Defining and Measuring Successful Emergency Care Networks: A Research Agenda

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Abstract

The demands on emergency services have grown relentlessly, and the Institute of Medicine (IOM) has asserted the need for ''regionalized, coordinated, and accountable emergency care systems throughout the country.'' There are large gaps in the evidence base needed to fix the problem of how emergency care is organized and delivered, and science is urgently needed to define and measure success in the emerging network of emergency care. In 2010, *Academic Emergency Medicine* convened a consensus conference entitled ''Beyond Regionalization: Integrated Networks of Emergency Care.'' This article is a product of the conference breakout session on ''Defining and Measuring Successful Networks''; it explores the concept of integrated emergency care delivery and prioritizes a research agenda for how to best define and measure successful networks of emergency care. The authors discuss five key areas: 1) the fundamental metrics that are needed to measure networks across time-sensitive and non–time-sensitive conditions; 2) how networks can be scalable and nimble and can be creative in terms of best practices; 3) the potential unintended consequences of networks of emergency care; 4) the development of large-scale, yet feasible, network data systems; and 5) the linkage of data systems across the disease course. These knowledge gaps must be filled to improve the quality and efficiency of

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emergency care and to fulfill the IOM's vision of regionalized, coordinated, and accountable emergency care systems.

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The existing patchwork of emergency services provides care for over 120 million patient visits in the United States each year.[1] The demands on emergency services have grown relentlessly, such that by 2006, the Institute of Medicine (IOM) issued a three-volume report calling for fundamental reorganization of that care.[1–3] The IOM asserted the need for ''regionalized, coordinated, and accountable emergency care systems throughout the country.''[1] The Office of the Assistant Secretary for Preparedness and Response within the United States Department of Health and Human Services has identified effective and accountable regionalized systems of emergency care as a major national health priority.[4] Institutional and scientific consensus has been building to substantiate an intuition shared by thousands of practicing physicians, nurses, and emergency medical services (EMS) providers that despite the substantial resources and vast efforts of the current emergency system, it is inadequate and suffers from a lack of care coordination.[1] Yet this is not a problem of individual provider competence. The problem is one of system-level organization and the failure to get the existing skilled care to the patients who need it in a timely fashion. There are gaping holes in the research evidence base needed to fix the problem of how emergency care is organized and delivered. New science is urgently needed to define and measure success in the emerging network of emergency care.

Traditionally, EMS systems were developed based on time-sensitive conditions, particularly acute myocardial infarction (AMI), cardiac arrest, and injuries.[5,6] Trauma systems were an outgrowth of the recognition that addressing this problem required important prehospital and hospital infrastructure and coordination.[5] Systems of emergency care have evolved beyond trauma into ''a systematic method of bringing patients from a defined geographic region with specific emergency medical or surgical needs to designated facilities with the capabilities and resources available to provide such treatment.''[1] These systems traditionally have a hub-and-spoke configuration, where resources are centralized and communication and patients tend to flow from peripheral facilities to larger clinical centers.

Recent changes, such as the growth in communications and transportation technologies, as well as changing economic incentives and organizational strategies, have changed the connections between many peripheral, nontertiary hospitals and larger, tertiary hospital centers.[7,8] As such, different models of prehospital and interhospital networks must be developed to make the most of these new opportunities. These new models must go beyond simply delivering patients to designated centers and devote greater focus to other indicators of the quality of patient care, including safety, effectiveness, efficiency, timeliness, equity, and patient-centeredness.[9] These models will also need to be sensitive to the unique needs, capabilities, and financial viability of both community and academic hospitals.

