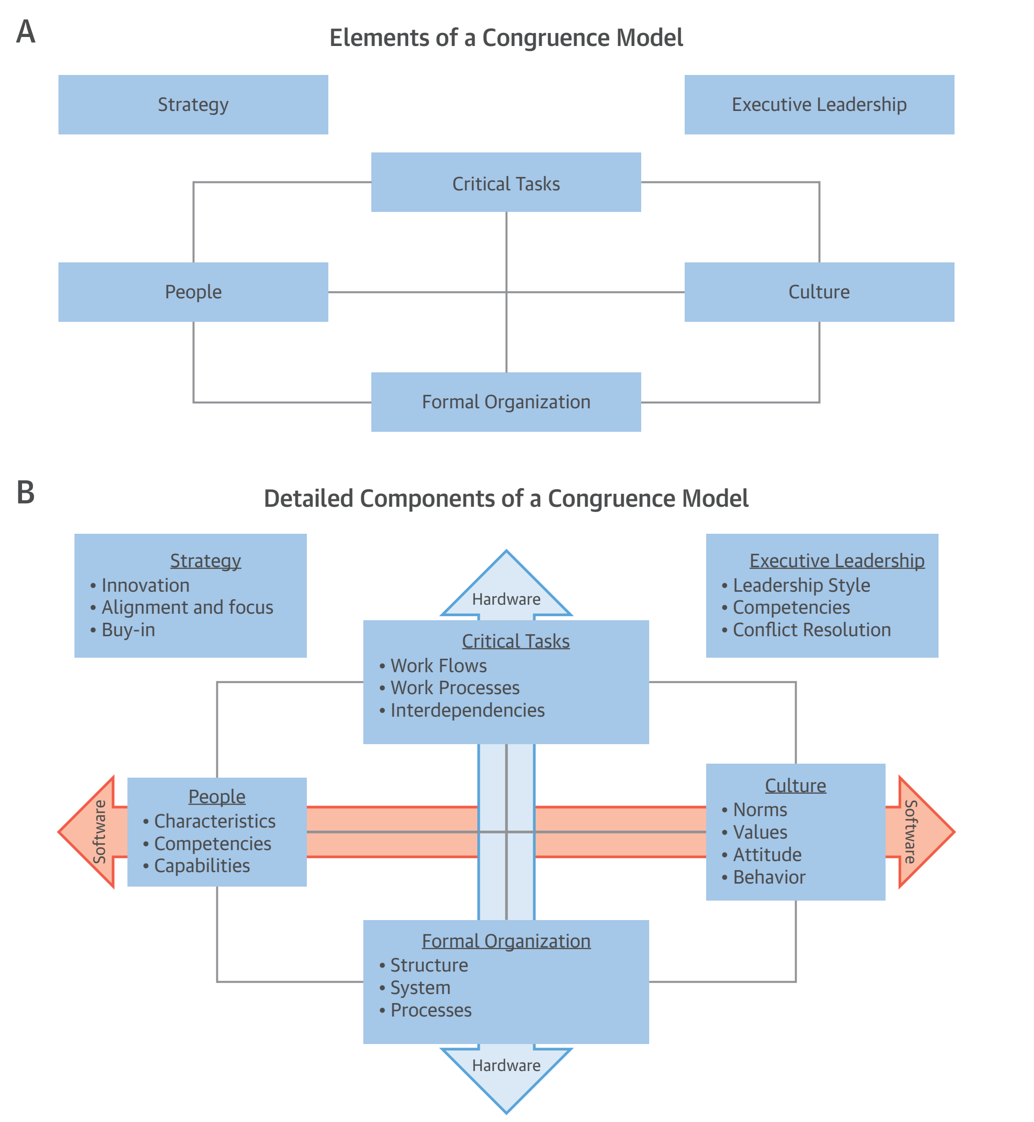
	Definition
Productivity	Volume of cath lab cases in a period of time (i.e., output).
Cost	Total sum of resources spent per episode of care (i.e., input). Includes time, money, and any other scarce resource that could be used elsewhere.
Efficiency	The ratio of cath lab productivity to costs. Can be viewed in terms of specific costs (e.g., time, money, or nursing resources).
Quality	Delivery of optimal patient outcomes and avoidance of complications. Judged by adherence to ACC/AHA practice guidelines. Monitored by national registries (e.g., ACC NCDR CathPCI, AHA Get With the Guidelines).
Value	A subjective measurement of worth. Cath labs that provide high-quality, efficient care can be considered to be providing high-value care. Given its subjectivity, use of the term "value" is limited in our discussion.

