Curr Anesthesiol Rep (2013) 3:65–72
DOI 10.1007/s40140-013-0010-0

Staffing Models for the ICU: Open, Closed, MD, NP, or Telemedicine?

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Published online: 12 February 2013

Abstract Intensive care is an expensive endeavor, estimated to account for more than 4 % of health care expenditure in the USA. The cost of critical care services is expected to increase as the population ages and requires more ICU-level care. Intensivists are physicians specially trained in the care of critically ill patients. A large body of evidence indicates that involvement of intensivists in the care of critically ill patients improves clinical outcome and limits costs. Currently, only about one third of critically ill patients benefit from the care of a dedicated intensivist. This number is expected to increase because the Leapfrog Group, an organization representing a large consortium of health care purchasers, is working to financially reward hospitals with dedicated intensivist staffing. Several different models of critical care delivery exist, and there continues to be debate about the best way to provide care. In addition, a shortage of intensivists has led to a search for the best way to provide off-hours critical care coverage. This article reviews the evidence regarding intensivist-driven care, nighttime coverage, and telemedicine.

Keywords Intensive care unit · Intensivist · Leapfrog Group · Critical care physician · Telemedicine

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Introduction

The origin of the intensive care unit (ICU) emerged from an appreciation that critically ill patients benefit when clustered together in a defined area of the hospital. Throughout history there are multiple examples of units which were strategically designed to place acutely ill groups of patients in close proximity to the personnel and resources required for optimal care. The first recognized ICU consisted of four beds for monitoring postoperative neurosurgical patients at the Johns Hopkins Hospital in Baltimore [1]. This "unit" housed patients for the first 24 h after craniotomy and critically ill neurosurgery patients. During World War I and Word War II, shock wards were established to resuscitate injured soldiers [2]. In the 1950s, the development and use of mechanical ventilation led to the widespread development of respiratory care units across the country. In the same fashion, ICUs evolved to care for sick patients to allow efficient access to caregivers. More recently, superspecialized ICUs have been developed which cater for patients with specific medical and surgical conditions. ICUs are now recognized as an efficient way to care for our sickest patients. Today, ICUs share a common delivery model, which includes:

1. Specialized monitoring and therapeutic capabilities
2. A designated space
3. Resources to provide continual patient care
4. Appropriate nurse-to-patient ratios
5. Specialized personnel

ICUs are distinguished by a high nurse-to-patient ratio, usually 1:2 or less, but physician staffing in ICUs has not been standardized. It is recognized that critically ill patients consume a high proportion of medical resources, accounting for 20 % of hospital costs and 15 % of hospital days in the

USA [3, 4•]. In total, critical care medicine is estimated to account for almost 1 % of the gross domestic product [5]. Demand for improvements in patient outcomes, coupled with increasing pressure to decrease the cost of medical care, has encouraged research into the optimal physician staffing model to treat critically ill patients. As intensivists are physicians trained to manage critical illness, including sepsis, acute respiratory failure and hemodynamic instability, multiple studies have shown an association between intensivist-driven patient care and a reduction in ICU costs, hospital/ICU lengths of stay (LOS), and hospital/ICU mortality [6–10].

Defining an Intensivist

To answer the question of who should take care of critically ill patients, it is important to understand the definition of an intensivist. An intensivist is a physician who specializes in the pathophysiology of the critically ill. In a sense, intensivists are the primary care physicians of the ICU, coordinating the tests, treatments, and consultant recommendations for patients who experience multiorgan system failure. Intensivists are experts in implementing preventative therapies for diseases that are more commonly seen in the critically ill [11, 12]. In addition, intensivists are often asked to oversee ICU bed management, design clinical care guidelines, and make decisions about the purchase and use of equipment. In 1992, the Society of Critical Care Medicine (SCCM) published guidelines for the definition of an intensivist and the role of the intensivist in the ICU.

According to these guidelines, the definition of an intensivist may be summarized as:

1. A physician board-certified in the subspecialty of critical care medicine after completing an Accreditation Council for Graduate Medical Education approved training program or one who has equivalent qualifications
2. A physician who devotes more than 50 % of professional practice time to critical care medicine and participates in a unit-based 24/7 coverage model
3. A physician who has the ability to perform critical care procedures, including
   (a) Tracheal intubation and ventilator management
   (b) Catheter placement for venous access and hemodynamic management
   (c) Pacing wire placement
   (d) Cardiopulmonary resuscitation
   (e) Tube thoracotomy

