The incomplete infrastructure for interhospital patient transfer

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Objective: **Interhospital transfer of critically ill patients is a common part of their care. This article sought to review the data on the current patterns of use of interhospital transfer and identify systematic barriers to optimal integration of transfer as a mechanism for improving patient outcomes and value of care.**

Data Source: **Narrative review of medical and organizational literature.**

Summary: **Interhospital transfer of patients is common, but not optimized to improve patient outcomes. Although there is a wide variability in quality among hospitals of nominally the same capability, patients are not consistently transferred to the highest quality nearby hospital. Instead, transfer destinations are selected by organizational routines or non-patient-centered organizational priorities. Accomplishing a transfer is often quite difficult for sending hospitals. But once a transfer destination is successfully found, the mechanics of interhospital transfer now appear quite safe.**

Conclusion: **Important technological advances now make it possible to identify nearby hospitals best able to help critically ill patients, and to successfully transfer patients to those hospitals. However, organizational structures have not yet developed to insure that patients are optimally routed, resulting in potentially significant excess mortality. (Crit Care Med 2012; 40: 2470–2478)**

Key Words: healthcare value; hospital quality; informatics; interhospital transfer; Medicare; networks; quality improvement

The US critical care system suffers from a number of seemingly paradoxical problems. The system can save lives, particularly in intensive care units (ICUs) well-organized and staffed by specialists in intensive care medicine (1–4). Yet many ICUs are not staffed in this way (5). Wide-spread shortages of intensivists are predicted to get worse in the future (6, 7). Burnout of intensive care clinicians—in part due to perceived overwork—further drains the existing workforce (8–10). But, in another twist, much of the work of intensivists in the United States seems to be caring for patients who may not need intensive care medicine. Rates of "ICU-mandatory" interventions such as vasopressors or mechanical ventilation are much lower in the United States than in the United Kingdom during the first day in the ICU (11). It has been provocatively argued that much of the growth of intensive care medicine in the United States in the last decade may be attributable to the expansion of care to patients with low risk of death, and therefore low absolute benefit from intensive care (12, 13; C.R. Cooke, personal communication, 2011). Pessimists might see a system in which highly talented professionals are often frustrated by overwork and the inability to focus on the patients to whom they might offer the most benefit.

A commonality in these paradoxes is the mismatch between patient needs and provider capacity. The United States—and every other advanced medical system—has developed a specialized health care system in which the ability to treat relatively rare conditions is unevenly distributed. Specialization achieves economies of scale and scope, and makes possible learning by doing. Yet specialization also implies that the expertise necessary to treat rare conditions (e.g., advanced acute respiratory distress syndrome) is unevenly distributed so that the treatment of common community-acquired pneumonia and acute exacerbations of chronic obstructive pulmonary disease can be nearby. Nguyen et al (14) have recently proposed that there are three approaches for fixing some of these paradoxes: tiered regionalization, telemedicine, and community outreach. Framed another way, one can move some patients to the expertise (interhospital transfer to specialized centers), move the specific clinical expertise to the patients (telemedicine), or build the expertise and systems everywhere (quality improvement). These approaches are not mutually exclusive.

Interhospital transfer of critically ill patients—moving patients to expertise—has already become quite common. Nearly one in 20 Medicare patients admitted to one hospital's ICU will be transferred to another hospital's ICU (15). Between one-third and half of myocardial infarction patients admitted to nonrevascularization hospitals will be transferred to another hospital (16, 17). Both prehospital redirection and interhospital transfer are fundamental to the trauma system (18, 19). Such high rates of interhospital transfer are also true in the United Kingdom, for example (20). This review examines the systems issues in the current practice of adult interhospital transfer of critically ill patients in the United States.

Conceptual Framework: Interhospital Transfer as Infrastructure

In an idealized picture, the interhospital transfer system functions as follows. Clinicians at hospitals with limited capabilities identify patients who would benefit from a higher level of care, arrange transfer, and then the patients are sent to that higher level of care. In this idealized system, the interhospital transfer system functions as an *infrastructure* (in a technical sense of the word) to smoothly transport patients to the best hospital for them to get the care they need. Such an idealized system would prevent many of the above-mentioned patient-need/hospital-capacity mismatches, as patients could be fluidly matched to hospitals optimally suited to their needs. The continued

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Supported, in part, by a grant from the U.S. National Institutes of Health, K08, HL091249.