A new network model of emergency care can be broadly visualized as a nodal system, in which each hospital is a node and is interconnected with multiple other health care facilities.[8] Under the new scheme, hospital centrality, hospital periphery, and hospital connections within isolated networks become less important. Instead, although each node and each internodal pairing is unique, multinodal communication and sharing of resources are emphasized. This integrated network of care model can perhaps be best described as ''get the right resource to the right patient at the right place at the right time,'' and is a departure from the traditional model of the centripetal movement of patients.[10]

Developing approaches to define and measure successful networks of emergency care is critical to optimizing the delivery of health care and patient outcomes. In June 2010, the journal *Academic Emergency Medicine* convened a consensus conference on emergency care entitled ''Beyond Regionalization: Integrated Networks of Emergency Care,'' whose goal was to create a research agenda to support the development of the IOM's vision of regionalized, coordinated, and accountable emergency care systems. This article is a product of the conference breakout session on ''Defining and Measuring Successful Networks.'' This paper explores the concept of integrated emergency care delivery and prioritizes a research agenda for how to best define and measure successful networks of emergency care.

1. WHAT ARE THE FUNDAMENTAL METRICS THAT MEASURE NETWORKS ACROSS TIME-SENSITIVE AND NON–TIME-SENSITIVE CONDITIONS?

Development and measurement of emergency care networks begins with the definition of a ''regional unit,'' the population-based denominator over which outcomes are measured. However, this definition may vary across networks. For example, regions can be defined according to geographical boundaries such as counties or states, by market-based health referral regions that contain a major referral center, or by government-defined hospital service areas. Important early steps in comparative evaluation of regional systems might be undertaken as a hybrid of the natural boundaries from geographic regions and preexisting health care or hospital networks. The definition of a regional unit should also include out-of-hospital systems, from prehospital triage to transfer to postacute care.[11–16] It is preferable, if not expected, for individual regional units to overlap and connect in forming larger super-regional units that share information and best practices and provide mutual aid at times of excessively high volume. It is also

likely that there will be some redundancy in services, so that the networks will be robust and allow for change when needed, in response to either sudden-onset disasters or gradual resource allocations.

Development and measurement of emergency care networks will also require the definition of the emergency care network's target patient population. Although the 2006 IOM report recommended regional coordinated care, the target conditions for these systems of care requires further evaluation.[1] Research to date has focused on emergency care–sensitive conditions within specific disease silos. Conditions such as AMI, stroke, specialty surgery, and cardiac arrest have a positive volume-outcome relationship, supporting a rationale for studying regionalization.[17–21] It has also been argued that undifferentiated, acute illness may require early recognition, triage, and care by specialized providers.[22] Yet patients without a disease-specific chief complaint (e.g., severe sepsis) are difficult to recognize, and little comparative data exist to support regionalization in conditions other than trauma.[23,24] Greater study of health care delivery systems, which encompass both disease-specific and undifferentiated, symptom-based severe illnesses, may lead to future networks that reduce inefficiencies created by overlapping disease-specific networks. This is particularly important for emergency-based care, where identifying the diagnostic category into which the patient should be sorted is among the key tasks—systems that take this sorting for granted, or function only after sorting, necessarily overlook this particularly important and difficult task.

Development and measurement of emergency care networks will also require the network's performance to be defined, measured, and tracked. Efforts will need to identify meaningful performance metrics relevant to specific disease states and regions. Developing a set of metrics serves several important functions, including: 1) real-time assessment of the state of the network (e.g., electronic dashboard shared among hospitals with on-call specialist availability, bed capacity, emergency department [ED] diversion); 2) ongoing network quality improvement and benchmarking (process measures); and 3) overall network effectiveness (outcomes). It may be important to move beyond ''network'' as a metaphor and engage the particular quantitative and organizational insights of the rapidly maturing field of network science—although off-the-shelf standardized metrics are not yet available.[25,26]