The Leapfrog Group, a consortium of large corporations and public agencies formed to advance improvements in medical care quality and safety, has attempted to clarify the role of an intensivist [13]. This group was formed after a report from the Institute of Medicine stated that 98,000 Americans die each year from preventable medical errors [14, 15]. The Leapfrog Group explicitly states that an intensivist should manage or comanage ICU patients and also defines the availability of intensivists within the ICU and their role in care as follows:

1. All ICU patients are managed or comanaged by physicians certified in critical care.
2. Intensivists are present in the ICU (on-site or available by telemedicine) for a minimum of 8 daylight hours per day, 7 days per week.
3. Intensivists are available to return ICU pages within 5 min.
4. Patients can rely on a physician or nonphysician "effector" who is in the hospital and can reach the patient within 5 min.

In the USA, critical care is considered a subspecialty of several fields, including anesthesiology, surgery, pediatrics, internal medicine, neurology, neurosurgery, and emergency medicine. The critical care training within each specialty is not uniform, and it is recognized that subspecialty ICUs may require intensivists with a thorough understanding of the problems common to a particular patient subset [16•]. For example, a cardiac surgery ICU may have patients with cardiovascular complications, including heart failure, ischemia, and arrhythmias. The interventions may include sophisticated treatments such as intra-aortic balloon pumps, ventricular assist devices, and complex vasoactive medication management. The importance of having an intensivist with a thorough understanding of cardiac physiology and pathophysiology cannot be overstated.

Open Versus Closed ICU

The question of how to staff ICUs is a problem unique to the USA, as ICUs in the rest of the developed world are generally closed or mandatory intensivist consultation units [17]. In the USA, the quality of care and patient outcomes appear to differ widely between ICUs across hospitals [18, 19]. Differences in ICU staffing models may explain some of these differences in outcome.

To understand the literature addressing ICU staffing, it is necessary to understand the terminology used to describe the organization of patient care responsibilities (see Table 1). Broadly, ICUs may be divided into open or closed units [20]. In the closed unit model, the intensivist is responsible for all aspects of the patient's care, including ICU admission, discharge, and clinical management. In the open unit model, the primary attending is responsible for

Table 1 Terminology

Term	Definition
Closed ICU	An intensivist is primarily responsible for full-time ICU care
Effector	A nonintensivist physician or allied health care provider trained to recognize and treat acute decompensation in critically ill patients
High-intensity staffing	An ICU staffing model which includes mandatory intensivist consultation or a closed ICU
Intensivist	A physician who specializes in managing the care of critically ill patients
Leapfrog Group	A large consortium of health care purchasers and public agencies working to improve health care using recognition and rewards
Low-intensity staffing	An ICU staffing model which includes elective intensivist consultation or no intensivist consultation
Open ICU	A patient's primary physician is responsible for full-time ICU care. In many open ICUs the primary physician may consult an intensivist

ICU intensive care unit

individual patient clinical management, and intensivist involvement ranges from mandatory consultation to no involvement at all. Many of the early studies attempting to link improved patient outcomes to intensivist staffing compared cohorts of patients before and after introduction of a closed ICU model.

In 1984, Li et al. [6] analyzed outcomes of patients in a community hospital ICU before (year 1 patients) and after (year 2 patients) introduction of physicians dedicated to ICU patient care. They stratified the year 1 and year 2 patients using severity of illness (need for therapeutic intervention or mental status) and other characteristics (age, location prior to ICU admission, reason for admission), and demonstrated that year 2 patients had significantly lower mortality [odds ratio (OR), 0.62; 95 % confidence interval (CI), 0.45–0.98; $P = 0.01$]. In addition, they reported that mortality dramatically declined from year 1 to year 2 in patients with congestive heart failure and sepsis.

Subsequently, the results of multiple retrospective cohort studies have demonstrated improvement in mortality, morbidity, and other markers of care improvement [7, 8, 19, 21–28]. The weakness of these studies was the use of historical controls. This leaves open the question of whether the improvements in outcome were due to intensivist intervention or simply advances in medicine. One simultaneous cohort analysis by Hanson et al. [9] compared ICU patients cared for by dedicated intensivists versus ICU patients cared for by a group of general surgeons. This study did not demonstrate a difference in mortality, but patients cared for by dedicated intensivists had significantly shorter ICU and hospitals stays, a lower number of mechanical ventilation days, and sustained fewer complications. A variety of studies have shown improved outcomes in specific diseases when ICU management is directed by a dedicated intensivist. Improved outcomes have been documented in acute lung injury [29], moderate to severe trauma [30], abdominal aortic surgery [19], esophageal resection [22], and neurocritically ill patients [31].

