Economics of ICU Organization and Management

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KEYWORDS

• Critical care • Intensive care unit • Length of stay • Staffing • Organization • Economics

Intensive care is an integral but expensive component of healthcare in developed countries.[1] An estimate in the United States is that fully 2% of the population receives intensive care every year,[2] and overall the percentage of patients who receive intensive care before they die is increasing.[3,4] Projections of the need for mechanical ventilation predict an exponential growth in the coming years due to the aging population and their over-representation among mechanically ventilated cohorts[5]; this increase in need for mechanical ventilation will be associated with increasing costs of intensive care.[6,7] Much of the focus of intensive care is on improvements in technology for organ support and resuscitation. Yet quality healthcare also involves appropriate organization of resources, with the potential to both impact patient outcomes and the costs of the care provided. These economic considerations are likely to become increasingly important as the demand for critical care increases in the face of limited resources.

The economics of organizing the delivery of intensive care can focus on the management of human resources and operating costs within an ICU itself, or the use

Funding was provided by award K08AG038477 from the National Institute on Aging to Hannah Wunsch.

The authors have nothing to disclose.

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Crit Care Clin 28 (2012) 25–37

doi:10.1016/j.ccc.2011.09.004 **criticalcare.theclinics.com**

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of ICU resources within a healthcare system. This article will focus on both these perspectives, emphasizing issues related to optimal staffing and the economic consequences of different staffing choices.

PERSPECTIVE REGARDING COSTS

The costs of providing critical care can be considered in short-term and long-term time horizons and are incurred to varying degrees by patients, hospitals, insurance companies, the government or other payer, and society as a whole. Thus, the first question to ask when evaluating the economic impact of any organizational change affecting the ICU is which party actually accrues a cost change.[8] In this article, we will primarily focus on the potential economic implications of organization and management choices from the perspective of the individual hospital.

Fixed Versus Variable Costs In the ICU

Hospital costs are composed of fixed and variable costs. In brief, the *fixed costs* remain constant and are independent of small changes in the number of patients being cared for in the hospital. They also generally reflect the operational costs required to provide care.[9] Examples of fixed costs in the ICU include staff salaries, the money paid to purchase mechanical ventilators, and the maintenance required on the building. *Variable costs* are the hospital costs associated with the care of individual patients, and will fluctuate with patient volumes. Examples of variable costs are the costs of specific medications the patient receives or the cost of an additional central venous catheter inserted.[10] The majority of costs associated with care in the hospital are fixed costs, often estimated to account for over 80% of total costs.[9] Whether or not hospital (or ICU) beds are occupied, the hospital continues to pay the fixed costs of care, and therefore most cost reductions associated with any system change will be small if due to changes in variable costs only.

The economics of intensive care from the perspective of the hospital also depend on how a hospital is reimbursed by a health system.[8] For example, under one type of payment system, a hospital receives a set amount of money for the care of all patients, regardless of the number that are actually admitted. Another option is a fixed level of reimbursement to the hospital to provide care for each patient admitted with a specific diagnosis or surgical procedure. In these situations, the actual components of treatment that are provided to an individual patient are not reimbursed separately, but instead the hospital receives a lump sum based upon expected costs. In a "per diem" model, the hospital is paid an additional sum for each day that a patient remains hospitalized. Hospitals can also be paid using a fee-for-service model, receiving a sum of money for each additional test, procedure, medication, etc that is provided to each patient. Within each of these payment schemes, there are opportunities for the hospital to change the system to maximize revenue. In this article, we primarily consider the actual costs of providing treatment when discussing strategies for reducing total costs, rather than strategies to improve the economic outlook for the hospital based on different payment schemes.