Rapid diagnosis and early intervention in acute illness or acutely decompensated, chronic illness can improve patient outcomes for a variety of disease conditions. Because emergency care for these conditions can be delivered across a wide region (e.g., rapid diagnosis of ST-segment acute myocardial infarction [STEMI] in the prehospital or community setting followed by timely transfer to a center for percutaneous coronary intervention), performance metrics need to consistently address the quality and timeliness of care across various regions and networks. The traditional structure-process-outcomes framework is one approach in formulating network performance metrics.[27,28] Structural measures include organizational characteristics key to successful network integration (e.g., whether up-to-date communications technologies are in place across facilities, as well as precise characterizations of the particular organizations of the resources).[29] Process measures could include key dynamic or time-dependent measures (e.g., procedures completed within certain times, appropriateness of interfacility transfers, avoidance of unnecessary repeat procedures). Outcome measures could include assessments of deaths, disabilities, costs, patient and provider satisfaction, completeness and accuracy of information exchange between facilities, health care utilization (e.g., hospital-acquired infections, hospital readmissions), or some combination of these outcomes (e.g., cost-effectiveness measures). Validation of these measures will be important for assessing the care of a network.

Implementation of regional networks for acutely ill patients may also affect patients with nonacute illness. For example, specialized orthopedic, neurosurgical, or cardiothoracic surgical cases may be best performed at larger centers where greater case volume improves outcomes.[30,31] These transfer and referral patterns may change within newly regionalized systems, and network metrics must be able to concurrently assess performance. For these types of conditions, evaluating for both improvement and declination in performance for these secondary conditions across the entire network will also be necessary.

Based on these basic and necessary definitions, we propose the key research questions to better inform the definition and measurement of integrated networks of emergency care in Table 1.

2. HOW CAN A REGIONAL NETWORK BE DEVELOPED SO THAT IT IS SCALABLE AND NIMBLE AS NEW CONDITIONS ARE TARGETED, AND HOW DO WE DEVELOP A SYSTEM THAT CAN BE CREATIVE IN TERMS OF BEST PRACTICES?

Current approaches to regionalization began as disease-specific referral networks that even now rely heavily on certification of hospitals as a defining activity. STEMI and trauma are the paradigm examples of this classic approach to regionalization. Hospitals are largely certified on the basis of their possession of equipment, certified pathways of care, and/or access to specialists. However, this traditional, facility certification-based model may not be the ideal model for the development of networks of emergency care. Several questions about this approach remain unanswered: how responsive is this system to patient care needs; is it ideal, or even adequate, for current emergency care delivery; and is it appropriate in the delivery of newly emerging therapies for time-sensitive diseases?

Certain assumptions underlie the traditional model. The traditional model assumes that the major requirement of patient care is possession of the necessary equipment and specialists by certified facilities. It also tends to assume that all hospitals certified at a certain level to deliver specific care perform more or less equally, and there is little variation in the quality of staff, the form of the organization, or availability of resources.[32,33] These models assume that if hospitals

Table 1
Key Research Questions to Better Inform the Definition and Measurement of Integrated Networks of Emergency Care

1. What are the functional regional units, and which acute care conditions should be the focus of regionalized networks of emergency care?
2. Should performance assessment begin with time-sensitive, disease-specific metrics, or should metrics be developed more broadly across acute, undifferentiated illness?
3. What are useful emergency care performance metrics for both acute time-sensitive conditions and nonacute illness?
4. How do we assign and create accountability for patient-level outcomes across the continuum of care (from prehospital to receiving hospital to referral hospital to discharge facility to aftercare)?
5. What formal quantitative measures of network structure are needed to characterize (for comparative purposes) the organization of the resources with a given region?
6. Who is responsible for measuring the quality of emergency care networks, and how should metrics be disseminated to patients and health care providers?

have the same key capabilities, they will deliver the same outcomes. It is very clear, however, that important differences between hospitals of similar certification are commonly found, including for disease states such as AMI,[34] congestive heart failure,[35] mechanical ventilation,[36] trauma,[30] and cardiac arrest.[37] However, thus far there are no good studies of the underlying reasons for these differences between centers of similar certification levels.