The author has not disclosed any potential conflicts of interest.

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DOI: 10.1097/CCM.0b013e318254516f

existence of these mismatches suggests that idealized picture must diverge from reality.

Infrastructures have been defined as "basic systems and services that are reliable, standardized, and widely accessible, at least within a community. For us, infrastructures reside in a naturalized background … we notice them mainly when they fail." (21). This definition draws on large body of scholarship (21–23), including synthetic work sponsored by the National Science Foundation in the context of planning the US's cyberinfrastructure (24). Two characteristics of infrastructure discovered by this research are particularly salient. First, infrastructure is a socio-technical system—that is, it is a set of interacting technologies embedded in organizations and human practices that are built around and utilize those technologies. Second, a well-functioning infrastructure simply works, and requires little explicit interaction on the part of users. This leads mature infrastructures to seem ubiquitous, accessible, reliable, and transparent—in contrast to immature infrastructures. In the early years of London's electrification, multiple utilities might serve a single residential block, so that electrical appliances that worked in one house would not work next door (22). Similarly, a key innovation in the development of the internet was the imposition of a unified framework for remote access of university research computers, mandating interoperability even over the objections of many early computing pioneers (24). Prior to this, complex computer-to-computer protocols needed to be negotiated for each pair-wise collaboration.

A qualitative examination of the process of interhospital transfers from the perspective of the sending hospitals—who typically initiate transfers—identified four components of the work involved in transfers (25): 1) identifying transfer-eligible patients; 2) identifying a destination; 3) negotiating the transfer; and 4) accomplishing the transfer (Table 1, and discussed in detail below). The variety of data on actual practice suggest the unifying thesis of this review: that in the United States, the interhospital transfer system is an incomplete infrastructure, where many of the technical problems of fluid interhospital transfer have been solved, but that organizations have not yet developed that take full advantage of these new technical capacities.

Table 1. Key components and recurrent issues in the transfer process[a]

Components	Recurrent Issues
Identifying transfer-eligible patients	Protocolized vs. unprotocolized chief complaints Hospital capabilities for treatment Hospital capabilities for possible complications Insurance-mandated moves Patient age, demographics
Identifying a destination	Existing institutional relationships Routinization Insurance-mandated moves Quality and proximity of destination hospital Patient preferences Pre-existing patient/doctor relationships
Negotiating the transfer	"Is this a dump?" Contacting the receiving physician Timeliness of phone calls
Accomplishing the transfer	Transportation difficulties, including ems policies for unstable patients Synchronizing the medications Processing the paperwork

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[a]Patients did not necessarily progress unidirectionally through the processes, because they were, to a degree, interrelated.

Identifying Patients Who Would Benefit from Transfer

There are few data on how patients are actually identified for transfer. These data suggest poor agreement between patients, transferring physicians, and receiving physicians about why the transfer was performed (26). In the absence of such data, we can consider interhospital transfer as a therapy that has risks and benefits to be weighed (27). Reasoned medical decision-making must consider such a calculus, outlined in Table 2 with regard to mortality. The transfer destination should be selected, in principle, for which the absolute benefit (improved survival) most greatly exceeds the absolute risk (worsened survival). The absolute benefits of an interhospital transfer depend on the absolute risk of death, and the relative benefit of improved survival at each transferring hospital. There has proven to be quite significant hospital-to-hospital variation in their relative benefits for any given condition; pragmatic suggestions for exploiting that variability in quality (particularly short-term mortality benefits) to improve one's patients' care have been published elsewhere (28).

There are empirical studies which suggest a benefit of transfer, on average, for patients with select conditions. Such data may be most robust in cardiology and trauma (29–34). These studies do not explicitly incorporate the variability across potential transfer destinations, about which more below. It is fascinating to note that the benefits of transfer are often not explained by the particular procedure by which a transfer was justified. Thus revascularization-capable hospitals offer better performance on many non-catheterization-related process measures (35, 36); the benefits of stroke centers are not entirely explained by more timely access to thrombolytics (37); and a randomized trial of transfer to an extracorporeal membrane oxygenation-capable hospital showed benefits even though many "treatment" patients never received extracorporeal membrane oxygenation (38). This may be even more true when the transfer leads to a revision of the presumed diagnosis.

