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Emergency department structure and operations

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Why should anyone in medical practice be interested in operations management? Or, if you are like most of us clinicians, perhaps it would be better to ask: What is "operations management"?

The trivial answer is that operations management (closely related to the field of operations research) is the applied science of managing operations. In a business context, "operations" refers to the production of a good or the delivery of a service. For physicians, the particular service of professional interest, obviously, is the practice of medicine. So, for us, from a certain point of view, operations management becomes the science of how to practice our art.

Medicine has been widely criticized in recent years as having service-delivery methods, processes, and habits of medical practice that emanate simply from tradition—handed down by mentors, during rigorous, intensive, and lengthy training—and adopted, unquestioningly, by their trainees. Have you stopped to reflect or—better yet—study critically and in depth how medical service-delivery methods, processes, and habits actually work? People who conduct operations research have.

What outcomes—intended or unintended—occur because of our processes? What feasible alternatives exist to established practices? What factors determine the effectiveness of those alternatives? In short, how *could* we and how *should* we organize and operate various kinds of clinical practice? And why? There is a distinct body of knowledge—separate from clinical

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knowledge—with answers to these important questions. Operations management uses this body of knowledge rather than mere tradition to answer the key questions that arise in managing human productive activities, be it manufacturing widgets or practicing medicine. There really is a science to our art. The sad reality is that few of us in medicine, however, are knowledgeable about this field. From that perspective the crass, commercial world arguably could be—the authors assert, clearly is—more professional than we are; it is we who are the amateurs. And this is a clarion call to change that state of affairs.

Have we subjected them to scientific inspection? Have we experimented with alternatives?

The purpose of this article is to explore some of the tools and techniques available in operations management in health care in general, and in emergency medicine in particular. The intent is to stimulate the reader to explore some of these approaches and tools in further detail. Various theories are noted, but the intent of this article is to be eclectic, so as to give the reader a feel for the rich variety of approaches available.

The emergency department as a service: moving toward modern operations tools from a solid quality management theoretical base

Emergency medicine is, quintessentially, a professional service. Emergency physicians intuitively and readily recognize that their work is more akin to a service industry than to a manufacturing plant. Interest on the part of emergency physician organizations, such as the American College of Emergency Physicians, in understanding disciplined operations and quality management tools to support our primary service nature dates to approximately 10 years ago [1]. There are many operations management models that can be illustrated at this point. As Thom Mayer has noted, one particularly strong model is that of Joseph Juran, whose work is applicable to service industries [2]. Many early efforts to introduce industrial quality management in emergency medicine borrowed from Juran's work [Espinosa].

Juran divides operational management into Planning for Quality, Improvement of Quality, and Control of Quality. These notions are syntonic with most major thinkers in service and manufacturing [3].

Quality planning of the emergency department underscores the importance of data-driven knowledge about the customer's wants and needs

The linchpin of the Juran trilogy is the quality planning arm.

The essential aspects of quality planning include asking the following questions: (1) Who are our customers? (2) What services do those customers need? How satisfied are our customers with the services we are currently

needs? (4) How do we plan to build the processes and systems that will generate those services? (5) How do we get those plans off the drawing board and into operation?

It is a crucial exercise for emergency department (ED) planners to define their customer base in a qualitative sense, looking at the internal and external customers of the center. The development of even a qualitative list of our patients and other customers, together with the related services that we provide them, is an enlightening exercise. Modern ED information systems now allow for the development of what approaches micro-epidemiologic support of the ED service planning.

Modern operations theories all insist on the core importance of the development of a systematic way to communicate with those customers. The last decade has seen an explosion of patient and other customer satisfaction survey instruments. Properly designed and analyzed, customer feedback is powerful. In essence, the entire modern ED concept can be said to have arisen out of the desire to create a service that would better meet the needs of patients. The notion is to keep this creative, data-driven link alive on an ongoing basis [4].

In practice, survey strategies and methodology have sparked considerable ongoing controversy. The most common concerns expressed relate to questions of methodology and scientific validity and reliability. Many practitioners have experienced a sense of alienation from the survey process and have believed the data were used for punitive rather than constructive purposes.

From the perspective of modern operations management, health care providers must find ever better methods to hear the voices of patients and other customers in ways that are valid and reliable because of the value of the customer input to planning and other elements of operations.

Quality control of the emergency department

The quality plan of every ED in the United States no doubt has quality measures. A key concept is that the quality measures to be studied ought to be selected with thought and care. There should be a profound concern in quality control (QC) planning that the indicators of quality be studied with an eye on statistical treatment of the data. The data must be reflected back to the practitioners of the work in a way that invites their participation and minimizes fear.