In contrast to this system of formal regionalization, other systems are considered ''informal regionalization.'' Informal regionalization is the concentration of select patient populations at specific local centers as a result of selective, historic, or de facto referral patterns to those centers by providers and EMS systems. Such regionalization is informal primarily because selective referral is based on decentralized decisions by individual providers and is not mandated by formal legal or administrative organizations. Such informally regionalized systems have been documented in early trauma systems and the care of critically ill patients[8,38] and AMI patients.[39] Informally regionalized care of AMI patients has been shown to be able to selectively channel patients to the hospitals with better patient outcomes among those with equivalent capabilities.[39]

The absence of a formally organized regional system does not necessarily mean that no system has been developed by capable on-the-ground practitioners. However, systematic and consistent data regarding the outcomes of these different informal networks are lacking. Also, data regarding disparities in accessing these systems of care and the effect of these disparities on outcomes are lacking. For example, there is some suggestion that elders with injuries are cared for disproportionately in nontrauma facilities.[40] To provide an evidence base for the future development of regionalized care, empirical data are needed on how different configurations have developed, which systems provide the best outcomes, and within the best performing systems, what relationships (both formal and informal) exist between facilities.

There are many possible models of emergency care networks, but there has been little systematic study of the effects of different regionalization approaches on the adaptiveness of the system to changing demands. Such studies will likely require careful experimental approaches (where possible), but also observational work complemented by simulation-based designs. If the only standard of evidence for best practices in regionalization is the region-scale cluster randomized trial, then little progress will be made.

Based on these key notions of regionalization, we propose the key research questions pertaining to network development, listed in Table 2.

3. WHAT ARE THE POTENTIAL UNINTENDED CONSEQUENCES OF NETWORKS OF EMERGENCY CARE?

A newly created network of emergency care may bring improved service and outcomes to certain groups of patients, but it may also generate unintended consequences. For example, several recent studies have highlighted inefficiencies and quality gaps in regionalized networks of emergency care. A large portion of ED patients who undergo transfer receive unnecessary repeat computed tomography imaging, resulting in higher costs and radiation exposure.[41,42] Another study determined that over half of the patients transferred to a Level I trauma center for orthopedic injuries were inappropriate, and this effect was magnified on nights and weekends.[43] These factors could exacerbate problems with ED crowding at referral centers, which has been shown to adversely affect quality of care.[44–48] More effective communication across networks is needed, and smaller hospitals could be given better access to expertise and medical decision-making at specialty referral centers as one approach to alleviating this unintended consequence.

At the institutional level, there may be unintended consequences for both the hospital transferring patients and the hospital receiving patients. Transfer of patients with certain, often more complex, diseases from one type of hospital to another may result in a general reduction in the quality of care at transferring hospitals, as those hospitals over time will have less experience handling more complicated cases, although effective transfers may also free up transferring hospitals to focus their limited resources on the cases most appropriate to their skills. Conversely, unintended consequences of regionalization include overwhelming referral centers with more patients than they have the capacity to treat, resulting in long waits for placement, boarding of patients awaiting transfer in transferring EDs, delays for patients awaiting admission in their

Table 2
Key Research Questions to Develop Networks of Emergency Care That Are Scalable and Nimble as New Conditions Are Targeted and Incorporate Innovative Approaches in Delivering Care

