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CONSENSUS BREAKOUT SESSION

Achieving Efficiency in Crowded Emergency Departments: A Research Agenda

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Abstract

In 2011, *Academic Emergency Medicine* convened a consensus conference entitled ''Interventions to Assure Quality in the Crowded Emergency Department.'' This article, a product of the breakout session on ''interventions to safeguard efficiency of care,'' explores various elements of the research agenda on efficiency and quality in crowded emergency departments (EDs). The authors discuss four areas identified as critical to achieving progress in the research agenda for improving ED efficiency: 1) What measures can be used to understand and improve the efficiency and quality of interventions in the ED? 2) Which factors outside of the ED's control affect ED efficiency? 3) How do workforce factors affect ED efficiency? 4) How do ED design, patient flow structures, and use of technology affect efficiency? Filling these knowledge gaps is vital to identifying interventions that improve the delivery of emergency care in all EDs.

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In 2001, the Institute of Medicine (IOM) identified ''efficiency'' as one of the six goals for developing the 21st century U.S. health care system. For a health care system to be of high quality, the report indicated that it should be safe, effective, patient-centered, timely, equitable, and efficient.[1] While the measurement of quality has improved since the publication of the IOM report, progress in the measurement and application of the efficiency aim in health care has been lagging.[2] This point was underscored when the National Academy of Engineering and the IOM issued a joint report estimating that 30 to 40 cents of every health care dollar spent is lost to waste and inefficiency.[3] In 2008, the Agency for Healthcare Research and Quality (AHRQ) produced a report examining the measurement of efficiency and how it can be improved. Four major points were

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identified: 1) the definition of efficiency depends greatly on perspective, 2) there is a lack of crossover between peer-reviewed research and methodologies in use, 3) many efficiency measures do not incorporate quality of care, and 4) there is a lack of validation in efficiency measurements.[2]

The conclusions of the AHRQ report further emphasized the challenges facing specialties such as emergency medicine. In fact, the crowding of U.S. emergency departments (EDs) is now considered a public health concern by the IOM.[4] Nevertheless, crowding in U.S. EDs continues to worsen, threatening the delivery of efficient and simultaneously safe health care. The American Hospital Association reports that annual ED visits have climbed from 88.5 million in 1991 to 123 million in 2008.[5] Meanwhile, from 1990 to 2009, the number of nonrural EDs has decreased from 2,446 to 1,776 (–27.2%).[6] As a result, 38% of all EDs are working at or over capacity.[5] Crowding and system delays have a detrimental effect on health care delivery and patient outcomes.[7–15]

Despite the worsening conditions in U.S. EDs and the inconsistent standards for measuring efficiency in the ED and for translating research results into practice, various agencies have encouraged the development and implementation of methods for measuring efficiency. The National Quality Forum, an early leader in this movement, has served as a clearing center for proposed efficiency and quality measures, subsequently proposing them to the Centers for Medicare and Medicaid Services (CMS). In 2010 alone, more than 140 measures were evaluated.[16] Despite the incorporation of these measures in the evaluation of emergency care systems, and potential pay for performance measures, much research has yet to be done on efficiency in emergency care, particularly on the definition and measurement of efficiency and on the translation of research results into practice.

In June 2011, the journal *Academic Emergency Medicine* convened a consensus conference on ''Interventions to Assure Quality in the Crowded Emergency Department'' to identify interventions targeted at mitigating the negative effects of ED crowding on each of the six goals identified by the IOM. This article, a product of the breakout session on ''interventions to safeguard efficiency of care,'' discusses the concept of efficiency as it relates to the ED, identifies the major interventions targeting efficiency that would benefit from a concerted research effort, and outlines a research agenda for each topic area. Initial research domains and related questions were developed by the authors of this article prior to the consensus conference and were presented to participants. Conference participants further refined the research agenda and prioritized the agenda through voting. Responses are presented in order of priority in each of the accompanying tables.

1. WHAT MEASURES CAN BE USED TO UNDERSTAND AND IMPROVE THE EFFICIENCY AND QUALITY OF INTERVENTIONS IN THE ED?

The study of efficiency in health care, and especially of interventions to improve efficiency in the ED, is still in its infancy. To be able to improve ED efficiency, one must first understand the gaps in research on ED efficiency. The IOM defines ''efficiency'' as ''avoiding waste, including waste of equipment, supplies, ideas, and energy.''[1] However, the meaning of ''efficiency'' depends on the perspective of the stakeholder (e.g., consumers, payers, and providers). For example, patients may perceive efficiency as not ''wasting their time'' in a waiting room, payers may view efficiency as the avoidance of high-cost treatments whenever possible, and providers may consider efficiency to be treating only those patients whose care in the ED is unavoidable.

Different measures of health care efficiency have emerged that reflect different dimensions of the provision of health care services.[17] One review of health care efficiency measures found ''very little convergence around a 'consensus' set of efficiency measures that have been used repeatedly.''[18] Many of the existing measures focus on health outputs (e.g., number of patients treated) rather than health outcomes (e.g., change in a patient's functional status). The underdevelopment of efficiency measurement is particularly acute in the ED setting. Most of the methods used for measuring health care efficiency were developed for application in hospitals, health plans, or nursing homes or they are measures of the resources used in providing treatment for patient episodes of care.