In 2002, Pronovost et al. [10] attempting to evaluate the impact of intensivist ICU staffing on patient outcomes performed a systematic review and meta-analysis of 27 observational ICU staffing cohort studies including 27,473 patients. To stratify ICU intensivist staffing by the level of intensivist involvement in patient care, Pronovost et al. [10] introduced the terms "high-intensity staffing" and "low-intensity staffing." High-intensity staffing included ICUs using closed and mandatory intensivist consultation, and low-intensity staffing included elective intensivist consultation and no intensivist involvement. Pronovost et al. pooled the study results to compare 14,356 patients in high-intensity units with 13,117 patients in low-intensity units and found a significant decrease in ICU mortality (pooled estimate relative risk, 0.71; 95 % CI, 0.62–0.82) and hospital mortality (pooled estimate relative risk 0.61; 95 % CI, 0.50–0.75) in patients receiving care in high-intensity units. The study also noted that high-intensity staffing was associated with reduced hospital LOS in ten of 13 studies and reduced ICU LOS in 14 of 18 studies without case mix adjustment. They noted the potential for selection bias in the studies, but felt the results were representative because of the consistent results.

More recently, a study by Levy et al. [32] cast doubt on the benefit of intensivist-driven ICU care. They used the Project Impact database, a large voluntary administrative database developed by the SCCM, to examine the association between intensivist management and patient mortality. The study included 101,832 critically ill patients from 123 ICUs in 100 US hospitals and found that patients cared for by critical care physicians had a 40 % higher risk of mortality than patients cared for by non-critical-care physicians [OR, 1.4, 95 % CI, 1.32–1.49, $P < 0.001$). This study has many limitations and the findings run counter to a large body of evidence to the contrary, but should still be considered when examining the evidence.

In reviewing the literature, one finds the preponderance of evidence supports the involvement of an intensivist in the care of critically ill patients. The evidence indicates that critically ill patients are better served in an ICU with high-intensity staffing [10]. The weakness of the open model is the diffusion of responsibility, resulting in a lack of coordinated planning. In addition, in the open unit model, conflicting orders and plans from consulting services often result in ancillary staff dissatisfaction and ultimately may contribute to suboptimal patient outcomes [33, 34]. Evidence of improved outcomes with intensivist-driven care has spurred the design of units which allow the intensivist to assume responsibility for the patient and coordinate care.

One of the limitations of "closed" ICU care is the possible alienation of the patient's primary physician. This problem can be mitigated by maintaining open lines of communication and defined modes of transitions in care when transferring patients out of the ICU.

Nighttime Intensivist Staffing

On the basis of overwhelming evidence, daytime staffing of ICUs with trained intensivists is now strongly endorsed by the Leapfrog Group and the SCCM. Similar to most areas of the hospital, intensivists in many hospitals are present during daylight hours and provide limited weekend daytime coverage, but are not physically in the hospital at night. It has been recognized for decades that patients admitted to the hospital during nighttime and weekend hours have a higher risk of mortality [35]. There is some debate about the cause of this increased mortality. One theory is that there is a higher severity of illness in patients admitted in the nighttime hours. The recognized benefit of intensivist staffing during daytime hours has led for a call for 24-h intensivist staffing of ICUs [36]. At this time, only about 2 % of ICUs provide 24-h dedicated in-house intensivist coverage [17].

The evidence supporting in-house nighttime staffing by dedicated intensivists is less robust than that supporting daytime staffing. A study from the UK used historical controls to compare outcomes in ICU patients after introduction of 24-h intensivist coverage. A decrease in the mortality ratio from 1.11 to 0.81 (95 % CI 0.55–0.97; $P < 0.05$) after the change to 24-h intensivist coverage was reported [37].

Banerjee et al. [38] compared costs in cohorts of patients admitted to a medical ICU separated by a change from daytime in-house intensivist staffing to 24-h in-house intensivist staffing. This study specifically noted a reduction in the mean ICU LOS from 3.0 to 2.6 days ($P < 0.001$) after switching to a 24-h intensivist coverage model. To further evaluate the effect of 24-h intensivst coverage, Banerjee et al. separated the patients into daytime and nighttime admissions, and then stratified patients by APACHE III score quartiles. They found that the sickest patients admitted at night were the only group to see an actual reduction in LOS and cost. They also noted an estimated cost saving of US$10,000 for each of the sickest patients admitted at night. In this study, the cost of staffing the ICU with nighttime intensivists was completely offset by the savings associated with decreased ICU LOS. It was also noted that staff satisfaction and perceptions of patient safety, education, and unit organization improved with the 24-h staffing model, but there was not a statistically significant reduction in mortality or improvement in patient and family satisfaction [39].

