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International comparisons of intensive care: informing outcomes and improving standards

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Abstract

Purpose of review—Interest in international comparisons of critical illness is growing, but the utility of these studies is questionable. This review examines the challenges of international comparisons and highlights areas where international data provide information relevant to clinical practice and resource allocation.

Recent findings—International comparisons of ICU resources demonstrate that definitions of critical illness and Intensive Care Unit (ICU) beds vary due to differences in ability to provide organ support and variable staffing. Despite these limitations, recent international data provide key information to understand the pros and cons of different availability of ICU beds on patient flow and outcomes, and also highlight the need to ensure long-term follow-up due to heterogeneity in discharge practices for critically ill patients. With increasing emphasis on curbing costs of healthcare, systems that deliver lower cost care provide data on alternative options, such as regionalization, flexible allocation of beds, and bed rationing.

Summary—Differences in provision of critical care can be leveraged to inform decisions on allocation of ICU beds, improve interpretation of clinical outcomes, and assess ways to decrease costs of care. International definitions of key components of critical care are needed to facilitate research and ensure rigorous comparisons.

Keywords

Critical Care; Epidemiology; Healthcare Delivery; International Perspectives

Heterogeneity in patient populations, variation in structural design, and differences in even basic terminology create difficulties in comparing data on critically ill patients across regions or countries. These differences have their roots in differing healthcare needs, financial resources, and cultural values. Debate over the utility of international comparisons is thus largely justified; however, the differences in intensive care unit (ICU) populations and resources may also constitute the value of international comparisons. By examining varying strategies in intensive care unit (ICU) management and provision, we may gain information that will help to optimize critical care implementation and improve patient outcomes. In this review, we address the challenge of standardizing definitions within the field of critical care. We then focus on international data, from local to multi-national, that have provided insights that can inform interpretation of data and delivery of critical care worldwide.

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Definitions of critical care

Critical care is a young field, with its roots in the shock wards of World War II military hospitals, and the Copenhagen polio epidemic of 1952 [1, 2]. Over the following fifty years, ICUs proliferated worldwide. In most developed countries today, critical care is delivered almost solely in specialized units with sophisticated equipment and a high staff to patient ratio for the care of patients with multi-organ failure. However, beyond this broad statement, recent studies highlight the fact that these units are diverse in their staffing, resources, and target patient populations, hampering the ability to compare and contrast data across ICUs [3].

Definitions of ICU beds

The differences between ICU beds may be technological capabilities (e.g. ability to provide specific organ support) or staffing, or both [4*]. While many consider an ICU bed one in which a patient can receive mechanical ventilation, this definition is by no means universal. For example, American ICU beds are often defined by staffing availability while Belgian beds are defined by the characteristics of the patients themselves [4*]. Beds in the UK, Australia, and New Zealand may be Level 2 (high-dependency) or Level 3 (full intensive care), but both types of beds are categorized and counted as ICU beds [5, 6].

Staffing

Many aspects of staffing may differ across ICUs and are fundamental to the definition of an ICU bed in some regions. One primary difference in staffing definitions is the required (or preferred) nurse to patient ratio. The literature documents nurse to patient ratios ranging from one nurse for one patient to one nurse for four patients for care of critically ill patients [7]. It is notable that adverse patient outcomes have been associated with more patients per nurse, including complication rates, length of stay, [7, 8], and even risk-adjusted mortality [9]. These data have led to some regions adopting mandatory nurse to patient ratios [10, 11]. This fundamental variability in staffing can make comparisons challenging. For example, Level 2 (high-dependency care beds) in the UK are ideally staffed with one nurse for two patients. Yet many of the highest level ICU beds in the US are also staffed with one nurse for two or three patients [12].

ICU staffing may vary in more general ways and include differences in various clinical personnel. Multiple models of care center around which type of physician is primarily responsible for the patients: closed units where care is assumed by intensivists, open units where the primary surgical or medical team continues to direct patient care, and nurse or physician assistant-driven units with physician telemedicine consultation. It is notable that these alternate models of staffing for intensive care (other than closed) are primarily found in the US [13]. The involvement of multi-disciplinary teams may also vary. For example, some countries (such as the US) may include respiratory therapists on rounds, while in others there is often no respiratory therapist involved in the care [14]. How these differences in care delivery models may impact patient outcomes is only beginning to be understood [15, 16**].