Some of the measures now in use in EDs have provided insight into the efficiency of ED operations and subsequent interventions (e.g., timeliness metrics, left without being seen rates), but they have not been studied for the purpose of being identified, categorized, and evaluated as indicators of efficiency and quality.

Many of the measures that are currently in use in other health care settings could potentially be modified for use in research aimed at understanding and improving ED efficiency. Hospital performance is sometimes evaluated by using ratio-based measures, such as full-time equivalent employees per admission or expenses per admission, for example.[19] While the data requirements are low for such measures, a downside of these metrics is that they only provide information about a particular aspect of a unit's efficiency.

Numerous studies in the health care literature have relied on ''frontier techniques'' to measure efficiency. Frontier techniques are analytic tools that can be applied to facility-level data (e.g., hospital, nursing home) to generate facility-level estimates of efficiency. They are known as ''frontier techniques'' because they represent the farthermost limit of efficiency. The deviation between actual firm production and the frontier is used to measure the inefficiency of individual firms. The two most commonly used frontier techniques are stochastic frontier analysis (SFA) and data envelopment analysis (DEA).[20] SFA can produce measures of a facility's cost inefficiency, which is defined as the ratio of actual, facility-level costs to ''best practice'' total costs, which are estimated via statistics. For example, given the types and quantities of outputs a hospital produces and the input prices it pays, a best-practice hospital might incur expenses amounting to $100 million. If another study hospital was in an

identical situation, and its total expenses were $120 million, its estimated cost inefficiency would be 20%. SFA produces estimates that are particularly useful for ranking the relative efficiency performance of facilities.

Data envelopment analysis is useful because it provides measures of facility-level efficiency relative to an institution's peers, as well as potentially actionable information about how efficiency can be improved. Intuitively, DEA creates a best-practice frontier based on actual facility data and measures a facility's inefficiency as the distance from the facility to the frontier. The DEA best-practice frontier consists of firms that generally provide the same services as the comparison firms and which have the highest efficiency in production based on the inputs and outputs specified by the researcher. Facilities on the frontier are regarded as 100% efficient.

Data envelopment analysis takes into account the fact that facilities can be complex organizations, producing different types of ''output'' with a variety of inputs. DEA indicates how efficiency can be improved, for example, by holding outputs constant and reducing inputs through ''slack analysis.'' Slack analysis estimates, for example, that a hospital could improve its efficiency by holding its output constant and reducing the number of beds it has by some percentage.

Frontier techniques are used primarily by health care researchers rather than by those working in or overseeing facilities, in part because they are methodologically complex and are generally described using academic language in professional journals. EDs have not been the subject of much analysis using frontier approaches. Indeed, in one review of the health care literature, the author did not identify any research in EDs in which frontier methods had been used.[21]

Yet, despite these measurement tools of efficiency, one is not assured of identifying the highest quality health care. In fact, the most ''efficient'' organization may be significantly understaffed.[22] Therefore, organizations such as the AQA Alliance have identified quality as a necessary component of efficiency measurement. Indeed, the AQA regards resource use and unit price measures that do not take quality into account as ''cost of care'' measures, as distinct from ''efficiency measures.''[21] Work that AHRQ is currently undertaking on the development of ED patient safety indicators may help to facilitate the further development of ED efficiency measures.[23] Other barriers that hinder the creation, evaluation, and refinement and use of ED efficiency measures, such as the availability of certain kinds of data, will also need to be overcome.

Inefficiency in the ED has the potential to contribute to a suboptimal work environment, which can lead to adverse patient outcomes. Some ED efficiency measures are likely to reflect different components of ED operations, such as those that are easily correctable or those that require immediate attention. It will not be possible to improve all of these different components until research has demonstrated the best methods for doing so. On the basis of this discussion, we propose key research questions on measures of ED efficiency in Table 1.

2. WHICH FACTORS OUTSIDE OF THE ED'S CONTROL AFFECT ED EFFICIENCY?

While the ED sometimes feels like an isolated system, its performance is dramatically affected by factors outside of its control. These factors include operations of the hospital, physical infrastructure of the ED, patient population, or even availability of patient information. Little is known about their true effect on ED efficiency.

Although some integrated health care delivery systems have a good, enterprise-wide record that easily affords the emergency physician the opportunity to quickly retrieve pertinent data, most hospitals lack this capability. Few studies have been conducted on the effect of easy access to patient records on the efficiency of ED care. Previous work has examined the use of computerized hospital data to support ED quality assurance initiatives,[24] and the effects of computerized physician order entry (CPOE) and decision support on ED care.[25] Recently, the role of regional health information exchanges in emergency medicine has been explored.[26]

Table 1
Key Research Priorities for the Development and Evaluation of Measures of ED Efficiency

1. Which ED efficiency measures are most meaningful/actionable to driving anticipated/expected changes or improvements? (10 votes)
2. Should different measures of efficiency be used for institutions with different roles in the health care system? (7 votes)
3. How can efficiency measures be used in conjunction with outcomes measures to understand and improve ED performance? (5 votes)
4. What measures of efficiency are currently being used in the ED? (3 votes)
5. How is efficiency defined? (1 vote)
6. What dimensions of efficiency do current measures capture? What dimensions of efficiency do they not capture? (1 vote)
7. How could currently used measures of efficiency be modified to measure other dimensions of efficiency? (0 votes)
8. What other measures of efficiency exist that are not being used to measure efficiency in the ED (e.g., for other provider types, in other industries)? (0 votes)
9. What barriers exist to the use of new measures of efficiency? (0 votes)
10. Are there technological advances that are likely to facilitate efficiency measurement in the ED? (0 votes)
11. What are the most important aspects of efficiency in the ED to measure? (0 votes)
12. How can measures of ED efficiency be made more accessible to end users and decision-makers? (0 votes)
13. What are appropriate benchmarks of efficiency? (0 votes)

Future studies should examine the effects of unfettered access to prior hospital and ambulatory records and the ease of their access for emergency physicians. Similarly, more studies are needed on the effect of regional health information exchanges on emergency care.