Wallace et al. [40••] used a survey of hospitals included in the APACHE clinical information systems in 2009 and 2010. The respondents included 49 ICUs in 25 hospitals with a total of 65,752 ICU admissions. Data from 12 ICUs with nighttime intensivist staffing (including 14,424 ICU admissions) were compared with data from 37 ICUs without nighttime intensivist staffing (including 51,328 admissions). This study defined nighttime intensivist staffing as an intensivist in the ICU or in the hospital and available for emergencies. This study found that nighttime intensivist staffing was associated with lower mortality (OR, 0.62; $P = 0.04$) in ICUs with low-intensity daytime staffing (optional intensivist consultation model), but there was not a mortality benefit associated with nighttime intensivist coverage in ICUs with high-intensity daytime staffing (OR, 1.08; $P = 0.78$). One significant limitation of this study may be the definition of a nighttime intensivist. For instance, an intensivist with primary responsibility in another area of the hospital, but available for coverage, might confer a very different benefit from that conferred by a dedicated ICU intensivist.

The SCCM and the Leapfrog Group endorse a 24-h intensivist staffing model [41], but this model may be hard to justify financially purely on the basis of a mortality benefit according to the available evidence. In addition, an ongoing shortage of trained intensivists limits the ability of hospitals to convert to 24-h dedicated intensivist coverage [42]. One solution is to stratify the staffing requirements of ICUs on the basis of ICU size and patient acuity, similar to the method used to partition trauma centers [41]. ICUs can be designated into one of three levels, and the intensivist staffing intensity would vary on the basis of the ICU level. ICUs designated as level 1 would have comprehensive care including a dedicated in-house intensivist. ICUs designated as level 2 or 3 would still have daytime intensivist staffing, but off-hours staffing would use critical care "effectors" [43].

"Effectors" or "extenders" may be physicians or allied health care providers who are able to reach ICU patients within 5 min and are able to discuss patient care issues with an intensivist via the telephone or telemedicine [43]. In many academic hospitals, the physician extender is a resident physician. The Leapfrog quality initiative states that effectors should have completed the SCCM critical care support course [44]. This 2-day course was designed to train the nonintensivist to evaluate and treat the acute deterioration of critically ill patients. At this time, no study has evaluated the effectiveness of this course in lowering mortality or the hospital compliance with this initiative.

The current pool of effectors includes nurse practitioners, physician assistants, hospitalists, and resident physicians.

Few data exist comparing ICU patient outcomes using different types of care effectors [45]. One limited study compared care practices of nurse practitioners and physician assistants with those of resident physicians and found similar outcomes, but noted that resident physicians cared for older, sicker patients [46]. Multiple other studies have noted that nurse practitioners and physician assistants can be effective in implementing mechanical ventilation weaning protocols [47], and are proficient with ICU procedures [48, 49]. For practical purposes, a limited number of effectors are available to work nights and weekends, so a model may be generated using nurse practitioners, physician assistants, and hospitalists/residents interchangeably. Of course, this assumes that the effectors have been adequately trained to evaluate and treat acute changes in critically ill patients.

Telemedicine

The desire to improve patient outcomes with intensivist-supervised care has increased the demand for trained ICU physicians. The shortage of physicians in this field has generated a variety of solutions to increase availability of ICU physicians in all ICUs, including remote and smaller ICUs [50]. Theoretical benefits of a telemedicine program include more rapid intervention on alarms and abnormal laboratory values, and a rapid initiation of lifesaving treatment. Telemedicine is rapidly gaining acceptance in the ICU setting as a potential way to adhere to Leapfrog guidelines and gain the benefit of intensivist coverage of the ICU. A variety of versions of the telemedicine platform exist, but most have common features, including video conferencing and electronic monitoring. There are a wide range of telemedicine coverage models, and the level of involvement of the telemedicine service in patient care management differs by institution.