1. How have existing informal and formal regionalization systems responded to the advent of new disease states, new technologies (in research, medicine, communication, transportation, etc.), and population changes in their catchment areas?
2. To what extent can informal systems of regionalization be optimized in response to new information or incentives? What approaches can be used to more effectively adapt these systems, as opposed to attempt to completely build new systems?
3. Can systems of formal regionalization be adapted to include information on differential performance among hospitals at the same tier or level of certification? Does including such information improve patient outcomes?
4. What are the comparative strengths and weaknesses of using formal tiering and regulations as the mechanism for directing patients, as opposed to using informal, decentralized choice on the basis of available information?
5. What are the comparative strengths and weaknesses of using static hospital capabilities as the criteria for directing patients, as opposed to using dynamic risk-adjusted outcomes information?
6. How strong are the parallels in performance between conditions for which regionalization has occurred and other conditions; e.g., are trauma centers better at caring for nontrauma surgical emergencies?
7. Should existing disease-specific regionalization schemes guide the referral of patients with other conditions? Which systems are best able to buffer against changes in workload and maintain consistently high performance standards?
8. How do the systems respond to the availability of new interventions—do regionalized centers rapidly adopt effective interventions, or do these systems defend the status quo? Which approaches to coordinated networks of care are most effective at developing and disseminating democratizing technologies that suddenly allow complex conditions to be treated without regional referral?

Table 3
Key Research Questions Regarding the Potential for Unintended Consequences in Emergency Care Regionalization

1. In systems that have moved to a regionalized approach for emergency care, what is the impact on quality and outcomes at transferring hospitals? This should be studied not only in the patients who are transferred, but in other cohorts of patients treated at the hospital, as unintended consequences may positively or negatively impact the other patients.
2. In systems that have moved to a regionalized approach for emergency care, what has been the impact on quality and outcomes at the receiving hospitals?
3. What are the differences in social support systems for patients who are transferred to a referral center? Do these differences affect patient or family member satisfaction?
4. Do differences exist in social support systems for patients transferred to distant referral centers compared to patients who receive telemedicine support but remain in their local hospital?
5. What are the economic consequences to families when patients are transferred from the local hospital?
6. What is the incremental benefit or harm for patients and families of a regionalized system among those with poor prognosis or do-not-attempt-resuscitation orders or who are receiving end-of-life care?

own ED or surgical suites, or worse outcomes as a result of system congestion. Effective networks of care involve optimal matching of patient needs with hospital capabilities, and thus regionalized systems also rely on appropriate transfers into the specialty centers as well as ''back-transport'' of patients from tertiary hospitals to community settings.

The mechanism by which networks of emergency are accomplished may also lead to important unintended consequences. Current economic incentives have driven the decentralized development of STEMI, neonatal intensive care unit, and pediatric emergency care capabilities that may be more related to economic gain than the goal of expanding population access.[49] For less profitable diseases, such as psychiatric care, there has been little incentive for hospitals to develop centers of excellence to treat these patients, so other drivers have led to care regionalization based upon specialty care availability. As new programs are developed to provide incentives to states or systems to coordinate emergency care delivery, they must take into account condition-specific economics to ensure equitable distribution of regionalized centers of excellence across disease states. Potential loss of financial viability in transferring hospitals should also be studied.

It is also imperative that studies not only address unintended consequences for institutions and patients, but also for patients' families and their support systems, who may have to travel to distant hospitals. These effects may be magnified for children, as parental presence becomes more difficult when children are transported to distant hospitals. This is also true as parents age and the adult children become the primary care providers. Patient preferences around treatment location are currently not well studied in relation to regionalized systems of care.

We propose the key research questions regarding the potential for unintended consequences in emergency care regionalization (Table 3).

4. HOW DO WE SUPPORT THE DEVELOPMENT OF LARGE-SCALE, YET FEASIBLE, NETWORK DATA SYSTEMS?

There are five existing national data sources that allow for the evaluation of ED care at the patient or encounter level and some combination of the hospital, regional, or national levels.[50,51] These data sources include the Healthcare Cost and Utilization Project (HCUP) Nationwide Emergency Department Sample (NEDS)

Table 4
Key Research Priorities Using Existing Large Population-based Data Sets for Measuring the Costs and Effectiveness of Integrated Systems of Emergency Care