The ecology of hospital practice is highly variable regarding the magnitude of the effect that the admitting and medical staff consultation processes may have on ED throughput. A hospital that places a series of administrative barriers in the admission process, such as a process that relies heavily on consulting physicians to ''accept'' the patient on their service, will be less efficient than one that empowers the emergency physician to determine the ideal inpatient placement for the patient. Several good studies have correlated increased inpatient lengths of stay and inpatient costs with delays in transferring patients from the ED to inpatient units.[27,28] However, these studies have not delineated the proportion of the delay resulting from inpatient crowding, compared with the inefficient amount of decision-making provided to the admitting services. Further studies are needed on the most efficient way to allocate decision-making in the admission process among the ED and admitting physician services.

With regard to nurse staffing in the ED, there is an inseparable relationship between staff number, staff practice, and ED efficiency. Guidelines for nurse staffing in the ED were promulgated by the Emergency Nurses Association in 2003[29] and are currently under revision. These guidelines suggest that patient census, patient acuity, patient length of stay, intensity of nursing interventions, and an adjustment factor for nonpatient care time should all be considered when decisions are being made on nurse staffing levels. Most hospitals use a blended ratio of number of hours worked per patient visit, with an industry range of approximately 2.4 to 3.6 hours worked/visit. These hours include both nurse and ED tech time and may be adjusted for variations in the way that administrative personnel are managed and the amount of other hospital technical resources that are devoted to the ED.

The phenomenon of ''bed block'' (which results from the reluctance to exceed patient/nurse ratios on the inpatient services) and its deleterious effect on ED throughput has had mixed results on operational performance.[30,31] Research on the most adaptive response of nursing to ED surge, examining how these mandated ratios improve or diminish operational performance, is needed. Future studies should also focus on the physician–nursing teamwork needed to optimize efficiency during demand surges.

There is a robust literature concerning the effect on ED patient care of turnaround times (TAT) for both laboratory[32] and radiology services.[33] The effect of point-of-care testing on ED flow has been examined in the clinical laboratory literature, and most authors have concluded that its effect is minimal. This suggests that delays are due more to problems with specimen acquisition, transmission of reports to clinicians, hospital setting, and triage acuity than with TAT.[34] The radiology literature focuses more on the TAT of reports than on the time interval between order entry and study completion. There is scant literature on the levels of radiology department staffing that are optimal for the support of the round-the-clock variations in patient volume and the complexity of ED imaging requirements. There is a fairly robust literature on discrepancy management,[35] with the general agreement that this is a source of potentially serious error that is not well supported by current systems. Research in all of these areas is needed, and studies that take a systematic approach to ED ancillary support issues will help to improve overall ED performance.

Both governmental and professional regulatory agencies have promulgated a series of quality measures that look at both specific conditions (such as stroke[36] and acute coronary syndrome[37]) and overall ED system performance (such as brain computed tomography imaging in atraumatic patients[38]). New measures are being developed every year. Some of these, such as the CMS guidelines for door-to-antibiotic time in community acquired pneumonia, or the 4-hour throughput target in the United Kingdom, have engendered much controversy in the emergency medicine literature, largely because they were designed in a way that perverse outcomes, such as increased inappropriate antibiotic use, or last-minute disposition to meet timeliness targets, may have resulted.[39,40] As more and more guidelines are promulgated by well-meaning regulatory and quality-related organizations, the likelihood that perverse outcomes that might actually harm patient care is increased. Research is needed on the ways in which quality initiatives and metrics (particularly those focusing on a specific disease entity or patient category) can be introduced so that they blend harmoniously with ED operations and good practice and avoid a negative ''quality metric interaction.''

Finally, it is important to recognize that the ED operates within a larger market environment that can have important effects on the efficiency of its operations. There is a vast economics literature on the effect of ownership/control on the efficiency of a firm's operations. There have also been numerous studies that have reported an association between efficiency and competition among firms (for a review from a hospital perspective, see Rosko and Mutter[41]). Since these and other important environmental pressures can be affected by regulation and payment policy, it is important to understand their effects on ED efficiency. In Table 2 we propose key research questions that could lead to a better understanding of how factors outside of ED control affect ED efficiency.