The mortality risks of transfer can be distinguished into three classes: transfer mortality, front-end discontinuity risk, and back-end discontinuity risk. Moving a critically ill patient is not without risk, but the absolute risk of an adverse event during interhospital critical care transfer now appears to be quite low. The front-end discontinuity comes from the loss of patient information during the transfer, particularly as the receiving team is just getting to know the patient. The back-end discontinuity risks come at transfer out of the ICU, and again at transfer back from the referral hospital to the originating community. Post-ICU patients will need ongoing care and follow-up of problems discovered or caused in the ICU (39); likewise, the transfer away from the ICU care team may involve loss of the pragmatic physiologic and psychodynamic insights acquired in routine care of the critically ill patient (40, 41). There is a little

Table 2. Risks and benefits of transfer

Benefits of Transfer	Risks of Transfer
Mortality	Mortality
Access to new equipment or treatment modalities	In-transfer risk of harm
Hospital-specific skill in specific therapy	Front-end discontinuity: new team
Hospital-specific skill in other aspects of care	Back-end discontinuity: failure to follow-up new problems
Re-evaluation of proposed diagnosis and treatment plan	
Nonmortality	Nonmortality
Comfort in having gotten "the best" care	Anxiety from lack of familiarity
	Local care as end in itself
	Increased travel distance for family

literature on the absolute magnitude of such discontinuity risks across hospitals; the hand-offs literature spawned by recent work hour reforms suggests that the absolute mortality risk of such hand-offs may be non-zero, but is probably not high relative to the mortality of critical illness (42–44). Transferring and receiving physicians may be particularly able to minimize such discontinuity risk with effective hand-offs (44, 45).

The risks and benefits of interhospital transfer are not limited to mortality—although trading off mortality and nonmortality outcomes needs to be done with care. Nonmortality risks and benefits may be more of a function of individual patient or family preferences than of his or her medical condition. Thus, interhospital transfer may offer emotional benefits to patients and families with their perception of getting all possible care or particularly expert care (46). In contrast, some patients appear to affirmatively value care at a familiar site as good in itself (47, 48). There may be emotional hazards of discontinuity of care and greater family travel distance (49, 50). It is this author's suspicion that such emotional discontinuity effects can be overestimated, as such "transfer trauma" has been noted in transfers out of an ICU within the same hospital (51, 52), and continuity of care even in the same hospital can be overestimated with the frequent shift-changes and mandatory discontinuity of closed ICUs (1, 53, 54). Yet, these nonmortality risks need to be weighed, often case-by-case.

Identifying a Destination: Variability Among Seemingly Similar Hospitals

In mature trauma systems, level I hospitals are "full service" hospitals, rapidly able to provide a large suite of services to seriously injured patients. An implication of this nomenclature is that any level I trauma hospital can provide all the care needed for almost any patient; further, this "leveling" nomenclature suggests that there are no differences among trauma centers big enough to warrant the risks to patients of any additional travel time. Similar design decisions have been made in the design of prehospital regionalization systems for ST-elevation myocardial infarction, such as the Reperfusion of Acute Myocardial Infarction (AMI) in North Carolina Emergency Departments system in North Carolina (55–57).

Yet, in fact, a large body of research demonstrates that there are very substantial differences in outcomes between hospitals of seemingly the same "level". These outcome data are particularly robust for patient with pneumonia (58), non-postoperative mechanical ventilation (59), AMI (60), stroke (37), lung transplantation (61), congestive heart failure (62), trauma requiring massive transfusion (63), and major surgery (64). This wide variability in outcomes is paralleled by wide variability in process measures ranging from curative therapies (65) to "end-of-life" care in those over 65 yrs old (66). While reasonable people may disagree about precisely how to weigh these differences in order to rank hospitals, the contention that there are no differences between hospitals, even of seemingly similar capabilities, is simply not tenable in light of current data.