ACC = American College of Cardiology; AHA = American Heart Association; NCDR = National Cardiovascular Disease Registry.

One of the benefits of using the congruence model is that it graphically depicts the cath lab as both a technical-structural and social system. In **Figure 1**, consider the horizontal axis including people and culture as the social dimension of the cath lab, whereas the vertical axis including critical tasks and formal organization as the technical-structural dimension. Both axes are guided by executive leadership and strategy, and for the cath lab to be truly efficient, each axis must fit, or be congruent, with the other. Borrowing a computer analogy, the term "hardware" is synonymous with the technical-structural dimension, and "software" encompasses the social aspects that shape values, behavior, and culture. Use of these terms underscores that in both organizational and computer architecture, it is the fit between hardware and software that ultimately determines performance.

PERFORMANCE AND OPPORTUNITY GAPS. The performance gap is an important concept to congruence modeling, defined as the difference between actual and optimal performance. By definition, inefficiencies lead to performance gaps, which must be addressed for a cath lab to operate at its full potential. Performance gaps can be identified by analyzing common aspects of care delivery (e.g., cases done in a day, time between cases, canceled cases, etc.), and comparing performance in these areas to other institutions, historical trends, or proposed "gold standards" from professional society documents. The **Central Illustration** describes cath lab growth, with the

FIGURE 1 Diagram of a Congruence Model



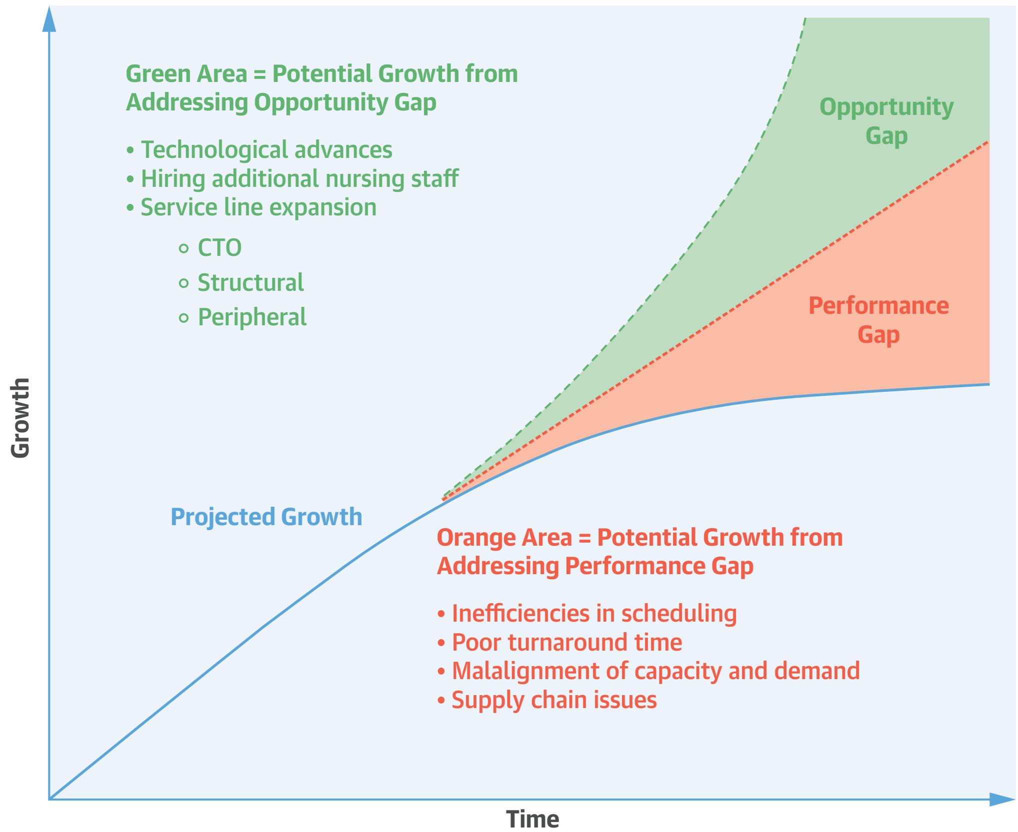
In a congruence model, managers examine the 6 essential elements of their organization and how they are interrelated with regard to specific processes of production **(A)**. Performance gaps are categorized as incongruences in one of these elements (detail in **B**).