3. HOW DO WORKFORCE FACTORS AFFECT ED EFFICIENCY?

One of the primary issues in identifying interventions to assure quality in the crowded ED is determining how workforce factors affect ED efficiency. Maximum efficiency in the physician practice is defined from the physicians' perspective by productivity equal to capacity, while maximum efficiency of the health care system is defined by lower health care costs given quality; if the physician practice is achieving its goal of maximum efficiency, the market economy will likely conflict with

Table 2
Key Research Priorities for Examining Factors Outside of ED Control

1. How does the implementation of quality initiatives by extramural regulatory agencies affect ED efficiency? Can this effect be predicted prior to implementation? (16 votes)
2. Does increased autonomy (e.g., admission gatekeepers, autonomy by consultants, availability of consultants) improve throughput and quality? (2 votes)
3. How does changing or eliminating mandated nurse-to-patient ratios affect operational performance? (1 vote)
4. Does the reduction of barriers in information exchange between providers improve quality and efficiency simultaneously? (0 votes)
5. Does benchmarking and mandating turnaround times for laboratory and radiologic imaging support ED throughput? (0 votes)
6. What market forces and other environmental pressure variables impact ED efficiency? Can they be impacted by policy changes to improve ED efficiency? (0 votes)

the public's goal of lowering health care costs.[42] However, a balanced approach of base pay plus incentives has demonstrated that it is possible to increase productivity while simultaneously achieving quality care.[43]

Staff compensation structures can have unpredictable effects on efficiency. If the ED has a large boarding problem or is very inefficient (e.g., physicians seeing only one patient per hour despite having a waiting room full of people), implementing productivity-based compensation will not necessarily improve efficiency.[44] On the other hand, if the department spends a lot of time on bypass and has a high left-without-being-seen rate, there is an opportunity to see more patients (increasing efficiency).[44] As an example, if the ED has a 4% left-without-being-seen rate, at a mean of 2.5 relative value units (RVUs) per patient, and a collection rate of $40 per RVU, a potential $200,000 of revenue is being lost.[44] It remains unclear, however, which staff compensation structures have the greatest effect on efficiency.

Few studies have examined the entire staffing profile of an ED and assessed its effectiveness.[45] Current workforce staffing models often result in suboptimal utilization of health care providers, but widely accepted solutions are not easily identified. Some EDs have addressed the mismatch currently experienced by employing part-time staff to commence at appropriate times, and placing physicians in triage, to match staffing to patient demand.[45,46] In a U.K. study, having a combination of a doctor and a nurse in triage reduced waiting times and led to an overall increase in the number of patients treated and discharged within 20 minutes, compared with traditional nurse-led triage.[47] Waiting time and processing time was also significantly reduced by the addition of a physician in triage in an ED in Hong Kong.[48] However, an English study that examined different triage staffing arrangements found no significant difference in patient waiting times, noting that "thought must be given to the potential effect on the overall patient throughput by tying up the triage practitioners for long periods with any individual patient."[49] At present, it remains unclear if having a physician in triage allows optimal use of this resource to maximize efficiency. Additional interventions, such as demand-capacity staffing to match appropriate staffing with accompanying demand, can potentially improve operational performance, but more studies are needed to further evaluate their effects.[50,51]

Practitioner variability is another element that is associated with increased length of stay and decreased operational performance in the ED. The association with increased ED length of stay has been demonstrated in several studies, particularly in the pediatric population.[52–54] While research on the link between ED practitioner variability and performance has only just begun,[55] this interdependency was identified in a non-ED setting in a study of intensive care units (ICU), in which it was found that diversion from the ICU was more dependent on variability in surgical scheduling than emergency admissions.[56] In addition to the research needed on this interdependency of practitioner performance, surgical scheduling, and admissions, studies are needed that specifically target a reduction in practitioner variation and the effect of this variation on efficiency and quality.

Lean thinking, or "Lean methodology," has been proposed for use in the ED to enhance workforce efficiency; however, the true difference between Lean thinking and improving efficiency is unclear. Lean thinking may simply represent a different approach to achieving efficiency. One of the key principles of Lean thinking is "eliminate unnecessary waste, and maximize value to the customer."[57] In a recent review of the literature on the application of Lean thinking in the ED, the author concluded that physicians do not thoroughly understand the use of Lean in the ED, nor do they know how to appropriately apply Lean methods in the ED.[57] Others are far more supportive of the Lean concept, noting that Lean is a "tough and resilient concept that has been tested thousands of times in a variety of manufacturing and service industries" and that health care services will not be an exception.[58] A surgical clinic found the application of Lean methods helped to address variability in provider behavior and improve clinic efficiency.[59] Further research into process improvement strategies and how they affect provider efficiency will be required prior to widespread adoption of Lean methods in the ED. We propose the key research questions pertaining to the ED workforce in Table 3.

4. HOW DO ED DESIGN, PATIENT FLOW STRUCTURES, AND USE OF TECHNOLOGY AFFECT EFFICIENCY?

While it is important to examine the effect of staffing models and external factors on ED efficiency, it is also

Table 3
Key Research Priorities for Evaluating the Effect of Workforce Factors on ED Efficiency

1. Do flexible, demand-driven staffing models for physicians, nurses and ancillary staff improve efficiency while justifying cost? (6 votes)
2. Do staff compensation structures affect the care provided along with the efficiency of the ED within which the staff operate? Which staff compensation structures have the greatest effect? (4 votes)
3. How does the reduction of provider variability affect quality and operational metrics? (3 votes)
4. Does early first patient contact with the physician improve patient care and efficiency? Does this effect vary by region of the country and type of environment? (0 votes)
5. Does implementation of process improvement strategies (e.g., ''Lean,'' six sigma, etc.) increase operational efficiency? (0 votes)

essential to address the physical structure of the ED, patient flow strategies, and the potential effects of implementing new technologies on overall ED efficiency. While other specialties have begun to examine the relationship between design and performance,[60] the layouts that enhance performance in given emergency practice settings are currently unknown. Undoubtedly, the ideal layout for a high-volume, high-acuity academic ED will differ from that of a smaller, suburban community ED or a free-standing ED. Therefore, understanding efficiency in the appropriate context will be necessary to allow for appropriate comparisons with similar entities.