Identifying a Destination: Decision Making and Routinization

Since there are significant differences among hospitals, the process of arranging a transfer must be recognized to be more complicated than simply picking up the phone. In practice, the patterns of interhospital transfer resemble less a World War I military hierarchy—secondary hospitals which uniquely refer to tertiary care hospitals, which then refer up to a few "quaternary care" hospitals—and more like a Facebook network. (Figure 1) In the United States, hospitals transfer critically ill medicare patients to a median of four other hospitals (15), and those interhospital relationships are relatively stable over time (67). This provides a high degree of interconnectedness for the nation as a whole (68). Similar degrees of interconnectedness appear even in Italy and the Netherlands, despite their very different financing models (69, 70).

This heterogenous network structure confronts hospitals with choices as to where to transfer patients. The transfer of patients with AMI to revascularization-capable patients has strong empirical support, for both ST-segment elevation myocardial infarction and non-ST-segment elevation myocardial infarction patients (30, 31, 71, 72). Physicians caring for patients with AMI have the advantage of rigorously constructed, carefully risk-adjusted publicly-available 30-day mortality data for every hospital in the country (60, 73, 74). These data could be used to guide patients toward nearby hospitals with the best 30-day risk-adjusted mortality (28). One study considered AMI patients who had been admitted to a nonrevascularization hospital, and were transferred to a revascularization hospital (17, 75). Such patients were by definition outside of any original 90-min windows; most were transferred on or after their second day at the nonrevascularization hospitals. Average urban patients were not transferred 10 miles further unless that small distance would allow them to go to a hospital with a full 9.3 percentage point lower absolute risk of death (95% confidence interval 6.2, 12.3). A simulation examined the potential impact of improving the routing of transfer patients to more highly value hospital 30-day outcomes. Even if transfers were restricted to consider only destination hospitals within 25 miles of the sending hospitals, such improved routing might reduce the relative risk of 30-day mortality by 9.4% (95% confidence interval 9.2%–9.6%).

Qualitative interviews at a number of community hospitals support a hypothesis that some of this systematic dysfunction arose because transfers were not perceived as therapeutic choice. Little mention was made by providers of hospital quality (however defined) when recalling

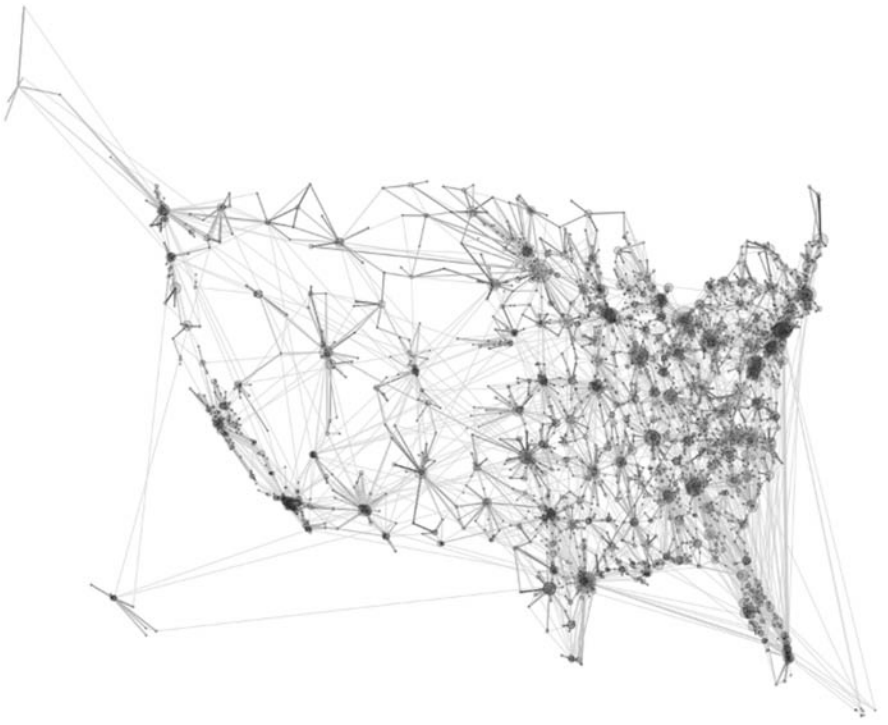

Figure 1. The U.S. interhospital transfer system. Based on previously published data (16), visualization by James Moody. Marker size is proportional to network centrality, and the width of lines connecting hospitals is proportional to the number of patients transferred between the hospitals.

how they made transfer decisions (25). This reinforces classic studies of patient referral by Shortell (76), who emphasized that such referrals were primarily about interprofessional relationships. Recent work in the Italian health care system has emphasized that interhospital transfers can be viewed as a form of organizational collaboration and a mechanism for institutional learning—with the implications that transfer destinations are chosen with an eye to institutional advantage rather than optimizing the care of individual patients (69, 77). This contrasts with studies focusing on patients who had been transferred. Patients who were transferred into a high profile tertiary care center in Baltimore, for example, reported that their reasons for initiating that transfer were predominantly related to inadequacies of communication at the original hospital and perceptions of differential quality (46).