Patient Populations

Which patient populations are served by designated critical care beds also varies according to national population demographics, hospital size and location, and regionalization of care. Some systems primarily provide care in mixed medical-surgical ICUs, while other systems may favour specialized care units, such as neurological ICUs, or trauma ICUs [13]. The inclusion or exclusion of certain types of patients from individual units, as well as differing beliefs regarding the appropriateness of intensive care for certain groups, such as patients

with metastatic cancer, or the very elderly, may impact the targeted patient population within an individual ICU. In this regard critical care medicine is unique from other medical specialties in that there is no specific target organ system or pathology.

Consensus committees in many medical fields have found that standardization improves data collection and ensures comparability of patient data, such as in oncology and hematology [17–19]. Within the field of critical care, standardization of basic definitions may allow for clearer comparisons. For example, the ability to draw conclusions regarding trends in mortality for patients with the Acute Respiratory Distress Syndrome (ARDS) was facilitated by the adoption of a standard definition in 1993 [20]. The study determined that mortality had not changed, and this steady mortality across many studies was clear only after the adoption of the standardized definition [21]. The specialty of critical care medicine would benefit from adoption of additional international definitions, particularly regarding the definition of an ICU bed and critical illness, to facilitate clear discussion and aid in appropriate comparisons across regions and countries.

Understanding the need for intensive care beds—With so much heterogeneity, what can be gained by examining intensive care across countries? Even accounting for possible discrepancies due to differences in definitions, ICU bed availability clearly varies substantially worldwide, ranging from less than 1 to greater than 30 ICU beds per 100,000 people (Table 1)[3, 6, 22–27**]. Despite this enormous variation, there is no consensus on the ideal number of ICU beds to serve a population [28*]. Information on the relative impact of fewer or more ICU beds is important information that can be gleaned by examining different systems. A comparison of medical admissions to ICUs in the US and UK highlights the impact of different choices regarding bed availability on access to intensive care. For example, the comparison of data demonstrates that having more beds (in the US) allowed for more patients to be transferred directly from the emergency room, rather than receiving care on a general ward first [29*]. Further data from the UK, with very few ICU beds, suggested that their provision of intensive care was too low [30]. This possibility was supported by a number of studies which showed many patients denied intensive care due to a lack of beds [31], many patients discharged from the ICU prematurely [32], and a reduction in mortality (with steady severity of illness) when more ICU beds were built throughout the country [30].

However, we must be cognizant of the fact that the relative provision of (and therefore need for) intensive care may be driven by many factors. First are distinct differences in patient populations. Data comparing middle-aged Americans with a similar population in the United Kingdom demonstrated a higher burden of chronic illnesses among the American cohort – double the rate of diabetes and a third higher rate of hypertension [33]. Such comparisons are essential to understanding the relative healthcare needs of populations. Frequency of interventions and surgical procedures may also impact the need for intensive care. For example, patients who receive a liver transplant will require a stay in an ICU. This need for intensive care is, therefore, driven not solely by disease, but also by management choices [34]. An older study comparing admissions to intensive care in Alberta (Canada) and western Massachusetts (US) found that ICU days per million population were two to three times higher in western Massachusetts, primarily due to a higher ICU incidence (i.e. percent of hospitalized patients treated in the ICU). This discrepancy was driven by all of the factors described above [35].

Outcomes with Intensive Care—Despite the *a priori* idea that ICU care improves patient outcomes, studies empirically supporting this idea are ethically difficult to design. Therefore, comparisons across systems and cultures where different choices are made regarding “appropriate” use of intensive care are helpful. Data from multiple countries with