One aspect of physical plant design that deserves special attention is the segregation of resources and patient populations within the ED. For instance, does this separation of patient populations (for example, separate pediatric, minor complaint, or critical care areas) improve operations and quality? If so, what census thresholds and patient population characteristics would determine when segmentation is appropriate?

Given the inherent difficulty and cost of plant expansion, the ability to perform predictive modeling (such as discrete event simulation) may reduce unnecessary expenditures in a cost-effective manner.[61,62] Modeling enables administrators, clinicians, and researchers to identify potential roadblocks or unanticipated consequences of the proposed changes and allows testing of different scenarios before full implementation. For instance, a common phenomenon experienced by EDs faced with the need for capacity expansion is that increasing the number of ED beds may actually result in a degradation of efficiency metrics such as ED length of stay or laboratory TAT.[63,64] Modeling a proposed expansion may help avoid such costly pitfalls.[65–67] Further, once a structure or process change is decided upon, discovering the optimal implementation strategy is also of great importance. While modeling may not provide the optimal solution, it allows users to explore multiple ''what if'' scenarios to be more efficient with planning prior to actual changes in process, flow, and physical space. Specialties other than emergency medicine have used simulation to optimize operational performance as well.[68–71] Further study to determine the efficacy of simulation and predictive modeling in ED operational change management is needed.

One additional strategy worth considering is the use of standardized protocols in ED patient treatment. Standardized protocols, such as those used for asthma, have been found to reduce length of stay.[55] While not applicable to all patients, some researchers advocate the use of clinicians to identify those patients who can be triaged into a standardized protocol, with the remainder triaged into an individualized protocol.[72] These practices have been implemented at heart failure clinics, urgent care centers, and other facilities dealing with patients with variably complex disease processes.

Beyond operations, EDs may also use simulation to model their response to public health emergencies such as multicasualty incidents (e.g., airplane crash), infectious diseases (e.g., influenza pandemic), or natural disasters (e.g., floods or tornadoes).[73] As some early initiatives have suggested, coordinating efforts with the public health system may enable investigators to focus on operations of the health care system as a whole, rather than studying disaster response in individual EDs.[74,75]

Due to the potential for operational disruption, the implementation of technology in the ED workplace has significant implications for ED efficiency. Given the national focus on reducing health care costs, it is imperative that technological advances touted to reduce costs and improve efficiency (such as point-of-care testing, triage kiosks, electronic tracking boards, electronic health records [EHR], CPOE, etc.) be thoroughly investigated to determine their impact on clinical operations. Not only should long-term consequences be evaluated, but so should the implementation process. For example, there is a lack of rigorously performed, multicenter studies examining the effect on ED operations of tracking system, EHR, and CPOE implementation and use.[76–80] Reliable means to measure these effects and to identify contributing factors must be developed and utilized consistently. In particular, how and to what extent does the human–computer interaction affect operational measures? Is there an efficiency benefit that can be gained from improved information exchange? Finally, it will also be vital to determine the best practices for implementation of new technologies and informatics that mitigate potential deleterious effects on ED operations. As a result of the questions raised above, we propose key research questions on the effect of ED design and technology (Table 4).

CONCLUSIONS

Efficiency is a complicated topic with tremendous applications for improving the delivery of emergency care.

Table 4
Key Research Priorities for the Effects of ED Design, Patient Flow Structures, and Technology Use on ED Efficiency

Technology 1. What are the unintended consequences of implementation strategies for technology designed to increase efficiency? (8 votes) 2. Does the implementation of technology (e.g., EHRs, point-of-care testing, real-time reporting systems) improve the delivery and efficiency of emergency care? If so, how long does it take to realize such benefits? (3 votes) 3. Do specific implementation strategies minimize operational degradation during the transition? (0 votes) Design/flow 1. Do customized and standard treatment protocols reduce variability and improve efficiency of patient flow? (2 votes) 2. How does the physical plant and design of an ED affect efficiency? Which settings determine which layouts maximize efficiency? Which design maximizes flexibility/minimizes interruptions? How does segregation of resources and patient populations (pediatrics, critical care) affect efficiency? (1 vote) Predictive Modeling 1. Does predictive modeling improve the success of implementation strategies? (1 vote) 2. What are the best ways to incorporate lessons learned from industrial engineering? (0 votes)
EHR = electronic health record.

However, a number of steps must be taken to improve the evaluation of interventions that safeguard efficiency. First, the process of and definition of measuring efficiency must improve. Next, emergency care–specific metrics are needed, but may use those from other specialties as a foundation. Additionally, quality is an essential component of efficiency measures, and while it may not be present in every metric, there must be a balance between the two.