performance gap depicted as the shaded orange area between actual and potential growth if inefficiencies are addressed.

Even when a cath lab is performing well, there may be opportunities to embrace novel procedures or therapies, new technologies, or indigenous innovations. These areas of potential growth are known as opportunity gaps, depicted as the shaded green area between the orange and green lines in the Central Illustration. Identifying opportunity gaps can be a very important growth strategy for an already well-functioning cath lab. An "ambidextrous" cath lab leader should identify and find solutions for performance and opportunity gaps that may exist at the same time. Typically, it is simpler to address performance gaps from "hardware" problems (e.g., critical tasks), as performance gaps from "software" issues (e.g., culture) or opportunity gaps in a well-functioning lab need more insightful leadership.

ELEMENTS OF A CATH LAB CONGRUENCE MODEL. **Executive leadership.** The physician cath lab director should be viewed as the "cath lab chief executive officer." It is important to provide power to print & web 4C/FPO

CENTRAL ILLUSTRATION Effect of Performance and Opportunity Gaps on Cath Lab Growth



Reed, G.W. et al. J Am Coll Cardiol. 2018;72(20):2507–17.

Initially, cath lab growth **(blue line)** is rapid. Over time, inefficiencies slow productivity, leading to a gap between actual and optimal performance known as a performance gap (difference between the **blue and orange lines: shaded orange area**). A well-functioning lab may have potential to grow by realizing untapped opportunities, known as an opportunity gap (difference between the **orange and green lines: shaded green area**). CTO = chronic total occlusion.

the cath lab director to manage and modify cath lab personnel and operations. The director should be a respected physician in a position of influence, with the permission to make changes to the cath lab structure and organization. He or she should have the knowledge and expertise to lead the lab in both clinical and financial decisions. The director should possess the ability to motivate employees to achieve common goals and to align individuals' goals to organizational priorities, which is important to employee satisfaction and buy-in. Likewise, the leader should be perceived as fair, approachable, respectful, and open minded. Ideally, the lab director should be relatively young (i.e., mid-career), invested in the long-term goals of the institution, malleable to change, and be active in his or her own succession planning. The physician director should establish a team to assist in carrying out critical tasks, consisting of representatives from all stakeholder groups to assure buy-in when change is made and facilitate problem solving from different perspectives. In most cases, this team includes the physician cath lab director, cath lab nursing manager, prep-recovery area nursing supervisor, and relevant hospital administrators. The experience and capabilities of the cath lab director are crucial, because ineffective leadership is often one of the major root causes in many performance gap analyses.

Critical tasks. It is the responsibility of leadership to obtain a full understanding of the duties of each employee and time elapsed at each step in the care delivery process. An effective technique in accomplishing this is to create a workflow map of every