relatively limited numbers of ICU beds suggest that ICU bed availability can affect patient mortality. The important difference in these studies is that they examine not just the patients who received intensive care, but also those who were deteriorating in some way and did not receive the higher level of care, as this avoids the problem of selection bias. For example, Robert et al studied 1,762 French patients referred for ICU admission and found mortality was higher in patients refused admission secondary to bed shortage (33.3% vs. 27.2% p = 0.06 at 60 days) [36**]. The study also found a significantly higher mortality rate in those patients admitted to ICU after subsequent referral compared to patients who had been admitted directly. In an Israeli observational study of patients admitted to ICU versus general ward (in the setting of bed scarcity), mortality was lower in those for whom early intensive care was available [37], which was confirmed in a follow-up study across the European Union [38]. Other studies have not demonstrated a direct correlation between ICU bed availability and mortality, but have shown that bed scarcity contributes to decreased likelihood of ICU admission, and alterations in care choices, such as increasing the likelihood of the decision to withhold or withdraw care [39**]. It is notable that these studies were carried out mostly in countries with relatively low provision of intensive care (and not in the US, where pockets of under-provision of intensive care occur, but where overall provision is very high in comparison with most of the world) [3]. It is also important to also note that the relative life expectancy at birth in most developed countries does not correlate well with critical care resources (see Table 1).

Long-term mortality—Many studies of intensive care focus on hospital mortality as a primary patient outcome. But, in-hospital mortality can be significantly decreased if very sick patients are kept alive for prolonged periods of time with poor quality of life, or are transferred out of acute care hospitals to long-term care facilities [40**]. International comparisons bring data on discharge practices into stark relief. For example, discharge destinations for medical ICU admissions in the US and UK are markedly different, with 29% discharged to skilled care facilities in the US, and only 6% in the UK [29*]. While UK hospital mortality is high, the mortality for patients discharged to skilled care facilities in the US is also very high [41]. Such comparisons highlight the danger of drawing conclusions from short-term outcomes generated using patients in different healthcare systems without detailed knowledge of discharge practices, as well as cultural norms regarding acceptable quality of life after a critical illness. Moreover, as the problem of caring for chronically critically ill patients and patients requiring prolonged mechanical ventilation becomes a universal concern, comparisons of discharge customs across countries will become even more valuable to allow different systems to adopt care models that are effective and cost efficient.

Decreasing costs of care—Healthcare expenditure accounts for a large percentage of the Gross Domestic Product (GDP) in most countries, and critical care expenditures alone now account for almost 1% of the United States GDP [42]. Population studies suggest that critical care demand is growing almost exponentially as the populace ages [43]. This is especially true in developed countries that are able to provide organ transplants, cardiovascular surgery, and chemotherapy for cancer. These interventions increase both lifespan and morbidity, further increasing the need for critical care [24]. Despite these trends, there is limited research on ways to decrease costs of critical care.

Increasing per-capita healthcare expenditure is associated with increasing delivery of critical care (see Table 1), demonstrating that the economics of critical care resources and delivery are at least partially shaped at the national level [3]. In order to begin to decrease costs, delivery of critical care must minimize both fixed and variable costs. The fixed costs of critical care include staff salaries and equipment (e.g. beds). Variable costs include treatments, provision of studies, and invasive equipment (e.g. ventilators, catheters). Many

systems questions can only be addressed by looking beyond small regions to gain information from models other than what is currently in place in a given location.

Regionalization of Care

One option for improving the economics of critical care is to optimize the efficiency of delivery through regionalization of services. While discussions of the best ways to regionalize critical care delivery are nascent, patient outcome benefits associated with regionalization have been demonstrated in the care of patients with trauma, as well as cardiogenic shock, acute myocardial infarctions (requiring percutaneous coronary interventions), and acute care surgery [44]. Regionalization of critical care currently occurs to varying degrees in different countries, and studies from different systems can help inform the direction of planning for critical care worldwide. For example, in Japan, regional consolidation of ICU beds was instituted in 1993 in order to maintain a focus on academic medicine in tertiary centers and remove the burden of care from community hospitals [45]. Other countries, such as Italy and Spain, have systems to transfer patients between hospitals to access the nearest ICU bed [46*]. While in the US there is no explicit regionalization of critical care services, informal networks of care do exist but may be improved by adoption of a more rigorous system [47]. Regionalization may contribute cost-savings to medical care by avoiding the duplication of costs associated with high-tech equipment and subspecialist personnel [48]. It also adds flexibility to healthcare systems to increase capacity for epidemics and/or disasters [49, 50]. However, transport of patients away from their support networks and pooling all highly specialized care in tertiary centers may have negative effects on smaller communities, particularly when larger distances are involved [51].