We identify three additional areas that require focused research to improve the efficiency of emergency care systems. As EDs are complex entities that interact with just about every aspect of the health care system, factors outside of ED control tremendously affect an ED's ability to be efficient. Rigorously studying the reduction of barriers to information exchange, autonomy in decision-making, mandated nurse–patient ratios, and external agency reporting measures is needed to evaluate their effects on ED operational performance.

Workforce factors that involve payment compensation structures, staffing models, location of first physician contact, practitioner variability, and application of Lean methodologies must all be researched to explore how they affect ED operations and whether they provide improved performance. ED design, patient flow structures, and use of technology comprise the last domain of this consensus conference breakout session. Identifying effective physical plant designs and patient flow strategies, determining optimal use of predictive modeling and standard protocols, and investigating the untoward effects of technology and technology implementation strategies round out the topic domains for interventions designed to safeguard efficiency.

Ultimately, by using the framework developed from this consensus conference, we will be able to advance the science of efficiency in emergency care. High-quality, rigorous research on this topic will allow organizations to understand how they perform and give them tools to improve the delivery of emergency care.

References

1. Institute of Medicine (U.S.). Committee on Quality of Health Care in America. Crossing the Quality Chasm: A New Health System for the 21st Century. Washington, DC: National Academies Press, 2001.
2. McGlynn EA, Southern California Evidence-Based Practice Center/RAND, United States. Agency for Healthcare Research and Quality. Identifying, Categorizing, and Evaluating Health Care Efficiency Measures Final Report. AHRQ Publication No. 08-0030. Rockville, MD: Agency for Healthcare Research and Quality, 2008.
3. Reid PP, Compton WD, Grossman JH, Fanjiang G, National Academy of Engineering, Institute of Medicine (U.S.), and National Academies Press (U.S.). Building a Better Delivery System: A New Engineering/Health Care Partnership. Washington, DC: National Academies Press, 2005.
4. Institute of Medicine, Committee on the Future of Emergency Care in the United States Health System. Hospital-based Emergency Care: At the Breaking Point. Washington, DC: National Academies Press, 2007.
5. American Hospital Association. Trendwatch Chartbook 2010: Trends Affecting Hospitals and Health Systems. Washington, DC: American Hospital Association, 2010.
6. Hsia RY, Kellermann AL, Shen YC. Factors associated with closures of emergency departments in the United States. JAMA. 2011; 305:1978–85.
7. Fee C, Weber EJ, Maak CA, Bacchetti P. Effect of emergency department crowding on time to antibiotics in patients admitted with community-acquired pneumonia. Ann Emerg Med. 2007; 50:501–9.
8. Schull MJ, Vermeulen M, Slaughter G, Morrison L, Daly P. Emergency department crowding and thrombolysis delays in acute myocardial infarction. Ann Emerg Med. 2004; 44:577–85.
9. Pines JM, Hollander JE. Emergency department crowding is associated with poor care for patients with severe pain. Ann Emerg Med. 2008; 51:1–5.
10. Mills AM, Shofer FS, Chen EH, Hollander JE, Pines JM. The association between emergency department crowding and analgesia administration in acute abdominal pain patients. Acad Emerg Med. 2009; 16:603–8.