COSTS WITHIN THE ICU

Decreasing Length of Stay

Many studies in critical care target reductions in ICU length of stay and equate this outcome with a "cost savings." In reality, large cost savings will only be realized if the reductions in ICU length of stay result in a reduced number of total admissions and consequent reductions in number of ICU beds and fixed costs of care.[11] In addition,

one must be cognizant of the concept of "cost-shifting," in which reductions in costs in one area are accompanied by increases in costs elsewhere in order to address clinical needs. In most situations the actual cost savings associated with decreased ICU length of stay therefore comprise only a small fraction of total costs. For example, Kahn and colleagues analyzed the potential cost savings attributable to reductions in ICU length of stay for ICU survivors who had received mechanical ventilation and ICU admission of more than 3 days. The authors found that the mean variable costs of the last day in the ICU was $397, while the cost of the next day on the hospital ward was $279; thus, reducing ICU length of stay by 1 day would only result in a cost savings of 0.2% of all hospital expenditure for that patient.[12] Conversely, if there is typically high demand for ICU resources (and the absolute number of patients in the ICU remains relatively constant), reducing ICU length of stay can paradoxically increase variable costs because higher acuity patients requiring more intensive and expensive treatments replace the lower-acuity patients who are discharged.[12] Moreover, the overall economic effect of accommodating an additional ICU patient may be different depending on the type of ICU and the type of patient. For example, if any decrease in one patient's ICU length of stay helps avoid the cancellation of an elective surgery such as coronary artery bypass grafting for another patient, the actual economic impact on the hospital may be different than providing admission for an additional patient with pneumonia, but will also depend on how the hospital is reimbursed, as described earlier. In this article we address specific organizational aspects of the ICU by focusing on the actual costs incurred by providing direct care and, where possible, avoid inferences based on economic implications of reducing ICU length of stay. However, we generally consider interventions that decrease ICU length of stay to be desirable.

Staffing

The largest and primarily fixed costs of operating an ICU are staff salaries, which are estimated to account for over 50% of fixed costs for all hospitalized patients in the United States[9] and 33% to 69% of total ICU costs in other countries (**Fig. 1**).[13–20]

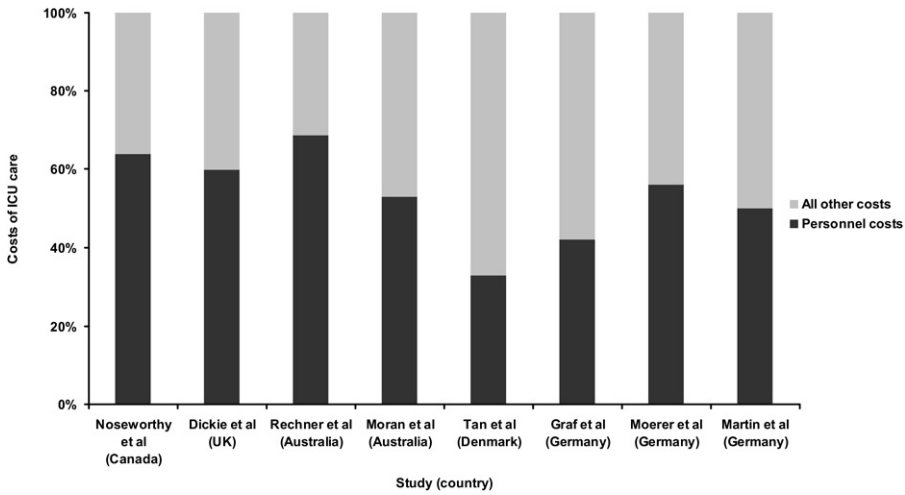

Fig. 1. Estimates of personnel costs associated with the ICU.

Staffing patterns in the ICU vary markedly between ICUs and between health systems, with variations in the specialty of the physicians, nurse-to-patient ratios, and the presence of other healthcare professionals on the team. Yet, the large proportion of costs in the ICU taken up by the compensation for its staff seems to be relatively consistent across many countries, despite the different staffing patterns and health-care systems.

Nursing

Nurses are an integral, if not the most vital, component of all ICU teams, but perhaps paradoxically, nurse-to-patient staffing ratios and other issues related to the provision of ICU nursing care differ from country to country, from region to region, and even may differ between ICUs in a particular hospital. One European study, for example, from the 1990s found that the majority of ICU nurses cared for 2 patients but also observed substantial variation between the planned nurse-to-patient ratios and actual staffing ratios in the ICU.[21] Studies conducted outside of the ICU have shown that higher nurse-to-patient ratios and more highly trained nursing staff are associated with fewer adverse events[22] and possibly decreased hospital mortality.[23] Fewer data are available to inform the most cost-effective nurse-to-patient ratio in an ICU, although some studies have suggested that higher nursing ratios decrease adverse event rates and lead to better patient outcomes.[22,24,25] Obviously, maintaining a higher nurse-to-patient ratio increases the fixed costs of intensive care and is a major barrier to providing one-on-one nursing in many ICUs (**Table 1**). It is also possible that savings associated with reductions in adverse events for patients could offset the higher fixed costs of higher nursing ratios, but this possibility remains speculative. Some ICUs have adopted a "flex" system that flexibly schedules nurses based on the anticipated workload in the unit at that time, rather than staffing based on the number of admitted patients or total beds. This structure may be financially beneficial for the hospital and may also improve nursing satisfaction by matching staff to workload demands.[26] However, this model may also result in unpredictable working hours and salaries for individual nurses.