1. How can emergency care–sensitive conditions be defined and catalogued?
2. What quality metrics for emergency care can be measured using population-based data?
3. Which state and national data sets have the necessary data elements to measure regional variations in emergency care? To which data sets should we encourage the addition of key data elements to otherwise well-validated data sources or conduct de novo studies to selectively augment existing resources?
4. Which data elements in population-based data sets need additional information to better measure regional variations in emergency care?
5. How can a hospital be classified as being a specialty center or part of an integrated system of care in a population-based data set?
6. What are the results of demonstration projects evaluating regional variations in emergency care using observational, population-based data?
7. What are the results of demonstration projects comparing cost and outcomes of care for an emergency care–sensitive condition at the state level before and after the implementation of a statewide integrated system of care?

sponsored by the Agency for Healthcare Research and Quality,[52] the Medical Expenditure Panel Survey (MEPS) sponsored by AHRQ,[53] the National Hospital Ambulatory Medical Care Survey (NHAMCS) managed by the Centers for Disease Control and Prevention (CDC),[54] the National Health Interview Survey (NHIS) sponsored by the CDC,[55] and the National Electronic Injury Surveillance System-All Injury Program (NEISS-AIP) managed by the CDC and the U.S. Consumer Product Safety Commission.[56] There are also important statewide, encounter-level data sources that permit hospital- and regional-level analyses, which are discussed below.

These data sets present a unique opportunity for measuring regional differences in emergency care and disparities in access to high-quality services at the level of the patient or encounter, beyond prospectively collected data gathered for research studies.[50,51] These patient information resources can be used to shed light on populations that may benefit from increased access to integrated systems of emergency care and to evaluate the effect of emergency care systems on costs and outcomes at the state and regional levels.

Using uniformly formatted HCUP data, AHRQ is developing quality indicators (QIs) to measure processes and outcomes of care occurring in the inpatient and outpatient settings.[57] These QIs have already been developed to measure the quality of preventive care, inpatient care, inpatient patient safety, and pediatric inpatient care. The QIs are developed de novo or from existing studies through a rigorous development process involving systematic literature review, empirical analyses, and structured clinical panel review.[58] To be able to study quality emergency care at the regional level, appropriate quality metrics will need to be developed for emergency care–sensitive conditions.[22] Given the previous work in this area, AHRQ would be an ideal agency to coordinate this effort.

There are a number of other important data resources for conducting research on emergency care networks, including large voluntary quality improvement registries such as the National Cardiovascular Data Registry ACTION-Get With the Guidelines, The University Health System Consortium, and Center for Medicare and Medicaid Services (CMS) Medicare claims data.[59,60]

Based on these data opportunities, we propose key research priorities related to using existing large population-based data sets for measuring the costs and effectiveness of integrated systems of emergency care in Table 4.

5. HOW DO WE PROMOTE LINKAGE OF DATA SYSTEMS ACROSS THE DISEASE COURSE?

To understand the delivery of care in a network, it is necessary to have data from across the many sites where patients are treated. By leveraging the deidentified unique patient identifier on certain HCUP databases, tracking patients across different inpatient and other care settings (i.e., ED, ambulatory surgery center) and over time is possible through the HCUP Supplemental Files for Revisit Analyses for nine states (Arizona, California, Florida, Hawaii, Nebraska, North Carolina, New York, South Carolina, and Utah) that make their data available to the public through the HCUP Central Distributor.[61]

However, there here have been calls at numerous venues for the development of data that encompass the entire emergency care enterprise from the prehospital environment to the ED to inpatient settings to rehabilitation.[62] If data from across this continuum of care could be made available on a large-scale basis, it could facilitate the analysis of treatment for time-sensitive conditions, the characterization of the current level of regionalization of services, the identification of high-performing systems, and improved disaster planning. Given the frequency with which metropolitan communities span state boundaries, integrated regional data systems are needed.