11. Hwang U, Richardson L, Livote E, Harris B, Spencer N, Sean Morrison R. Emergency department crowding and decreased quality of pain care. Acad Emerg Med. 2008; 15:1248–55.
12. Bernstein SL, Aronsky D, Duseja R, et al. The effect of emergency department crowding on clinically oriented outcomes. Acad Emerg Med. 2009; 16: 1–10.
13. Pines JM, Pollack CV Jr, Diercks DB, Chang AM, Shofer FS, Hollander JE. The association between emergency department crowding and adverse cardiovascular outcomes in patients with chest pain. Acad Emerg Med. 2009; 16:617–25.
14. Sprivulis PC, Da Silva JA, Jacobs IG, Frazer AR, Jelinek GA. The association between hospital overcrowding and mortality among patients admitted via Western Australian emergency departments. Med J Aust. 2006; 184:208–12.
15. Richardson DB. Increase in patient mortality at 10 days associated with emergency department overcrowding. Med J Aust. 2006; 184:213–6.
16. Welch SJ. Quality matters: CMS measures a train wreck for emergency medicine. Emerg Med News. 2011; 33:1, 4,5.
17. Agency for Healthcare Research and Quality. 2007 National Healthcare Quality Report. Rockville, MD: U.S. Department of Health and Human Services, 2008.
18. Hussey PS, de Vries H, Romley J, et al. A systematic review of health care efficiency measures. Health Serv Res. 2009; 44:784–805.
19. Mutter RL, Rosko MD. The impact of ownership on the cost-efficiency of U.S. hospitals. Adv Health Econ Health Serv Res. 2008; 18:113–38.
20. Hollingsworth B. Non-parametric and parametric applications measuring efficiency in health care. Health Care Manag Sci. 2003; 6:203–18.
21. Hollingsworth B. The measurement of efficiency and productivity of health care delivery. Health Econ. 2008; 17:1107–28.
22. Metters RD, Frei FX, Vargas VA. Measurement of multiple sites in service firms with data envelopment analysis. Prod Operat Manag. 1999; 8:264–81.
23. Agency for Healthcare Research and Quality. AHRQ Quality Indicators. Available at: http://www.qualityindicators.ahrq.gov/. Accessed Sep 2, 2011.
24. Husk G, Waxman DA. Using data from hospital information systems to improve emergency department care. Acad Emerg Med. 2004; 11:1237–44.
25. Handler JA, Feied CF, Coonan K, et al. Computerized physician order entry and online decision support. Acad Emerg Med. 2004; 11:1135–41.
26. Shapiro JS, Kannry J, Lipton M, et al. Approaches to patient health information exchange and their impact on emergency medicine. Ann Emerg Med. 2006; 48:426–32.
27. Huang Q, Thind A, Dreyer JF, Zaric GS. The impact of delays to admission from the emergency department on inpatient outcomes. BMC Emerg Med. 2010; 10:16.
28. Richardson DB. The access-block effect: relationship between delay to reaching an inpatient bed and inpatient length of stay. Med J Aust. 2002; 177:492–5.
29. Ray CE, Jagim M, Agnew J, McKay JI, Sheehy S. ENA's new guidelines for determining emergency department nurse staffing. J Emerg Nurs. 2003; 29:245–53.
30. Chan TC, Killeen JP, Vilke GM, Marshall JB, Castillo EM. Effect of mandated nurse-patient ratios on patient wait time and care time in the emergency department. Acad Emerg Med. 2010; 17:545–52.
31. Spetz J. California's minimum nurse-to-patient ratios: the first few months. J Nurs Admin. 2004; 34:571–8.
32. Hawkins RC. Laboratory turnaround time. Clin Biochem Rev. 2007; 28:179–94.
33. Boland GW, Guimaraes AS, Mueller PR. Radiology report turnaround: expectations and solutions. Eur Radiol. 2008; 18:1326–8.
34. Deledda JM, Germann GJ, Lindsell CJ, Rohlfing RA, Gibler BW. Cardiac point-of-care testing: impact on emergency department door to disposition time is modified by patient acuity and hospital setting. Point Care. 2011; 10:1–6.
35. Patient Safety Authority. Communication of radiograph discrepancies between radiology and emergency departments. PA Patient Saf Advis. 2010; 7:18–22.
36. Adams HP Jr, del Zoppo G, Alberts MJ, et al. Guidelines for the early management of adults with ischemic stroke: a guideline from the American Heart Association/American Stroke Association Stroke Council, Clinical Cardiology Council, Cardiovascular Radiology and Intervention Council, and the Atherosclerotic Peripheral Vascular Disease and Quality of Care Outcomes in Research. Interdisciplinary Working Groups: the American Academy of Neurology affirms the value of this guideline as an educational tool for neurologists. Stroke. 2007; 38:1655–711.
37. American College of Cardiology. D2B: An Alliance for Quality. Available at: http://www.d2balliance.org/JoinD2B/tabid/147/Default.aspx. Accessed Sep 2, 2011.
38. National Quality Forum. National Voluntary Consensus Standards for Imaging Efficiency Measure Summary. Available at: http://www.qualityforum.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=26315. Accessed Sep 19, 2011.
39. Locker TE, Mason SM. Analysis of the distribution of time that patients spend in emergency departments. BMJ. 2005; 330:1188–9.
40. Nicks BA, Manthey DE, Fitch MT. The Centers for Medicare and Medicaid Services (CMS) community-acquired pneumonia core measures lead to unnecessary antibiotic administration by emergency physicians. Acad Emerg Med. 2009; 16: 184–7.
41. Rosko MD, Mutter RL. What have we learned from the application of stochastic frontier analysis to U.S. hospitals? Med Care Res Rev. 2011; 68:S75–100.
42. Shaw DV. Practice efficiency and physician compensation: a case study. J Med Pract Manage. 2002; 18:138–41.