Intensivist staffing

A great deal of attention is focused on the role of intensivists in the management of critically ill patients, particularly in the United States where there is a mix of staffing systems with only approximately one-third of ICUs covered by intensivists.[27] Overall, most studies demonstrate that intensivist staffing in the ICU improves clinical

Table 1
Examples of potential effects on hospital costs of different changes to ICU organiz±ation and management

Organizational Change	Possible Clinical Outcome	Fixed Costs	Variable Costs
Closing ICU beds	Unclear	Decreased	Decreased
Intensivist staffing	Decreased mortality	Increased	Unclear
Pharmacist staffing	Fewer adverse drug events, deceased LOS	Increased	Decreased
Lower nurse to patient ratio	Fewer adverse events, decreased LOS	Increased	Unclear
Checklist prompter	Decreased mortality, decreased LOS	Increased	Decreased

outcomes[28] and both the American College of Critical Care and the Society of Critical Care Medicine recommend intensivist coverage.[29] However, these studies have varied in the definition of a "closed" or "open" ICU and the number of hours of intensivist coverage and are hampered by potential selection biases associated with which patients received intensivist coverage as well as other factors such as the type of ICU, concomitant staffing patterns, and ICU culture.[30,31] Few studies have considered the cost-effectiveness of intensivist staffing. One simulation of intensivist implementation demonstrated cost savings (for the hospital), depending on the size of the ICU, but involved many large assumptions to draw conclusions regarding the impact of intensivists on the hospital system as a whole.[32]

Recent discussions have questioned whether 24-hour in-house intensivist coverage might lead to additional improvements in patient outcomes compared to daytime-only intensivist coverage.[33] One study demonstrated improved compliance with recommended processes of care, but no effect on hospital mortality with 24-hour in-house coverage.[34] Recent work by Banerjee and colleagues examined 24-hour in-house intensivist coverage (vs daytime only) and demonstrated a decreased length of stay for the sickest patients admitted at night and cost savings associated with the decreased length of stay.[35] The study did include estimates of the costs of additional intensivists, but did not clearly differentiate between fixed and marginal costs of care, thus potentially overestimating the cost savings associated with the decreased length of stay.

Multidisciplinary teams

Nonphysician team members have a large role in the ICU.[36,37] Data suggest that multidisciplinary teams on rounds can potentially impact the mortality[38] and length of stay of patients in the ICU.[39] However, expanding the membership of the multidisciplinary team, especially non-nursing healthcare workers, may also increase fixed costs in an ICU (**Table 1**).

Pharmacists have become an integral component of many ICU teams and several studies demonstrate the economic impact of clinical pharmacists in the ICU. One study in particular detailed the changes made in medication management with the input of a clinical pharmacist over a 3-month period, with a substantial portion of the consultations (47.1%) resulting in decreased drug costs.[40] More recent studies examined the impact of clinical pharmacists on management of particular groups of patients, such as critically ill patients with thromboembolic or infarction-related events[41] and infections.[42] Both studies demonstrated that direct involvement of pharmacists in care led to decreased charges for medications. However, it is important to note that the decreased variable costs may be offset by the fixed costs of the additional salaries.

Perhaps the more important benefit of pharmacists is the potential to decrease adverse drug events.[43] Preventable adverse drug events in the ICU may occur twice as frequently as on the regular hospital ward, primarily due to the greater number of drugs ordered in the ICU,[44] thus making the ICU a prime target for improvement in this area. One study demonstrated a decrease in prescribing errors by two-thirds with the addition of a senior pharmacist on rounds in the ICU.[45] The cost-effectiveness of pharmacists should therefore consider not only the pharmacist's salary and prescribing costs but also the potential reduction in the incidence of expensive complications.