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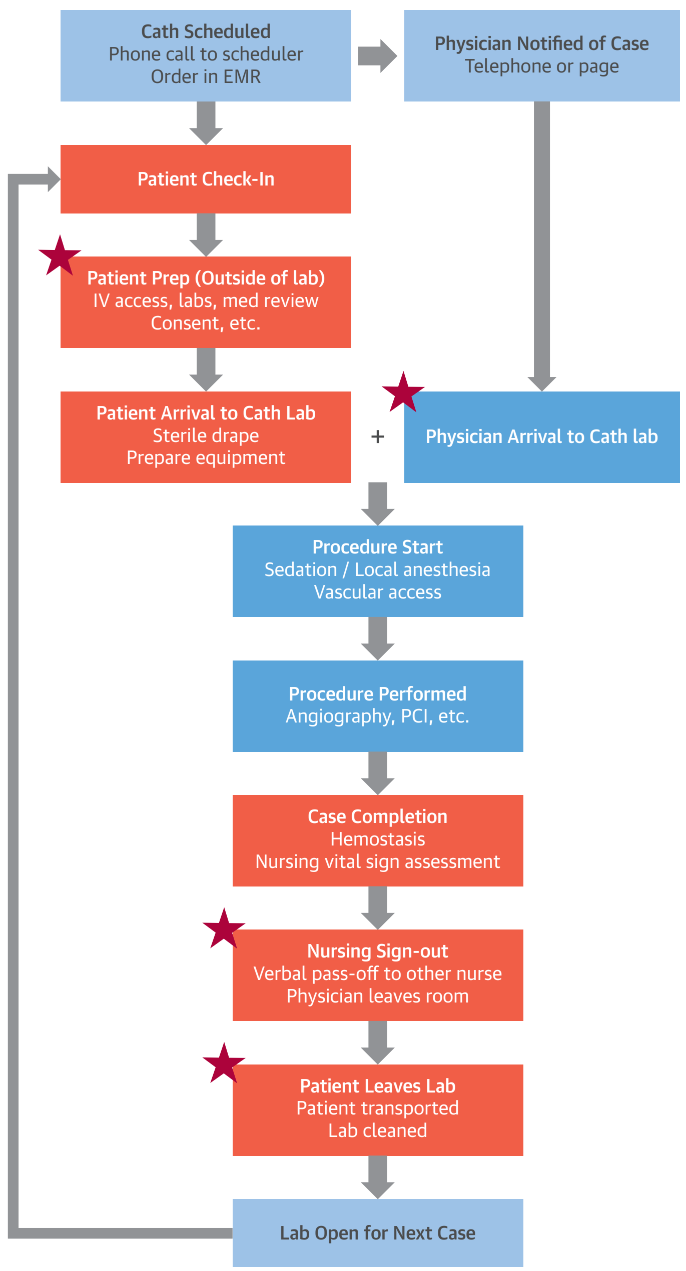
FIGURE 2 **Example of a Cath Lab Workflow Map**



Orange boxes denote steps most dependent on nursing care. **Shaded blue boxes** indicate steps most dependent on the physician, rather than system variables. **Red stars** represent steps with the most variability case to case, and are ideal targets for process improvement. Adapted from Reed et al. (2). EMR = electronic medical record; IV = intravenous; PCI = percutaneous coronary intervention.

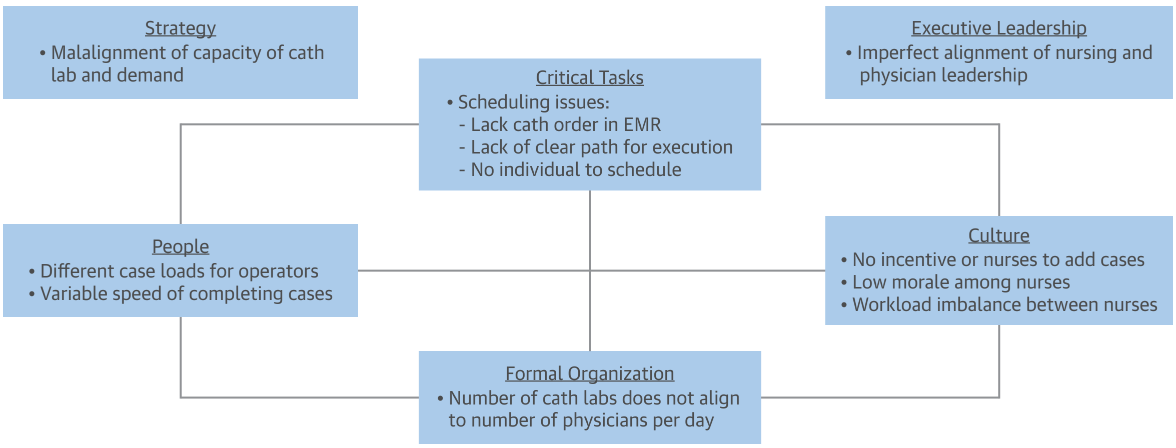
critical task in the continuity of a typical cath lab case. This process starts with a representative from the leadership team assuming the role of every individual involved, including the patient, nurse(s), technician(s), and physician(s), and carefully documenting workflow and material transfers at each step. An example of a workflow map for a cardiac catheterization is provided in **Figure 2**. Through workflow mapping, labs may develop a deeper understanding of cath lab tasks and interdependencies between components at their specific institution. Steps in care delivery that consume the most time, have the most variability, or have the most uncertainty in time spent are optimal targets for process improvement.