What would we like to measure? What do we need to measure?

Here we see the importance of Juran's notion of "the vital few." This derives from the quality management axiom that suggests we learn to separate those functions or aspects of a process or problem that are most critical. In Juran's view, we must separate "the vital few" from "the many others." This notion is related to what is often called the "Pareto principle."

wealth of the nation was in the hands of a minority of the people. In the adaptation to the ED, these notions would suggest there might be dozens of processes in our department, each with many steps. If we could identify the vital few, however, we could make the greatest overall impact on the system with an economy of effort.

What areas would most likely fit this description? The JCAHO suggestion that we look at processes that are high-risk, high-volume, high-cost, and problem-prone is still a valid notion. In fact, environmental and practical survey pressure from the JCAHO has been a driver to improved methods of ED measurement and management.

Using the JCAHO ideas and the notion of the vital few, however, we ought to come to some agreement about what quality control measures are most meaningful. Although each institution has its own spin on the specific indicators selected and the data elements to be studied, there probably will be some remarkable inter-institutional similarities. An exciting new area for discussion has been made possible by the advent of various modern ED information systems. These systems vary greatly, but have in common the capacity to look at a variety of operational domains, such as cycle times for important ED operational processes. Such processes include arrival, treatment, and disposition processes. Some of the modern systems have embraced clinical process operation support, including protocols, order entry, real-time risk management feedback, and graphic display of function in real-time and retrospective analysis tools.

Obviously choices for operations studies must rationally be responsive to hospital, state, federal, and regulatory body requirements.

Quality improvement of the emergency department

At the risk of over-simplification, for Juran, quality management is the sum total of the quality planning, control, and improvement processes.

Let us assume that the quality control arm of the ED's quality management (QM) program detects a problem of an operational nature. What do we do next?

In the old world of "quality assurance" (QA), when QA studies were all that were available, QA data would all too often be used in and of themselves to improve the process or system. All too often individuals would be accused of a failure of will, intention, alacrity, or intelligence [5,6].

The culture and philosophy of modern operations management suggests that at least 85% or more of the problems we find in our operational studies are systems problems and not people problems [7,8].

Once a process has been identified for improvement, a team can be brought together that understands the process. Another core notion is that

The central idea is that the team should be comprised of workers who know and understand the process to be analyzed. This involves interdisciplinary teamwork, which implies that the group process of the team meetings should be one of mutual respect and openness.

There are various models by which the team can move through a quality improvement cycle. Various tools and techniques pertain to various stages of the cycle [9–22].

Interesting challenge: framing emergency department operational management in the context of outcomes theory

Meaningful discussions of operational management in health care require some mapping to outcomes. There are multiple useful frames. One of the most practical is that of Nelson and Batalden, who see four types of outcomes [23].

- Clinical outcomes
- Patient and other customer outcomes
- Cost outcomes
- Quality of life

Many operations and quality thinkers in emergency medicine believe that quality of life outcomes can and should refer not only to the quality of life of patients but also to the quality of work life of ED providers. These outcomes notions lead us to a discussion of metrics.

Metrics—what types of metrics are relevant and appropriate to the management of emergency departments?

Metrics can be shown to relate then to elements of clinical, operational, customer satisfaction, cost, and quality of life measures, with the intent of application to the purposes of planning, improvement, or maintenance of ED systems.

Modern challenges, such as ED overcrowding, challenge the capacity of ED-based management paradigms to adapt. Such challenges move us inevitably to an understanding that the ED is a microsystem in the context of a larger hospital macrosystem. This hospital macrosystem exists, in turn, in a larger context of regional and national forces, many of which are massively outside of ED control.

Coning down on patient flow at the ED microsystem level, we find that there is no single set that has been widely accepted. The most common operations domain indicators include (but are not limited to):

- Volume demographic metrics, eg:
  Arrivals by hour

- Cycle time measures, eg:
  Arrival to nurse triage
  Arrival to placement in a bed
  Arrival to nurse evaluation
  Arrival to physician evaluation
  Arrival to discharge
- Customer satisfaction metrics:
  Most individual hospital and proprietary survey company metrics embed measures of customer satisfaction with various elements of "wait time." This is often a driver for the urge to improve ED operations around waits and delays.
- Quality of life measures relating to ED operations:
  These measures are rarely found in ED operations work. Some hospitals use employee satisfaction measures that may provide metrics concerning ED employee satisfaction.
- Cost:
  The capacity to date of hospital information systems to provide accurate information on cost parameters to ED operations managers has been limited. There is some evidence that this is improving with unit-based information systems. Commonly available metrics concern staffing, equipment, and other costs. Billing data are available. It is predictable that ED operations management will increasingly be enlightened by enabling technologies that gather, organize, select, synthesize, and distribute actionable and value-based cost data.