Respiratory therapists are common in North American ICUs and often assume important clinical roles, especially with respect to ventilator management. The use of respiratory therapists varies in other countries. Outside of the ICU, respiratory therapist–initiated treatment protocols have led to better compliance with institutional

algorithms for care.[46,47] In the ICU, respiratory therapists have been shown to improve compliance with weaning protocols and decreased duration of mechanical ventilation.[48,49] Guidelines for weaning and discontinuing ventilatory support recommend that protocols designed for nonphysician health-care professionals should be developed and implemented by ICUs.[50] However, the impact of respiratory therapists on both patient mortality[51] and the economics of care is still not well defined.

The role of the physical therapist in the ICU appears to be evolving to include early rehabilitation, including mobilization of mechanically ventilated patients. Several recent studies have suggested that early rehabilitation may lead to improved patient outcomes, including functional status[52,53] and length of stay.[52–54] The full economic impact along with the cost-effectiveness of this intervention requires further study, but limited evidence suggests that this therapy may not lead to increased costs of care, even after accounting for the salaries of the physical therapy team.[52] Further research to evaluate the impact of this intervention is required, but the potential for large systemwide savings may also exist if some of these patients no longer require additional care in nursing or rehabilitation facilities due to early intervention.

Finally, the role of a palliative care team in the ICU, either as a separate consult team or as part of the ICU team itself, is still being defined, and the potential financial implications are not yet well explored. No studies have specifically addressed the financial impact of palliative care in patients in the ICU, but introducing these teams may lead to less use of intensive care (in subsets of patients)[55] and reductions in ICU length of stay.[56,57] However, the cost savings of these interventions may be limited since these patients represent a relatively small proportion of patients who (may) be cared for in the ICU and are likely to influence only the marginal costs of care.[11] It remains unknown whether reducing use of ICU at the end of life through aggressive palliative care can lead to any substantial impact on costs of care.

Standardization of Care

Health technology in the ICU, such as mechanical ventilators, pulmonary artery catheters, and other monitoring devices, may represent either fixed or variable costs. Many of these ICU technologies have a limited evidence base supporting their use and could be considered targets for cost-reduction strategies. The use of intensive care technology has been shown to vary widely among different intensivists working in the same ICU, with no discernible variation in patient outcomes. In one study, the daily discretionary costs of care varied by 43% across different intensivists, with a mean difference of $1,003 per admission and no differences in ICU length of stay or hospital mortality.[58] Reducing use of technology and equipment that have not been linked to improved patient outcomes will likely decrease costs[59] but can be slow to occur if clinicians consider these to be an integral part of ICU care. A recent example of changing practice is the use of pulmonary artery catheters; after multiple studies failed to demonstrate any clinical benefit associated with their systematic use in different ICU populations, the frequency of insertion has dropped dramatically in the United States.[60,61]

Standardization of treatment approaches and the use of protocols to help organize ICU care can help reduce the use of unproven and expensive treatments (or at least ensure that they are used only in situations that are supported by strong levels of evidence) and also may lead to increased use of evidence-based therapies and improved patient outcomes. There are many ways to approach standardization of care, which include the addition of multidisciplinary staff (as described earlier), the implementation of checklists,[62,63] prompting and the use of clinical reminders,[63] and the adoption of clinical protocols and treatment "bundles."[64] Some of these options

have been examined as individual components (such as checklists[65]) and others as "bundles" of care to be delivered together.[64,66] The combination of checklists on rounds with a "prompter" to ensure that the elements of the checklist were addressed was associated in one single-center study with decreases in mortality and length of ICU stay, potentially decreasing variable costs associated with care.[63] However, the fixed costs of requiring additional staff to act as "prompter" may offset the potential economic benefit of this intervention (see **Table 1**).