43. Szabo J. With physician employment on the rise, new compensation models emerge. Hosp Health Netw. 2010; 84:e10.
44. Silverman M. Understanding productivity-based incentives. Emerg Phys Mon. Available at: http://www.epmonthly.com/subspecialties/management/understanding-productivity-based-incentives-/. Accessed Sep 2, 2011.
45. Callander EJ, Schofield DJ. Emergency department workforce models: what the literature can tell us. Emerg Med Australas. 2011; 23:84–94.
46. Travers JP, Lee FC. Avoiding prolonged waiting time during busy periods in the emergency department: is there a role for the senior emergency physician in triage? Eur J Emerg Med. 2006; 13:342–8.
47. Subash F, Dunn F, McNicholl B, Marlow J. Team triage improves emergency department efficiency. Emerg Med J. 2004; 21:542–4.
48. Choi YF, Wong TW, Lau CC. Triage rapid initial assessment by doctor (TRIAD) improves waiting time and processing time of the emergency department. Emerg Med J. 2006; 23:262–5.
49. Lyons M, Brown R, Wears R. Factors that affect the flow of patients through triage. Emerg Med J. 2007; 24:78–85.
50. Levin S, Aronsky D, Hemphill R, Han J, Slagle J, France DJ. Shifting toward balance: measuring the distribution of workload among emergency physician teams. Ann Emerg Med. 2007; 50: 419–23.
51. Sinreich D, Jabali O. Staggered work shifts: a way to downsize and restructure an emergency department workforce yet maintain current operational performance. Health Care Manag Sci. 2007; 10:293–308.
52. Jain S, Elon LK, Johnson BA, Frank G, Deguzman M. Physician practice variation in the pediatric emergency department and its impact on resource use and quality of care. Pediatr Emerg Care. 2010; 26:902–8.
53. Chang YC, Ng CJ, Chen YC, Chen JC, Yen DH. Practice variation in the management for nontraumatic pediatric patients in the ED. Am J Emerg Med. 2010; 28:275–83.
54. Seow VK, Lin AC, Lin IY, et al. Comparing different patterns for managing febrile children in the ED between emergency and pediatric physicians: impact on patient outcome. Am J Emerg Med. 2007; 25:1004–8.
55. Wright SW, Trott A, Lindsell CJ, Smith C, Gibler WB. Evidence-based emergency medicine. Creating a system to facilitate translation of evidence into standardized clinical practice: a preliminary report. Ann Emerg Med. 2008; 51:80–6.
56. McManus ML, Long MC, Cooper A, et al. Variability in surgical caseload and access to intensive care services. Anesthesiology. 2003; 98:1491–96.
57. Holden RJ. Lean thinking in emergency departments: a critical review. Ann Emerg Med. 2011; 57:265–78.
58. Dart RC. Can lean thinking transform american health care? Ann Emerg Med. 2011; 57:279–81.
59. Waldhausen JH, Avansino JR, Libby A, Sawin RS. Application of lean methods improves surgical clinic experience. J Pediatr Surg. 2010; 45:1420–5.
60. Zusman EE. Form facilitates function: innovations in architecture and design drive quality and efficiency in healthcare. Neurosurgery. 2010; 66:N24.
61. Lewis RJ. Modeling complex systems: gaining valid insights and avoiding mathematical delusions. Acad Emerg Med. 2007; 14:795–8.
62. Parks JK, Engblom P, Hamrock E, Satjapot S, Levin S. Designed to fail: how computer simulation can detect fundamental flaws in clinic flow. J Healthc Manag. 2011; 56:135–44.
63. Han JH, Zhou C, France DJ, et al. The effect of emergency department expansion on emergency department overcrowding. Acad Emerg Med. 2007; 14:338–43.
64. Storrow AB, Zhou C, Gaddis G, et al. Decreasing lab turnaround time improves emergency department throughput and decreases emergency medical services diversion: a simulation model. Acad Emerg Med. 2008; 15:1130–5.
65. Anonymous. Use simulation to learn results in advance. ED Manag. 1999; 11:69–72.
66. Anonymous. Computer simulation assesses PI design prior to implementation. Healthcare Benchmarks Qual Improv. 2004; 11:25–9.
67. Huddy J, McKay J, Culp K. Computer simulation: making better operational and architectural ED design decisions. J Emerg Nurs. 1999; 25:307–10.
68. Bender J, Shields R, Kennally K. Testing with simulation before a big move at Women & Infants Hospital. Med Health R I. 2010; 93:145 149–50.
69. Berg B, Denton B, Nelson H, et al. A discrete event simulation model to evaluate operational performance of a colonoscopy suite. Med Decis Making. 2010; 30:380–7.
70. Chand S, Moskowitz H, Norris JB, Shade S, Willis DR. Improving patient flow at an outpatient clinic: study of sources of variability and improvement factors. Health Care Manag Sci. 2009; 12:325–40.
71. Sobolev BG, Sanchez V, Vasilakis C. Systematic review of the use of computer simulation modeling of patient flow in surgical care. J Med Syst. 2011; 35:1–16.
72. Bohmer RM. Medicine's service challenge: blending custom and standard care. Health Care Manage Rev. 2005; 30:322–30.
73. Amram O, Schuurman N, Hameed SM. Mass casualty modelling: a spatial tool to support triage decision making. Int J Health Geogr. 2011; 10:40.
74. Hirshberg A, Frykberg ER, Mattox KL, Stein M. Triage and trauma workload in mass casualty: a computer model. J Trauma. 2010; 69:1074–81.
75. Scheulen JJ, Thanner MH, Hsu EB, Latimer CK, Brown J, Kelen GD. Electronic mass casualty assessment and planning scenarios (EMCAPS): development and application of computer modeling to selected National Planning Scenarios for high-consequence events. Ann Emerg Med. 2009; 53: 226–32.
76. Bastani A, Walch R, Todd B, et al. Computerized prescriber order entry decreases patient satisfaction

and emergency physician productivity [abstract]. Ann Emerg Med. 2010; 56:S83–4.
77. Baumlin KM, Shapiro JS, Weiner C, Gottlieb B, Chawla N, Richardson LD. Clinical information system and process redesign improves emergency department efficiency. Jt Comm J Qual Patient Saf. 2010; 36:179–85.
78. Boger E. Electronic tracking board reduces ED patient length of stay at Indiana Hospital. J Emerg Nurs. 2003; 29:39–43.
79. Spalding SC, Mayer PH, Ginde AA, Lowenstein SR, Yaron M. Impact of computerized physician order entry on ED patient length of stay. Am J Emerg Med. 2011; 29:207–11.
80. Vartak S, Crandall DK, Brokel JM, Wakefield DS, Ward MM. Transformation of emergency department processes of care with EHR, CPOE, and ER event tracking systems. HIM J. 2009; 38:27–32.

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