This research suggests that, in principle, referring hospitals could make a choice of where to send each patient to get the best care for that patient. In practice, transfers are shaped by broader interorganizational relationships. These relationships do not seem to be principally engineered towards optimizing the care of individual patients, but rather driven by other organizational foci, if they are driven at all. Current practice are configured to offer little opportunity for objective quality information to be used at the point of care, perhaps contributing to the limited impact of public reporting (78). Nonetheless, there may be opportunities for new quality improvement efforts to inject greater patient-centeredness into these practices (28).

Negotiating and Accomplishing the Transfer

Having identified a preferred destination hospital, a negotiation process must occur between the would-be transferring hospital and the destination hospitals. Qualitative work suggests this can be a fractured and contentious process (25). Protocolization and advance negotiations may facilitate the process. The American Heart Association's Mission Lifeline program, for example, has developed a series of recommendations on integrating nonrevascularization hospitals with local percutaneous coronary intervention-capable hospitals to facilitate rapid transfer (79–81).

There are at least three further system barriers that are perceived to hinder transfer. First, some physicians may be concerned about the legal implications of attempting an interhospital transfer, although the relevant US law on the matter appears to be limited, minimally restrictive regarding good practice, and not often enforced (82–85) (Box 1). Second, community hospitals report significant difficulties in obtaining a qualified ambulance crew that is willing to perform the interhospital transfer (25). There are almost no quantitative data on the availability of ambulances in the United States to evaluate the magnitude of this problem. Ontario has published impressive safety numbers for a brisk transfer service (86), and anecdotal evidence suggests there are few refusals to transport due to medical instability (J.M. Singh, personal communication, 2011). Similar research is needed in jurisdictions other than Ontario. Third, a frequent concern in discussions of interhospital transfer is the availability of ICU beds at referral centers. There is a widespread perception that tertiary care ICUs are full (87). Unfortunately, granular data on ICU occupancy are scarce, although Halpern et al (13) cite an overall 65% occupancy rate. Capacity concerns persist despite the rapid expansion in ICU beds in the United States throughout the last two decades (12, 13); a relatively greater per capita supply of ICU beds in the United States than in most other healthcare systems (88–90); and a laxer standard for ICU admission in the United States than in the United Kingdom (11). Limited existing data suggest that a significant number of ICU bed-days are caused by "intensive care outflow obstruction," the inability to discharge medically-stable patients (91, 92). Thus the true extent of capacity constraint in the United States ICU system is unclear. We are unaware of data on the frequency with which capacity constraint leads to the refusal of transfer requests; regionalization of all non-postoperative mechanically ventilated patients, for example, would impose only quite small marginal increases in patient volumes at high-volume hospitals (93). It may be that straightforward improvements in operations could significantly relax whatever constraint does exist (92, 94, 95). Recent successes in shortening door-to-balloon times may offer inspiration and lessons (96).

Once a destination hospital has been found for the patient to be transported, a remarkably safe system has evolved. Early reports of interhospital transfer raised important safety concerns, with a majority of patients having some adverse event (98). But now, after decades of sustained

Box 1. US law relevant to interhospital transfer

The major provision of U.S. Federal law relevant to interhospital transfer is the Emergency Medical Treatment and Active Labor Act. It imposes on hospitals the following duty (130): (42 USC 1395dd(a-c))

In general, if any individual (whether or not eligible for benefits under [Medicaid and Medicare]) comes to a hospital and the hospital determines that the individual has an emergency medical condition, the hospital must provide either—(A) within the staff and facilities available at the hospital, for such further medical examination and such treatment as may be required to stabilize the medical condition, or (B) for transfer of the individual to another medical facility in accordance with subsection (c) of this section.