Rationing of Care

Differences in patterns of triage bring up the vital, yet divisive, issue of critical care: rationing. Rationing is “the allocation of healthcare resources in the face of limited availability, which necessarily means that beneficial interventions are withheld from some individuals,” [52] and is a part of all healthcare systems. Suitability for admission to or discharge from the ICU is traditionally determined by clinicians on a case-by-case basis. But the subjectivity of this approach is not ideal; in a survey of Italian critical care physicians, 86% acknowledged inappropriate ICU admissions – most were attributed to clinical doubt (33%) and limited time (32%) [53]. A recent study of admissions to ICUs in Veterans Affairs hospitals in the US found large variation in use of intensive care for medical patients, even after accounting for variation in the severity of illness of patients [54**]. A survey of critical care physicians across Western Europe by Vincent et al found that 64% of physicians surveyed had admitted patients with no chance of survival [55]. On the other hand, studies from Japan and the UK determined that admissions to ICUs are severely limited for the very elderly and patients perceived to have little chance of survival [45, 56].

We have learned from international comparisons that sociocultural norms, expectations and laws can impact such decisions in intensive care. For example, the ETHICUS study compared data on end-of-life practices from 37 ICUs in 17 European countries and found variation in the manner and treatment of death. Significant factors affecting end-of-life care included not only the diagnosis and age, but also the location (region) of care, and physician religion [57].

Socio-cultural attitudes towards end-of-life care affect not only patient outcomes but also those making the difficult decisions, namely patients’ families and healthcare providers. The relative responsibilities of decision-making rest on different parties in different nations. For example, a do-not-resuscitate order requires patient or surrogate approval in the US, while in some other countries this decision is made by the treating physician [46*]. The burden of

such decision-making on families with limited medical knowledge and conflicting desires may present a significant stressor; this is an area where research is scant, and the different cultural and legal models may be examined to shift systems in the future [46*].

Resource-limited Critical Care

Many people living in resource-poor nations, most notably those of sub-Saharan Africa, struggle with access to fundamental resources (i.e. clean water, food, and electricity) and often lack primary medical care, creating a disproportionately high prevalence of critically ill patients [58]. Critical care medicine as practiced in more developed nations is often not feasible in such settings, and research to improve cost-effectiveness and implementation in these environments is vital [59]. However, it is important to recognize that in facing the challenge of delivering critical care with fewer resources, or in less hospitable environments, these limitations force ingenuity and flexibility in systems design from which all critical care practitioners may learn. In particular, planning for epidemics and disasters may be influenced by data from many regions. For example, Kost et al examined healthcare provisioning and Point-of-Care testing (POCT) in post-tsunami Thailand and Hurricane Katrina–affected areas of Louisiana in the US [60]. Both were sites with massive critical care need, limited by available beds, physicians, and diagnostic equipment. In a survey of primary care units, and hospitals in Thailand, and 22 hospitals in Katrina-affected areas, limited availability of instruments and poor organization severely limited POCT use. Data on critical care from the Hajj, with an influx of three million people annually, may help other regions and countries understand what types of critical illness occur with crowding, and also provide information on how to approach the need for provision of high-intensity health care for short periods of time, as may occur with natural disasters [61].

International studies also demonstrate that the application of clinical concepts in disparate resource-settings can challenge the status quo, especially when applying strategies from high-technology settings to less developed areas. For example, the American College of Critical Care Medicine 2007 guidelines recommend early fluid resuscitation (up to 60ml/kg of isotonic fluid in the first hour) in neonatal and pediatric septic shock [62]. The Fluid Expansion as Supportive Therapy (FEAST) trial investigated the implementation of early fluid resuscitation in three nations of sub-Saharan Africa for 3,141 children with severe febrile illnesses, and found an increase in mortality rates in children who received fluid bolus therapy versus no fluid bolus (Relative Risk 1.45, 95% CI 1.13–1.86, P=0.003) [63**]. This study was especially robust because it was conducted across national boundaries on a large cohort of children, and the surprising results highlight the need to revisit our understanding of the role of fluid resuscitation in early sepsis.