Formal organization. The formal organization element encompasses the physical plant of the lab, the hierarchical relationship between the lab and the parent institution, as well as the number and roles of employees and incentive systems (if present). This element also includes "linking mechanisms," or the formal arrangements that knit together various parts of the lab and link it to the consumer (in this case, patients). This may include formal committees, teams, and task forces. Managers should identify the number of cath lab rooms available on each day, and determine the types of cases that can be performed in each room. Concurrently, there should be a formal assessment of the staffing requirements to run each room at capacity. The number of physicians, as well as urgent, elective, inpatient, and outpatient caseloads should be determined. The leadership team should define rewards for employees as performance goals are met to incentivize and promote alignment between organizational and employee goals.

People. The people employed are the most important part of a cath lab. The correct mix of physicians with different skills, availability, and interest should be balanced on a daily basis. Each physician's case experience, speed of performing procedures, teaching responsibilities, and case load should be considered. This analysis and balancing of physician talent is important not only to run a cath lab efficiently, but also effectively, and to prevent physician burnout. Similarly, nursing and technician requirements, continued education, call schedule, and expectations should be analyzed and appropriately balanced.

Culture. In order to create a healthy work environment and maintain an efficient cath lab, a formal assessment of work culture, known as a culture diagnosis, should be performed. This should assess the norms, values, social structure, and perceived power arrangements between employees in the lab. In promoting a healthy cath lab culture, the expectations of leaders and workers should be aligned. Formal processes should provide equal opportunities, proper reward systems, fair distribution of work, avenues for voicing concerns, and transparent communication at all levels. and leadership should be accessible.

FIGURE 3 Example of Root Cause Analysis Using a Congruence Model



The congruence model allowed for identification of root causes of the performance gap of inability to perform elective add-on catheterizations in a timely manner. Solutions for these issues were then strategized (Table 2). EMR = electronic medical record.

Strategy. Every cath lab faces decisions regarding its business strategy, which includes decisions on how to configure resources to adopt to changes, and eliminate performance gaps and opportunity gaps. A major part of strategy is a mission statement, which should include a clear purpose of providing care that is not only high quality but also time and cost efficient (20). Important to correcting performance or opportunity gaps is adopting strategies for change that are aligned to cath lab goals, are comprehensive, inclusive of all concerned parties, innovative, and practical.

Example of use of a congruence model to solve a performance gap. As an illustrative example, in our cath lab, we used a congruence model to study a specific performance gap—the inability to perform elective cardiac catheterization for inpatients on the same or next day of the request. Although there is an on-call team available during nights and weekends to handle critical cases, non-emergent cases were often delayed >24 h, leading to inefficiencies. Once this performance gap was identified, an “owner” of the gap was determined. The owner may be 1 or more individuals with the primary responsibility for correcting the performance gap. In this case, the cath lab director was identified as the gap owner. Figure 3 describes how a congruence model was used to identify the root causes of this gap. Once these root causes were analyzed, the cath lab director formulated strategies to address the various misaligned components (Table 2). Outcomes were carefully monitored to assess whether changes lead to desired results in an iterative fashion. In our cath lab, this method allowed for an increase in the number of cases completed the same or next day for weekday orders from 71.1% to 80.9% (Figure 4A). This has allowed for an increase in same-day discharge and cost savings from this. Further, we were able to increase the number of cases completed by Monday afternoon for weekend orders from 61.6% to 81.9% (Figure 4B) between 2017 and 2018.