Subsection (c) says, in part, that transfers can occur when "a physician has signed a certification that based upon the information available at the time of transfer, the medical benefits reasonably expected from the provision of appropriate medical treatment at another medical facility outweigh the increased risks to the individual and, in the case of labor, to the unborn child from effecting the transfer" and "the transfer is an appropriate transfer … to that facility"

Finally, an appropriate transfer is defined as

A. *In which the transferring hospital provides the medical treatment within its capacity which minimizes the risks to the individual's health and, in the case of a woman in labor, the health of the unborn child;*

B. *In which the receiving facility—i) has available space and qualified personnel for the treatment of the individual, and ii) has agreed to accept transfer of the individual and to provide appropriate medical treatment;*

C. *In which the transferring hospital sends to the receiving facility all medical records (or copies thereof), related to the emergency condition for which the individual has presented, available at the time of the transfer, …;*

D. *In which the transfer is effected through qualified personnel and transportation equipment, as required including the use of necessary and medically appropriate life support measures during the transfer; and*

E. *Which meets such other requirements as the Secretary may find necessary in the interest of the health and safety of individuals transferred.*

EMTALA also contains so-called Reverse Dumping provisions, intended to prevent potential receiving hospitals from refusing patients to whom they could offer benefits:

A participating hospital [in Medicare and Medicaid] that has specialized capabilities or facilities (such as burn units, shock-trauma units, neonatal intensive care units, or (with respect to rural areas) regional referral centers as identified by the Secretary in regulation) shall not refuse to accept an appropriate transfer of an individual who requires such specialized capabilities or facilities if the hospital has the capacity to treat the individual. (42 USC 1395dd(g))

The actual case law regarding EMTALA has been overwhelmingly focused on emergency care, rather than interhospital transfer of critically ill patients. While EMTALA may be perceived to be quite burdensome to physicians and hospitals, the actual amount of case law under EMTALA seems modest (85) such that the precise implementations of many aspects are unclear—and advocates have raised concerns that the problem is too few cases, not too many (82–84).

As always, this box should not be construed as formal legal advice and if one has questions, one should consult one's own counsel.

improvement, more recent data suggest that interhospital transfer is very safe. The data from Ontario's centralized transfer service are most robust; they reported only 981 of 19,228 (5.1%) urgent aeromedical transfers involved a critical event, and only 12 deaths occurred during transport (86). Such low rates have been noted in a number of other jurisdictions (20, 98–102), While some concerns about the safety of interhospital transfer practice persist (103, 104), a number of guidelines offer advice on the pragmatic issues in safely moving a patient from point A to point B (105–116).

Future Directions for Improving Patient Outcomes

The picture that emerges from this review of interhospital transfer is messy. Patients are frequently transferred, but the data on who will benefit from transfer are often murky. In conditions where the data are strongest, many patients are not transferred. When patients are transferred, the destination is often chosen for reasons of proximity and habit, rather than based on objective evidence on hospital performance and capability. Tertiary care centers may fail to accept patients they could benefit, even as their highly skilled ICUs sit filled with patients seemingly not requiring ICU-level interventions, or awaiting transfer to the floor or post-acute care. Community hospitals find it hard to find an accepting hospital, or even to get someone from a potential accepting hospital on the phone in a timely manner (25). Transport can be accomplished safely, yet community hospitals report frustration in arranging transport, and there are few US data on the subject.

Reviewing interhospital transfer in light of research on infrastructure shows a system where many of the key technical issues have been solved, but an integrated organizational framework to take advantage of these technical issues has not yet developed. The clinical expertise of safely transporting critically ill patients has been highly developed, if not always widely available. Significant progress has been made on assessing hospital quality, potentially allowing physicians to make the same evidence-driven thoughtful choice about which hospital should treat a patient as they aspire to make about with which drug to treat the patient. Still there is no system that routinely incorporates hospital quality and bed availability to route patients to the hospital best able to improve each patient's chances of survival.

This suggests certain key implications for clinicians, for systems designers, and future research on interhospital transfer, specifically, and for regionalization and public-reporting more generally.