Conclusions

International studies of critical care provide an external basis of comparison for healthcare systems and reveal ways in which the field may improve quality of care. Standardization of terms should be prioritized to limit errors in data comparisons, and knowledge of the differences in care delivery that may affect interpretation of data is also essential. What we have learned from outcomes in international comparisons also underscores the need for appropriate international metrics to quantify the outcome benefits of critical care. Physiological outcomes such as short-term mortality are objective, but vulnerable to manipulation by systems management, neglect to incorporate patient information post-discharge, and also overlook the socio-cultural aspects of healthcare.

Examination of different provision of critical care may also help to address cost containment by providing information to allow for optimal systems design, as it relates to provision of intensive care beds, unit staffing, and design of critical care networks for care. We may also

look to the creative solutions found in resource-poor settings and during natural or man-made disasters to improve delivery of critical care worldwide.

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References

1. Reisner-Senelar L. The birth of intensive care medicine: Bjorn Ibsen's records. Intensive Care Medicine. 2011; 37:1084–1086. [PubMed: 21611906]
2. Rodriguez R. Demystifying critical care. Western Journal of Medicine. 2001; 175:366–367. [PubMed: 11733417]
3. Wunsch H, Angus D, Harrison D, et al. Variation in critical care services across North American and Western Europe. Critical Care Medicine. 2008; 36:2787–2793. [PubMed: 18766102]
4*. Murthy S, Wunsch H. Clinical review: international comparisons of critical care--lessons learned. Critical Care. 2012; 16:218. A review containing detailed information on definitions of ICU beds worldwide. [PubMed: 22546146]
5. Society IC. Levels of Care. 2009. Levels of Critical Care for Adult Patients.
6. Martin J, Hart G, Hicks P. A unique snapshot of intensive care resources in Australia and New Zealand. Anaesthesia Intensive Care. 2010; 38:149–158.
7. Dimick JB, Swoboda SM, Pronovost PJ, Lipsett PA. Effect of nurse-to-patient ratio in the intensive care unit on pulmonary complications and resource use after hepatectomy. Am J Crit Care. 2001; 10:376–382. [PubMed: 11688604]
8. Amaravadi R, Dimick J, Pronovost P, Lipsett P. ICU nurse-to-patient ratio is associated with complications and resource use after esophagectomy. Intensive Care Medicine. 2000; 26:1857–1862. [PubMed: 11271096]
9. Tarnow-Mordi W, Hau C, Warden A, Shearer A. Hospital mortality in relaiton to staff workload: a 4-year study in an adult intensive-care unit. The Lancet. 2000; 356:185–189.
10. Newcastle upon Tyne. British Association of Critical Care Nurses; 2009. Standards for nurse staffing in critical care (updated 2010).
11. Unit NNR. Policy+. London: King's College London; 2012. Is it time to set minimum nurse staffing levels in English hospitals?.
12. Kane RL, Shamliyan TA, Mueller C, et al. The association of registered nurse staffing levels and patient outcomes: systematic review and meta-analysis. Med Care. 2007; 45:1195–1204. [PubMed: 18007170]
13. Angus D, Shorr A, White A, et al. Critical care delivery in the United States: distribution of services and compliance with Leapfrog recommendations. Critical Care Medicine. 2006; 34:1016–1024. [PubMed: 16505703]
14. Rose L, Nelson S, Johnston L, Presneill JJ. Decisions made by critical care nurses during mechanical ventilation and weaning in an Australian intensive care unit. Am J Crit Care. 2007; 16:434–443. quiz 444. [PubMed: 17724240]
15. Kim MM, Barnato AE, Angus DC, et al. The effect of multidisciplinary care teams on intensive care unit mortality. Arch Intern Med. 2010; 170:369–376. [PubMed: 20177041]
16**. Wallace DJ, Angus DC, Barnato AE, et al. Nighttime intensivist staffing and mortality among critically ill patients. The New England journal of medicine. 2012; 366:2093–2101. A high quality multi-center observational study that examines the question of the impact of nighttime intensivist staffing on outcomes for critically ill patients. [PubMed: 22612639]
17. Pheby D, Etherington D. Improving the comparability of cancer registry treatment data and proposals for a new national minimum dataset. Journal of Public Health Medicine. 1994; 16:331–340. [PubMed: 7999387]