These data are currently not available, nor are they part of any existing electronic medical record. However, there are several efforts under way that could provide the necessary components to create data spanning the emergency care enterprise. The National EMS Information System (NEMSIS), funded by the National Highway Traffic Safety Administration (NHTSA) in cooperation with the Health Resources and Services Administration (HRSA), aims to capture EMS events from the time that the EMS system is activated until the patient is released from care by EMS to create a uni-

Table 5
Key Research Priorities to Advance the Field and Offer Access to Large, Geographically Representative Data Sets in Better Understanding Emergency Care Networks

1. What are the administrative, legal, and technological facilitators and barriers to collecting EMS data and establishing the link between EMS, ED, and inpatient data?
2. How can data quality and standardization be best engineered? Should only census-based data be considered, or will sample-based data answer certain questions in a more expeditious, cost-effective manner?
3. Should the linkage of data sets necessarily proceed on a case-by-case basis or would probabilistic linkages suffice? If a probabilistic link is only possible for certain conditions, which conditions should receive focus (e.g., automobile accident, cardiac arrest)?
4. What are the most important system-level questions that can be addressed with these data (e.g., what are differences in transfer rates and outcomes for severely injured children treated in trauma and nontrauma centers)?
5. What are the most important clinical treatment questions that can be addressed with this data (e.g., are outcomes for trauma patients with head injury improved when they are intubated by EMS personnel)?

form, national EMS database.[63] NEMSIS hopes to collect and house EMS data from every state.[64]

Data captured by NEMSIS hold promise to be linked to ED and inpatient data sources, possibly including the HCUP State Inpatient Databases (SIDs), which contain the universe of the inpatient discharge abstracts in participating states, and the State Emergency Department Databases (SEDDs), which capture discharge information on all ED visits that do not result in an admission to the hospital in participating states.[65] Forty-three states provide SID files to HCUP; 28 states provide both SID and SEDD files, which means that the universe of ED encounters at short-term, acute-care hospitals is captured in those states. A number of the same organizations that capture EMS data also collect inpatient and ED data, suggesting that establishing the link between the two data sources is possible. Indeed, a number of data linkage efforts and associated research projects focused on single states are currently under way. For instance, North Carolina and Washington have pioneered efforts to develop population-based linkages across the entire disease spectrum (from prehospital to postdischarge care) for conditions such as stroke, trauma, STEMI, and undifferentiated critical illness.[66–68]

Based on these data opportunities, key research priorities to advance the field and offer access to large, geographically representative datasets in better understanding emergency care networks are listed in Table 5.

CONCLUSIONS

Existing research, the Institute of Medicine, experts in disaster-preparedness, and basic clinical experience all suggest that the current approach to the regional organization of emergency services is not adequate for the growing demands placed on it. A new, evidence-based model for networks of emergency care needs to be developed, but our review demonstrates that there are substantial gaps in the existing knowledge base; fundamental work needs to be done so that we can even assess whether any given change leads to system and patient level improvements.

Developing approaches to define and measure successful networks of emergency care will be critical in improving the delivery of such care and patient outcomes. There are large gaps in our current understanding of regional emergency care networks, including how we measure their effect on outcomes, what disease conditions they should target, how best to allocate resources across the network, and how to engineer such networks so that they ensure the financial health and sustainability of participating providers, EDs, and hospitals. Developing a set of metrics that can be used to characterize network structure and be systematically reported on a regular basis will allow comparability of results across different networks and benchmarking over time.

Future priorities should support the development of population-based data sources and linkages between key data systems that span the prehospital, ED, outpatient, and hospital settings. Streamlined best practices for data sharing that address existing privacy laws and heterogeneity across information technology platforms will be essential. Efforts should be made to create buy-in from professional societies, disseminate best practices to match local and regional resources and needs, and build collaborations with researchers who can bring expertise in resource allocation, optimization, and complex systems and network research. These steps are critical to improving the quality and efficiency of emergency care and to fulfilling the IOM's vision of ''regionalized, coordinated, and accountable emergency care systems throughout the country.''

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