Clinicians at potential *sending* hospital face the challenge of optimizing their practice of interhospital transfer. This can mean a focus on early identification of potential transfer patients and

development of rapid transfer protocols, consistent with such initiatives as Mission: Lifeline and the American College of Surgeon's Advanced Trauma Life Support programs. But, furthermore, clinicians may be able to offer their patients significantly improved outcomes if they use a strategy of guided transfer to select their destination hospital (28), although such potential benefits are unproven. Could the objective quality of the hospitals to which one transfers patient be a goal for quality improvement, in the same way that insuring the delivery of the best antibiotic for pneumonia—not merely some antibiotic—is a goal for quality improvement? Certainly clinicians must insure that inferior transfer destinations, or patients selected for transfer, are never chosen for organizational reasons that are contrary to the patient's goals.

Clinicians at *receiving* hospitals also have a role. One can reasonably recommend attention to the timeliness of responses to requests for transfer, remembering that what can often feel like a bureaucratic burden at the receiving hospital can be a life-or-death situation at the sending hospital. But the more general need to is to manage receiving hospital ICUs as a regional resource, with triage decisions including not just the competing needs of one's own Emergency Department or Operating Room, but also the potential needs of the other nearby hospitals. Both sending and receiving hospitals may benefit from carefully evaluating the adequacy of available transport, and working in advance to correct any defects.

At a *systems-design* level, there are substantial opportunities for improvement. Optimization of interhospital transfers offers a rare opportunity to improve patient outcomes without awaiting new fundamental biomedical discoveries, and potentially while only using existing resources. Within a hospital, there is a ripe opportunity for automated decision-support to help identify patients who could benefit from transfer and to direct them to the hospital with the best ability to help them. Such systems could complement efforts to develop early warning systems for ICU transfer. But such information technology is only likely to improve outcomes if it is embedded in an organizational culture and framework that places a priority on patient-centered transfers. Such a culture would take seriously the fact that transfer relationships serve important other functions for hospitals, but would weigh those values against the differences in patient outcomes. Such an organization might incorporate protocolization of transfer processes, and careful advanced negotiation about transfer agreements. Finally, integrated systems (such as the Veterans Administration or the Accountable Care Organizations emerging under healthcare reform) could consider an approach to the triage of scarce ICU beds that incorporates not just one's own hospital, but the full system's needs. Such an integrated approach would almost assuredly require improving ICU throughput to insure that needed transfers are not missed due to bedlock, and would assess the quality, ease and outcome of transfers as part of its basic quality metrics. An integrated system could also insure effective information flow, minimizing the discontinuity risks of transfer.

Finally, there are a number of *urgent research issues*. From an organizational studies and implementation science perspective, we need to design and evaluate approaches to reshaping organizational practice to incorporate new approaches to guiding transfer. Such a fundamentally organizational approach to incorporating new technology will be of quite general interest, and would likely offer benefits for the study of related issues such as successful telemedicine adoption and regionalization as well (117, 118). More research is needed on the extent to which so-called "reverse triage" might be safe and useful. In a reverse triage model, patients no longer actively needing specialized interventions are sent from receiving hospitals to (or back to) smaller hospitals. Interesting work has been done examining how rapidly post-percutaneous coronary intervention patients can be transferred out of catheterization-capable hospitals, which might be a model for other conditions (119, 120). Such work could address concerns about overtriage and "inappropriate" transfers (121–123), allowing the development of appropriateness criteria for acceptance of patients and of when patients could be safely returned to a less specialized hospital. Quantitative work is necessary to advance the technologies themselves. A recent study elegantly demonstrated the risks of observational analysis of interhospital transfer data, even while suggesting that it can be done rigorously and appropriately (18). Certainly careful risk adjustment is essential (124). Techniques for evaluating the benefits hospitals provide to interhospital transfer patients are needed (125, 126), building on recent advances in hospital evaluation (127, 128). Ideally such techniques would allow some degree of differentiation of effect for clinically important subgroups, allowing an evidence-based foundation for individualized patient care (129). Finally, innovative approaches to examining the extent to which transfers cause emotional trauma, and ways to mitigate that trauma are important to overcoming potential barriers to effective transfer (49, 50).

CONCLUSION

An effective infrastructure for interhospital transfer might offer substantial benefits for patients, as well as for providers. Many technical barriers are being solved to make rapid, patient-centered transfers a readily available infrastructure. However, an organizational framework that makes such transfers efficient, ubiquitous, and transparent is only now being developed that can fully capitalize on the technical breakthroughs.

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