18. Rodeghiero F, Stasi R, Gernsheimer T, et al. Standardization of terminology, definitions, and outcome criteria in immune thrombocytopenic purpura of adults and children: report from an international working group. Blood. 2009; 113:2386–2393. [PubMed: 19005182]

19. Jacobson I, Poordad F, Brown R, et al. Standardization of terminology of virologic response in the treatment of chronic hepatitis C: panel recommendations. Journal of Viral Hepatology. 2012; 19:236–243.

20. Bernard GR, Artigas A, Brigham KL, et al. The American-European Consensus Conference on ARDS. Definitions, mechanisms, relevant outcomes, and clinical trial coordination. Am J Respir Crit Care Med. 1994; 149:818–824. [PubMed: 7509706]

21. Phua J, Badia J, Adhikari N, et al. Has mortality from acute respiratory distress syndrome decreased over time? American Journal of Respiratory and Critical Care Medicine. 2009; 179:220–227. [PubMed: 19011152]

22. Offenstadt G, Moreno R, Palomar M, Gullo A. Intensive care medicine in Europe. Critical Care Clinics. 2006; 22:425–432. [PubMed: 16893729]

23. Carr B, Addyson D, Kahn J. Variation in Critical Care Beds Per Capita in the United States: Implications for Pandemic and Disaster Planning. JAMA. 2010; 303:1371–1372. [PubMed: 20388892]

24. Adhikari N, Fowler R, Bhagwanjee S, Rubenfeld G. Critical care and the global burden of critical illness in adults. Lancet. 2010; 376:1339–1346. [PubMed: 20934212]

25. Rodwin, V. Japan's Universal and Affordable Health Care: Lessons for the United States. In: WHG, editor. Making Universal Health Care Affordable: How Japan Does It. New York, NY: 1991.

26. WHO. World Health Statistics 2011. 2011.

27**. Rhodes A, Ferdinande P, Flaatten H, et al. The variability of critical care bed numbers in Europe. Intensive Care Med. 2012 An observational study that provides key information on ICU bed provision across Europe. 10.1007/s00134-00012-02627-00138

28*. Wunsch H. Is there a starling curve for intensive care? Chest. 2012; 141:1393–1399. An editorial that highlights the challenges of identifying the appropriate number of ICU beds for a population and raises the possibility of harm associated with frequent use of intensive care. [PubMed: 22670019]

29*. Wunsch H, Angus D, Harrison D, et al. Comparison of Medical Admissions to Intensive Care Units in the United States and United Kingdom. American Journal of Respiratory Critical Care Medicine. 2011; 183:1666–1673. A large observational study providing detailed information on differences between ICU patients in the US and UK.

30. Hutchings A, Durand MA, Grieve R, et al. Evaluation of modernisation of adult critical care services in England: time series and cost effectiveness analysis. BMJ. 2009; 339:b4353. [PubMed: 19906740]

31. Metcalfe A, Sloggett A, McPherson K. Mortality among appropriately referred patients refused admission to intensive-care units. The Lancet. 1997; 350:7–11.

32. Goldfrad C, Rowan K. Consequences of discharges from intensive care at night. Lancet. 2000; 355:1138–1142. [PubMed: 10791376]

33. Banks J, Marmot M, Oldfield Z, Smith JP. Disease and disadvantage in the United States and in England. JAMA. 2006; 295:2037–2045. [PubMed: 16670412]

34. Adhikari NK, Rubenfeld GD. Worldwide demand for critical care. Current opinion in critical care. 2011; 17:620–625. [PubMed: 22067878]

35. Rapoport J, Teres D, Barnett R, et al. A comparison of intensive care unit utilization in Alberta and western Massachusetts. Crit Care Med. 1995; 23:1336–1346. [PubMed: 7634803]