Many ICUs and hospitals have implemented protocols to limit the use of expensive technologies and treatments to their appropriate and evidence-based indications as a strategy to reduce costs and "indication creep." For example, there has been a substantial increase in off-label use of recombinant factor VIIa,[67] with little evidence to support its administration in many cases.[68] In the ICU, even a test as basic as an arterial blood gas may be subject to overuse, with one study demonstrating a substantial decrease in the number of arterial blood gas requests with implementation of guidelines and feedback.[69]

COSTS WITHIN THE HEALTHCARE SYSTEM

Organization of Admission and Discharge Practices and Alternatives to Care

Since ICU care is almost always more expensive than the care provided on a general ward,[12] choosing to *not* admit a patient to the ICU will likely decrease the costs of care for that individual. However, such decisions will also likely lead to worse outcomes if appropriate and potentially life-saving treatments are withheld; decreasing the use of intensive care is therefore only a feasible approach to decreasing costs if the admission to the ICU is not appropriate. One study examined the factors associated with being a "high-performance" ICU (defined as having a standardized mortality ratio of 1.0 or less) and found that these high-performing units all had ICU directors (or a designee) who were authorized to refuse admission to patients not meeting appropriate criteria and to triage requested admissions to extended-stay recovery rooms and intermediate care areas.[70] Cost savings for the hospital may also be realized if subacutely or chronically critically ill patients are discharged more expeditiously from the ICU, although as noted earlier, decreasing ICU length of stay by small amounts (such as a single day) may do little to impact costs of care.[12] However, patients with ongoing respiratory failure traditionally have had few options for care once their needs for acute intensive care are over, yet often stay in an ICU for extended periods. Different institutions attempt to accommodate these patients outside the traditional ICU setting in different manners. The designation of a flexibly sized section of the surgical ICU for the "subacutely ill" allowed for reductions in costly resources (eg, nursing) without the additional cost of building a separate step-down facility.[71] Similarly, several studies demonstrate that the creation of a physically separate step-down unit may result in reduced costs of care.[72–75] Another option in some hospitals, particularly in the United States, is to transfer patients quickly out of the acute hospital to receive prolonged care elsewhere. The use of long-term acute care facilities (which can care for mechanically ventilated patients) in the United States has increased dramatically over the past decade.[76] Whether the movement of patients to these facilities is cost effective for the healthcare system as a whole is unclear, but there may be a substantial decrease in costs for the acute care hospital if patients are discharged much earlier.

Regionalization

A broader approach to triage of patients to the most appropriate setting is regionalization of ICU beds and care of ICU patients, particularly mechanically ventilated

patients. In the United States this idea has been proposed based on data suggesting that outcomes may be improved for mechanically ventilated patients cared for at higher-volume hospitals.[77] Regionalized systems exist for both trauma and neonatal care,[78,79] and some regionalization occurs in most countries, either through formal systems[80] or informal networks.[81] However, the barriers to complete regionalization of intensive care are substantial, including concerns regarding strain on patients' families, lack of strong central authority to organize triage, and the potential to overwhelm capacity at larger hospitals.[82] The impact of regionalization of intensive care for the economics of hospitals is also uncertain, with concern that smaller hospitals may be hurt financially, while larger hospitals receiving patients may not have enough resources.[83]

Alternatively, telemedicine could allow for an increased reach of critical care expertise in remote ICUs by providing access to intensivists. These physicians may offer either monitoring or consultation as needed, and theoretically provide the associated benefits for patient care seen in studies of intensivist staffing.[28] However, the results are inconsistent[84]; two multicenter studies were unable to demonstrate an association between the use of telemedicine and patient outcomes,[85,86] while one has shown improvements for patients,[87] and another demonstrated some economic benefit.[88]

Assessing the potential impact of telemedicine programs is hampered by the fact that their adoption has often been studied in ICUs that already have high staffing ratios. The true benefit may be found only in small hospitals with limited access to intensivist care. Telemedicine could also be used as a tool to improve the implementation of specific interventions, and to facilitate adherence to current best practice, such as lung protective ventilation or early-goal directed therapy.[89]

SUMMARY

The ICU is a complex system and the economic implications of altering care patterns in the ICU can be difficult to unravel. While the clinical impact of many aspects of organization and management have been studied in the ICU, few studies have specifically examined the economics of implementing organizational and management changes. Even fewer have acknowledged the many competing economic interests of patient, hospital, payer, and society. It does appear, however, that for certain aspects of ICU organization (eg, the inclusion of a staff pharmacist on a multidisciplinary ICU team), there may be an alignment of clinical and financial goals for all parties. With continuously increasing healthcare costs there is a great need for more studies focused on economics to inform the optimal organization of the ICU. Ideally these studies should not focus solely on reductions in ICU length of stay but should strive to measure the true costs of care within a given healthcare system.

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