TABLE 2 Recommendations From a Congruence Model to Resolve a Performance Gap and Action Plans

	Action Plan
Require EMR orders for all cath lab procedures	Require outpatient and inpatient providers to formally order all cath lab procedures in the electronic order entry system to streamline scheduling.
Improve scheduling management process	Need to purchase master scheduling software to help us manage to an ideal target of 4 interventionalists, 1 heart failure, and 2 diagnostic physicians per day. Set scheduling boundaries of no more than 9 physicians (maximum) and no fewer than 7 physicians (minimum) for any given non-holiday.
Clarify “to be assigned” (add on) process	Establish formal policy for add-on case assignment during the day.
Access cath lab physician	The access interventionalist physician should only bring his/her own outpatients and should have ≤2 scheduled cases. This physician should take on same day cases from the intensive care unit including NSTEMI, and STEMI.
Administrative support	Ensure staffing to support 6 labs on a daily basis assuming the above physician scheduling plan.

EMR = electronic medical record; NSTEMI = non-ST-segment elevation myocardial infarction; STEMI = ST-segment elevation myocardial infarction.

FIGURE 4 **Improvement in Ability to Accommodate Same or Next Day Cath Requests Following Use of a Congruence Model**

Changes to the nursing schedule, adding the ability to schedule cath lab cases through an EMR, and realigning resources increased the ability to accommodate same or next day cath requests during the week **(A)** and weekend **(B)**. **Blue** = cases not completed; **Orange** = completed cases.

METRICS OF CATH LAB EFFICIENCY

ESTABLISHING METRICS. There is limited evidence upon which to establish standardized metrics of cath lab efficiency, given the few publicly reported articles published on this topic. One of the most comprehensive reports of an efficiency improvement initiative to date is from our institution, the Cleveland Clinic Sones Cardiac Catheterization Laboratory, from May 2013 to April 2016 (2,4). **Table 3** describes the metrics of efficiency followed longitudinally in our study, which include case volume, room utilization, % of days at full capacity, on-time starts, turnaround time, and % of nonradial cases in which the sheath was pulled in lab. Other important indicators of workforce efficiency that were followed included productivity per full-time employee (FTE), % of after-hours (night) cases, and % of hours considered overtime. In this study, procedural time was not considered an efficiency metric, because it is heavily influenced by the nature of the case rather than system variables that can be modified with adjustments to workflow patterns (**Figure 2**).

The impact of the Cleveland Clinic cath lab initiative on these metrics are provided as an example of results that could be expected from an effective efficiency improvement program. These gains were obtained largely from addressing the performance gaps identified from our congruence model described earlier in this paper. The net result was a gain of

TABLE 3 Metrics of Cath Lab Efficiency and Proposed Goals

	Definition	Example of Change	Goal
Case volume	Number of cases in a period of time.	731 ± 50 cases/month No significant change	Stable or increased
Room utilization*	Ratio of number of hours each lab room is staffed to the number of hours the lab room is utilized.	91% to 106%	≥100%
% Days at full capacity	Proportion of days in which the entire lab is at full operating capacity.	8% to 77%	≥75%
On-time start	On-time patient and physician arrival for the first case of the day in a given lab room.	62% to 89%	≥85%
Turn-around time	Duration of time between exit of the prior patient and arrival of the next patient to the cath lab.	21.6 to 16.4 min	≤17 min
% Sheath pull in room	Proportion of nonradial cases in which the vascular access sheath is pulled in the lab room.	10% to 3%	≤5%
Productivity per FTE	Ratio of case volume per non-physician FTE.	20.2 to 24.6 cases/month/FTE	Stable or increased
% After-hours cases	Proportion of scheduled cases that occur after normal operating hours (i.e., after 5 PM).	1.7% to 1.8%	Stable or reduced
% Overtime hours	Proportion of hours paid to FTE's classified as overtime.	5.1% to 3.8%	Stable or reduced

Metrics of cath lab efficiency, with changes after 1 large cath lab's efficiency improvement initiative, and proposed goals for standardization across institutions. *Utilization can be >100% if the number of cases performed is greater than the number expected given the hours each room was staffed.