36**. Robert R, Reignier J, Tournoux-Facon C, et al. Refusal of ICU Admission Due to a Full Unit: Impact on Mortality. American Journal of Respiratory and Critical Care Medicine. 2012; 185:1038–1040. An observational study that was able to follow both patients admitted to ICU as well as those who did not receive intensive care to examine the impact of early admission to ICU. [PubMed: 22589309]

37. Simchen E, Sprung C, Galai Nea. Survival of critically ill patients hospitalized in and out of intensive care units under paucity of intensive care unit beds. Critical Care Medicine. 2004; 32:1654–1656. [PubMed: 15286540]

38. Edbrooke DL, Minelli C, Mills GH, et al. Implications of ICU triage decisions on patient mortality: a cost-effectiveness analysis. Crit Care. 2011; 15:R56. [PubMed: 21306645]

39**. Stelfox H, Hemmelgarn B, Bagshaw S, et al. Intensive care unit bed availibility and outcomes for hospitalized patients with sudden clinical deterioration. Archives of Internal Medicine. 2012; 172:467–474. An important study from Canada that demonstrates the frequent changes in goals of care that occur when ICU bed availability is limited. [PubMed: 22412076]

40**. Hall W, Willis L, Medvedev S, Carson S. The implications of long-term acute care hospital transfer practices for measures of in-hospital mortality and length of stay. American Journal of Respiratory and Critical Care Medicine. 2011; 185:153–157. Observational data from the US that shows how short term mortality, length of stay, and costs of care can be shifted by varying use of long-term acute care faciilities.

41. Wunsch H, Guerra C, Barnato AE, et al. Three-year outcomes for Medicare beneficiaries who survive intensive care. JAMA. 2010; 303:849–856. [PubMed: 20197531]

42. Halpern NA, Pastores SM. Critical care medicine in the United States 2000–2005: an analysis of bed numbers, occupancy rates, payer mix, and costs. Crit Care Med. 2010; 38:65–71. [PubMed: 19730257]

43. Carson SS, Cox CE, Holmes GM, et al. The changing epidemiology of mechanical ventilation: a population-based study. Journal of intensive care medicine. 2006; 21:173–182. [PubMed: 16672639]

44. Kahn JM, Branas CC, Schwab CW, Asch DA. Regionalization of medical critical care: what can we learn from the trauma experience? Crit Care Med. 2008; 36:3085–3088. [PubMed: 18824900]

45. Sirio C, Tajimi K, Taenaka N, et al. A cross-cultural comparison of critical care delivery: Japan and the United States. Chest. 2002; 121:539–548. [PubMed: 11834670]

46*. Evans T, Nava S, Vazquez M, et al. Critical Care Rationing: International Comparisons. Chest. 2011; 140:1618–1624. International perspectives on delivery of critical care, highlighting the varying laws and culture worldwide and how they impact delivery of care. [PubMed: 22147820]

47. Iwashyna T, Christie J, Kahn J, Asch D. Uncharted Paths. Chest. 2009; 135:827–833. [PubMed: 19265091]

48. Nguyen Y, Kahn J, Angus D. Reorganizing Adult Critical Care Delivery: the role of regionalization, telemedicine, and community outreach. American Journal of Respiratory and Critical Care Medicine. 2010; 181:1164–1169. [PubMed: 20224067]

49. Aylwin CJ, Konig TC, Brennan NW, et al. Reduction in critical mortality in urban mass casualty incidents: analysis of triage, surge, and resource use after the London bombings on July 7, 2005. Lancet. 2006; 368:2219–2225. [PubMed: 17189033]

50. Fried MJ, Bruce J, Colquhoun R, Smith G. Inter-hospital transfers of acutely ill adults in Scotland. Anaesthesia. 2010; 65:136–144. [PubMed: 19995348]

51. Singh J, MacDonald R. Pro/con debate: Do the benefits of regionalized critical care delivery outweigh the risks of interfacility patient transport? Critical Care. 2009; 13:219. [PubMed: 19678918]

52. Truog R, Brock D, Cook D, et al. Rationing in the intensive care unit. Critical Care Medicine. 2006; 34:958–963. [PubMed: 16484912]

53. Giannini A, Consonni D. Physicians' perceptions and attitudes regarding inappropriate admissions and resource allocation in the intensive care setting. British Journal of Anaesthesia. 2006; 96:57–62. [PubMed: 16311284]

54**. Chen LM, Render M, Sales A, et al. Intensive care unit admitting patterns in the veterans affairs health care system. Archives of Internal Medicine. 2012:1–7. An important study that includes robust risk adjustment for hospitalized patients, examining the variability in ICU admission patterns across the Veterans Affairs health care system.