We have raised the issue of ED operations management in the context of such complex issues as ED overcrowding. Concerning the metrics of overcrowding, many researchers are working to develop valid metrics for microsystem and macrosystem flow that are useful in the larger context of hospital- and regional-based demand to capacity matching. This leads to the critical importance of interdisciplinary collaboration in operations work.

Interdisciplinary and interdepartmental collaboration and cultural change in operations management—microsystems and macrosystems

Understanding the emergency department as a component of a larger system—the hospital and even the health care system

Such researchers as Risser and Rice have worked to adapt elements of high-reliability communication, culture, and behaviors from other industries, such as the crew resource management (CRM) principles of

the ED. MedTeams' behavior-based teamwork system, developed by Dynamics Research Corporation, uses CRM methodology to improve performance in emergency medicine practice. This system uses CRM training to develop tools and team behaviors to avoid errors, identify them as they occur, and mitigate the consequences of errors that get through the system. The Emergency Team Coordination Course (ETCC) includes five team goals that include creating a team culture, problem-solving, enhanced team communication, team-building skills, and workload management tools. The system depends on peer monitoring, system checks, third party arbitration, and identification and debriefing of near-misses [24].

Kosnik's work suggests that such CRM principles have implications for the communication and behaviors of the larger organization, in safety between the units of the organization, and within the units, such as an ED [25]. The smaller units are known as microsystems. The larger are known as macrosystems. The operational state and behaviors of interacting microsystems are mutually interactive. The state of the larger organization is comprised, to some degree, of the states of the smaller units, such as the ED [26–32]. Modern operations research, however, using what are called demand-capacity models based on the mathematics of waits and delays (queuing theory) makes it clear that the state of the larger macrosystem (eg, hospital at full capacity) affects the microsystems of which it is comprised and vice versa.

In this thinking, ED operations management is said to best occur in the context of whole system operations management. These notions of large system and smaller system interactions are often referred to as flow principles, or demand–capacity matching. Information technology is now beginning to make these relationships visible so that management is possible through an integration of the parts of the whole.

As an example, Kosnik and Espinosa recently described a project to reduce ED admission cycle time. They propose that at the management level of admission cycle time, the capacity of the ED to effect change is minimal without widespread institutional support. In the case of admission cycle time reduction work, the relationship between the ED and various patient care units is influenced by the collaboration or lack of collaboration between several other support microsystems, including environmental services who clean the beds, bed control who assigns the appropriate bed, and the physician who has made the decision to admit [32].

The first challenge in such work is to create the will to be successful. One of the tools used to achieve this goal was the patient satisfaction survey that measures the perceptions of the stakeholders. It was identified that prolonged admission cycle times contribute not only to decreased ED satisfaction—and reduced ED efficiencies—but also to decreased inpatient satisfaction scores. Patients who wait for a bed in the ED come to the

the staff's best efforts. A fair, open, even-handed analysis and discussion of data was seen to be important in fostering the will to succeed. Data collections predictably show that a percentage of the burden of delay is on each side of the microsystem/macrosystem interface. Cycle times of an hour or less—from the time that the decision is made to admit the patient to the time that the patient is admitted—are possible. Interventions in one such successful system included:

- The "Czarina of bed control" concept.
  In this terminology, the "Czar(ina)" is the administrative leader who accepts ultimate responsibility for following up with units who have chosen not to cooperate with the ED in this process.
- Bed control processes were placed under the ED management.
  This allowed the ED to monitor, identify, and mitigate bed management problems in real-time. This intervention was responsible for eliminating discharge holding.
- Registration and housekeeping were decentralized.
- A standardized documentation tool was developed that did not require the unit nurse to fully re-evaluate the patient, but instead it required that she/he read the ED documentation.
- A nonverbal report form was developed. The authors found that giving verbal reports was the greatest opportunity for process delay. Some ED nurses gave short reports, others gave long reports. In either case, the unit nurse was required to leave the patient they were caring for and answer the phone. If the ED documentation is appropriate, the non-verbal report should be only the information the unit staff needs to take care of the patient for the first 30 minutes (ie, pumps, air mattress needs, and the like).

This collaborative approach to admission management requires unlike microsystems to work together toward a common goal. An important component of highly successful microsystems is access to information. This process therefore requires the availability of real-time data collection and monitoring with the capability to provide timely feedback to all or any of the microsystems involved. The need for timely feedback reinforced for the authors that one should never underestimate the value of communication in process improvement. The benefits of successful management of admission cycle times are significant. They include the reduction, if not elimination, of ED holding and diversions of patients to other EDs. Moreover, it is usually a budget-neutral solution.