FTE = full-time employee.

approximately 5.1 to 5.6 h per day of additional lab time due to improved utilization and reduced room turnaround times without a detrimental effect on case volume, an increase in productivity per FTE, and an improvement in employee satisfaction. On the basis of this study, goals for each of the cath lab efficiency metrics are proposed; however, each institution should modify these goals based on historical trends at their institution.

EMPLOYEE AND PATIENT SATISFACTION. Maintaining motivated and engaged employees is key to executing transformational change, whether it be in the cath lab, electrophysiology lab, hybrid operating room, or any other service line. Though not a metric of cath lab efficiency per se, managers should pay attention to employee satisfaction during this process and illicit feedback on the effects of the changes on employee experience. Common tools used to assess employee satisfaction and engagement are Press Ganey scores. Trends in these scores can be compared before and after making changes in workflow to assess employee well-being. Likewise, patient satisfaction should be followed over time to ensure the patient experience is improved, or at the least not harmed in the pursuit of efficiency.

REDUCING SUPPLY COSTS

In addition to saving time and maximizing productivity by streamlining care delivery, minimizing supply costs is a vital component of maximizing operational efficiency. As discussed in the preceding text, this will become increasingly important as the cost category is phased into MIPS and A-APMS (such as bundled payments for PCI, peripheral, and structural procedures) limit compensation to a capitated payment per episode of care.

FIXED AND VARIABLE COSTS. Similar to any business, the budget of a cath lab must consider revenues and expenses. Reimbursement for care is revenue, whereas expenses should include all employee wages, supply expenses, equipment costs, and overhead. Expenses may be broken down into fixed and variable costs. Fixed costs encompass those that are not easily modifiable, including facility expenses, costs to run and maintain equipment, and employee wages. Conversely, variable costs are driven primarily by use of inventory, including the number and type of catheters, wires, balloons, stents, contrast, and other devices used per case.

EBITDA APPLIED TO CATH LAB OPERATIONS. A widely-used indicator of a company's financial performance is "earnings before interest, taxes, depreciation, and amortization," or EBITDA. EBITDA is often used to compare "profitability" among companies, even across different industries, because it eliminates the effects of nonoperating decisions such as interest expenses (a financing decision), tax rates (a governmental decision), or large noncash items such as depreciation and amortization (accounting decisions).

Table 4 provides a sample cath lab balance sheet with calculations of EBITDA and the EBITDA margin. The EBITDA margin is a ratio of EBITDA to total revenues, or in the case of cath lab operations, reimbursement. In the example provided, the cath lab is able to turn 15% of its revenue into positive cash

TABLE 4 Balance Sheet and Calculation of EBITDA in a Hypothetical Cath Lab

	Amount
Revenue (e.g., reimbursement)	$20,000,000
Salaries (e.g., physicians, nurses, technicians, custodial)	(4,000,000)
Supply costs (e.g., catheters, stents, etc.)	(10,000,000)
Equipment costs (e.g., fluoroscopy maintenance, etc.)	(2,000,000)
Overhead costs	(1,000,000)
Amortization	(250,000)
Depreciation	(500,000)
Earnings Before Interest and Taxes (EBIT)	$2,250,000
Interest expenses	(250,000)
Earnings Before Taxes (EBT) (Operating Income)	$2,000,000
Taxes (e.g., 25% rate)	(500,000)
Net Income	$1,500,000
EBITDA	$3,000,000 [$2,000,000 + $250,000 + $500,000 + $250,000]
EBITDA Margin	0.15 [EBITDA / Total Revenue = $3,000,000 / $20,000,000]

EBITDA = earnings before interest, taxes, depreciation, and amortization.