55. Vincent J. European attitudes towards ethical problems in intensive care medicine: results of an ethical questionnaire. Intensive Care Medicine. 1990; 16:256–264. [PubMed: 2358559]

56. Wunsch H, Linde-Zwirble WT, Harrison DA, et al. Use of intensive care services during terminal hospitalizations in England and the United States. Am J Respir Crit Care Med. 2009; 180:875–880. [PubMed: 19713448]

57. Sprung C, Cohen S, Sjokvist P, et al. End-of-life practices in European intensive care units: the Ethicus Study. JAMA. 2003; 290:790–797. [PubMed: 12915432]

58. Dunser M, Baelani I, Ganbold L. A review and analysis of intensive care medicine in the least developed countries. Critical Care Medicine. 2006; 34:1234–1242. [PubMed: 16484925]

59. Riviello E, Letchford S, Achieng L, Newton M. Critical care in resource-poor settings: Lessons learned and future directions. Critical Care Medicine. 2011; 39:860–867. [PubMed: 21297458]

60. Kost G, Tran N, Tuntideelert M, et al. Katrina, the Tsunami, and Point-of-Care Testing. American Journal of Clinical Pathology. 2006; 126:513–520. [PubMed: 16938656]

61. Mandourah Y, Ocheltree A, Al Radi A, Fowler R. The epidemiology of Hajj-related critical illness: lessons for deployment of temporary critical care services. Crit Care Med. 2012; 40:829–834. [PubMed: 22080635]

62. Brierley J, Carcillo JA, Choong K, et al. Clinical practice parameters for hemodynamic support of pediatric and neonatal septic shock: 2007 update from the American College of Critical Care Medicine. Crit Care Med. 2009; 37:666–688. [PubMed: 19325359]

63**. Maitland K, Kiguli S, Opoka RO, et al. Mortality after fluid bolus in African children with severe infection. The New England journal of medicine. 2011; 364:2483–2495. A multi-national randomized controlled trial of early fluid resuscitation for febrile illnesses in children which found higher mortality with fluid resuscitation. This study calls into question the common practice of early fluid resuscitation used in higher-resourced settings, and more generally the ability to translate practices across regions and different populations. [PubMed: 21615299]

Key Points

- Recent international data provide important information on the impact of ICU bed availability on care for critically ill patients.
- International comparisons also highlight the need to ensure long-term follow-up due to heterogeneity in discharge practices for critically ill patients.
- Evaluation of different systems of care, such as regionalization, flexible allocation of beds, and bed rationing, may be important for containment of healthcare costs worldwide.
- Standardization of important terms, such as critical illness and critical care beds, should be prioritized to facilitate rigorous comparisons across regions and countries.

Table 1

Selected ICU Bed Availability by country with per capita healthcare spending and life expectancy at birth [3, 6, 22–27] *

Country	ICU beds per 100,000 people	Per Capita Healthcare Cost **	Life Expectancy at Birth
United States	20.0–31.7	$7,164	79
Canada	13.5	$3,867	81
Denmark	6.7–8.9	$3,814	79
Australia	8.0–8.9	$3,365	82
South Africa	8.9	$843	54
Sweden	5.8–8.7	$3,622	81
Spain	8.2–9.7	$2,941	82
Japan	7.9	$2,817	83
UK	3.5–7.4	$3,222	80
New Zealand	4.8–5.5	$2,655	81
China	2.8–4.6	$265	74
Trinidad & Tobago	2.1	$1,237	70
Sri Lanka	1.6	$187	71
Zambia	--	$80	48

* Estimates are pooled from multiple sources and involve different definitions of ICU beds, and different years of data

** includes all public and private expenditures, not limited to critical care