This example shows the linkage of an ED operations management problem to the behaviors of the parent macrosystem. Modern ED operations theory increasingly sees such issues at play. There is no meaningful likelihood of the success of such work, however, without the conscious support of the parent macrosystem, as illustrated by the previous example. Because

described by Risser, Rice, and others—are core, modern ED operations management must fully embrace the human science of change management and cultural transformation.

These forces are at play in a wide variety of ED operations work. Support service cycles times, such as laboratory, radiology, and transport supports, can impact ED processes. Patients awaiting inpatient beds reduce the functional capacity of the ED, as do patients awaiting consultations and other evaluation and treatment processes. Macrosystem- and microsystem-based information systems may help us identify sources and patterns of delay. Such data are necessary but insufficient by themselves, without such cultural elements as the will to change and the communication tools to operationalize interdepartmental improvements.

This leads to a discussion of tools that are critical in operations management—in process analysis and in persuasion.

Operations management tools

In this section the authors catalog and annotate some of the most common and important tools in ED operations management. Fuller descriptions of the tools are available in the references provided.

Tools for quality planning

- Mapping tools—process and flow [33,34]
- Service blueprinting tools—process chart; line of visibility; and failure points
- Quality function deployment (QFD) methods (a set of tools and techniques used to link quality planning, improvement and control; not widely known in health care at present; remarkable potential)
- Failure mode and effects analysis (looks at process, brainstorms possible ways that failure can occur, estimates frequency, impact, and severity of failure of a given step); directs work [35]
- Pareto analysis—"bang for the buck" (the notion of the investment of energy in the critical few processes rather than the very many)

Tools for process control and improvement

Measuring services

- Metric types
  - Capacity
  - Cycle times
  - Acuity
- Collection tools
  - Manual

Analyzing services

- Capacity planning—static
  Process capability analysis (relates actual to design performance)
  Demand/capacity matching
  Constrained optimization—linear programming
- Capacity planning—dynamic
  Simulation modeling
- Troubleshooting services
  Cause and effect analysis tools—"fishbone" diagram [36]
  Data mining
  Regression analysis
  Designed experiments (hypotheses of causes, designed experiments to tease out operant factors)

Managing services

- Managing supply
  Work-shift scheduling
  Customer (patient) participation
  Creating adjustable capacity
  Cross-training
- Managing demand
  Understanding demand–queuing theory [37–39]
  Poisson distributions
  Arrival process analysis
  Steady-state analysis
  Forecasting demand
  Subjective models
  Time-series models
  Dealing with demand
  Partitioning
  Price incentives
  Smoothing demand
- Promoting off-peak demand
- Changing the arrival process
  Reducing delays through changing the service process
  Creating parallel rather than linear processes
  Designing servers
- Statistical process control—run charts
- Benchmarking [40]
  Best-practice benchmarking
  Generic (out of industry) benchmarking
- Collaborating—working in groups
  Development of high leverage change packages
  Demand/capacity matching on a hospital-wide basis of which the ED is

Video-based storytelling: to tell as story of a need persuasively, share it across microsystem boundaries, and increase will to change [41,42].

Futurethink—next generation emergency department management

What does all of this mean to the future of emergency medicine and specifically to the management of EDs in the future? What will they look like when these concepts are in widespread and common use?

In this section the authors discuss three aspects for ED management Futurethink, namely:

- Advanced ED information system (EDIS) support
- Advanced human factors and design applications
- Real-time demand to capacity matching and the development of macrosystem-based and regional operations control centers (OCC)

Advanced emergency department information system support

ED information support systems are advancing rapidly. Most of these advances are driven by emergency medicine end-user feedback. ED information support systems can allow us to see through the fog of complex, simultaneous processes so as to allow us to see patterns in operations that were never seen before [43].

Advanced human factors and design applications

Recent safety research incorporates and honors human capabilities and respects the limitations of human data processing and cognition. Metacognition research in emergency medicine, often described as thinking about how we think, is increasingly an important part in the design and management of ED services, equipment, and environments of care [44].

Real-time demand to capacity matching/development of macrosystem-based and regional operations control centers (OCC)

The notion of advanced ED information system (EDIS) support can be writ large for the entire macrosystem, of which the ED is a component unit or microsystem. Workers in this area are finding ways to define stress loads on micro- and macrosystems. They look to create real-time warnings and trends in the match and mismatch of capacity to demand on those systems and to automate mitigation.

There are many other interesting aspects to the topic of the future of ED management, to be sure. A discussion of these three ideas, however, helps tie previous sections together and serves as a taking-off point for the readers' Futurethink ideas. The authors welcome interested readers to share their

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