TABLE 5 Strategies to Reduce Supply Costs in the Cath Lab

Consolidation of inventory (discontinue stocking rarely used items for PCI, peripheral, and structural cases)
Negotiation of volume-based rebates
Negotiation of product bundles for frequently used inventory
Initiation of a cost awareness program (physician education)
Limit waste during procedures (nursing education)
Substitution of similarly efficacious products of less cost (i.e., radial access and hemostasis kits, PTCA balloons, guidewires, contrast)
Limit use of bivalirudin, use unfractionated heparin instead
Prioritize same-day discharge and reduce hospital length of stay

PCI = percutaneous coronary intervention; PTCA = percutaneous transluminal coronary angioplasty.

flow for the institution. Although Table 2 describes metrics of cath lab efficiency, EBITDA can be viewed as a metric of the financial health of a cath lab. A positive EBITDA and favorable EBITDA margin are indicators of a cost-effective cath lab.

SUCCESSFUL STRATEGIES FOR SUPPLY SAVING

In the next section, specific strategies to reduce supply expenses are described to provide real-world examples of successful cost-saving efforts (summarized in Table 5). These performance gaps were identified with use of the congruence model in a similar fashion as above.

PCI COST REDUCTION. Stocking an extensive selection of wires, balloons, and stents can create waste when supplies are not used, and make it challenging to negotiate in bulk. Accordingly, from 2010 to 2016, there was a gradual reduction in the variety of inventory stocked in our lab. Physicians were surveyed of their preferences, and given 2 or 3 choices across different categories of coronary wires, balloons, and stents. In most cases, there was a clear 1 or 2 favorite items in each category. If there was equivalence in preference between products, the more expensive one was eliminated.

With a consolidated inventory, we then reached out to vendors to negotiate a volume-based rebate structure for each product. We further negotiated that products used routinely for each case be bundled together, at a significant cost savings. This was widely successful in reducing material expenses, because there was a 41% savings in PCI costs over this time period (over $2.7 million annually). There was a 59% reduction in the average cost per drug-eluting stent, and between 5% and 39% reduction in the cost in other materials.

In certain categories, we observed a substantial difference in cost without a clear difference in quality between products. Specifically, switching coronary balloon vendors saved $55,000/year, 0.035-inch guidewires saved $88,000/year, and awarding dual-vendor drug-eluting stent contracts saved $850,000/year.

In addition, in 2015, we adopted a policy that all PCIs be attempted via radial access by default if possible, given the well-documented advantages of a system-wide switch from femoral to radial access for bleeding complications, patient quality of life, and cost (21–23). Concordantly, >85% of our cases are now attempted via radial access, and the number of cases successfully completed radially increased from ~2% to 67% between January 2010 to June 2016. In 2016, we negotiated a bulk deal for a more affordable radial access kit, saving $160,000/year.

COST AWARENESS PROGRAM. Coincident with consolidating cath lab inventory, a physician cost awareness program was created in which material costs used during the case were displayed on a screen in the cath lab in real time, and each staff was provided with data on how many wires, balloons, and stents they used per procedure in comparison to their peers. The goal was not to penalize providers for high-cost procedures, but rather give them power in making financial decisions, and make them aware of their inventory expenses. This contributed to a reduction in use of more expensive wires and balloons over time. Nurses were also instructed to double check before opening any sheath, catheter, wire, balloon, or stent to avoid accidentally opening supplies not needed thus minimizing waste.

REDUCED BIVALIRUDIN USE. In light of recent data demonstrating equivalent bleeding and possibly reduced ischemic outcomes with unfractionated heparin monotherapy compared with bivalirudin (24), our lab adopted a policy that bivalirudin was only to be used with a strong clinical indication. From 2015 to 2016, bivalirudin use was reduced by 91%, amounting to a cost savings of over $520,000 annually. Bleeding and ischemic event rates were unchanged.

CONCLUSIONS

A principle familiar to the business world, operational efficiency is a concept that holds increasing importance to cath labs as we move away from a fee-for-service model. Identifying inefficiencies in cath lab care delivery can save time, maximize production, and minimize costs. Reducing supply expenses is likewise essential to realizing operational efficiency. A systematic approach to addressing operational efficiency using a congruence model can be an important tool for the management of cath labs. Cath labs should be encouraged to report results from their efficiency improvement initiatives utilizing the metrics similar to those defined in this review.

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