The published evidence supporting telemedicine as a program to increase access to intensivist patient care was initially positive. Grundy et al. [51] reported the first use of telemedicine in the ICU in 1977. This report demonstrated the feasibility of using audiovisual technology to allow remote intensivist consultation. Grundy et al. noted that the technology may be limited by the high cost of the equipment and that some clinical staff at the remotely monitored site had difficulty adapting to remote interactions with ICU practitioners. Rosenfeld et al. [52] conducted a prospective observational study comparing outcomes in patients in an academic-affiliated hospital surgical ICU before and after introduction of a telemedicine program. This ICU had intensivist coverage during the study period in the form of a consultant for 30 % of patients, and in the form of the primary management provider for 5–10 % of patients. In this study, the intervention was telemedicine used 24 h per day via intensivist coverage from home. The intensivist performed formal rounds or discussed each case with physician staff on a daily basis and discussed each patient with the bedside nurse twice a day. In addition, the intensivist was available for further consultation on an as-needed basis. The researchers compared 201 patients in the 16-week intervention period with patients in two separate 16-week baseline periods consisting of 225 patients in period 1 and 202 patients in period 2. Observed to predicted ratios for mortality decreased by 32 and 58 % from those in period 1 and period 2 after the intervention ($P < 0.05$). In addition, ICU LOS decreased by 26 and 35 % from that in period 1 and period 2, respectively ($P < 0.01$).

Since these two initial reports, multiple studies have been published examining ICU telemedicine and the impact on mortality and LOS. Most of these studies were reviewed and included in a meta-analysis by Young et al. [53••]. This meta-analysis analyzed 13 studies (including 41,374 ICU patients) which reported data on ICU and in-hospital mortality and/or ICU and hospital LOS. Young et al. noted that there was heterogeneity in the study setting, staffing models of the remote sites that were monitored, and the manner in which telemedicine was performed. Use of telemedicine coverage was associated with a reduction in ICU mortality (OR, 0.80; 95 % CI, 0.66–0.97; $P = 0.02$) but not in-hospital mortality (OR, 0.82; 95 % CI, 0.65–1.03; $P = 0.08$). Telemedicine coverage was associated with a reduction in ICU LOS (mean difference, −1.26 days; 95 % CI, −2.21 to −0.30; $P = 0.01$) but not hospital LOS (mean difference, −0.64; 95 % CI, −1.52 to 0.25; $P = 0.16$). One criticism of the studies in this analysis is most of the studies focused on outcomes based on interventions designed to rescue acutely ill patients at night [54]. In addition, there was a lack of randomized controlled studies included in the meta-analysis, although the same could be said of the evidence supporting intensivist-driven ICU care.

In 2011, Lilly et al. [55••] published the results of a prospective ICU telemedicine program implemented in a large academic medical center including 6,290 patients in seven ICUs. They compared ICU/hospital mortality, best practice compliance, rates of preventable complications, and hospital/ICU LOS before and after implementation of the program. In this study, the telemedicine team had full discretion in interventions and patient care (see Table 2). This is in sharp contrast to other studies in which the ICU telemedicine service had a reduced ability to intervene owing to limited physician approval [56]. The hospital mortality rate decreased from 13.6 to 11.8 % (OR, 0.40; 95 % CI, 0.31–0.52; $P = 0.005$) and ICU mortality decreased from 10.7 to 8.6 % (OR, 0.37; 95 % CI, 0.28–0.49; $P = 0.003$) after implementation of the

Table 2 Telemedicine ICU interventions in the study by Lilly et al. [55••]

Reviewed the care of individual patients
Audited best practice compliance
Venous thrombosis prevention
Cardiovascular complication prevention
Ventilator-associated pneumonia prevention
Stress ulcer prophylaxis
Care plan reviews for patients admitted at night
Electronic medical record
Imaging studies
Audio and visual interaction with patient
Communication with nurse and respiratory therapist
Active management and adjustment of care plan for patients admitted at night
Monitored telemedicine system generated alerts
Monitored clinician response to in-room alarms
Intervened in unstable patients or when in-house teams were delayed in response to alarms

telemedicine program. In addition, significant reductions in hospital and ICU LOS and the incidence of catheter-related bloodstream infections and ventilator-associated pneumonia were noted.

The study by Lilly et al. was unique because the physicians on the telemedicine team were allowed full discretion in patient care. This may have led to more interventions and direction of care [57]. In addition, the telemedicine team was used to ensure compliance with quality improvement guidelines. It is important to recognize that this study was performed in multiple ICUs in one academic center, so further study is required to evaluate this telemedicine practice model in other institutions.

Conclusion

ICU care is an expensive endeavor. Between 2000 and 2005 annual critical care costs increased by 44 % from US$56.6 billion to US$81.7 billion [4]. The number of patients requiring ICU care is expected to continue to increase with the aging of an increasingly multimorbid American population, since the elderly have a disproportionately higher demand for ICU-level care [58]. Controversy still exists regarding the best way to deliver care to critically ill patients. A large body of evidence supports the provision of an intensivist in the care of ICU patients. High-intensity ICU physician staffing is associated with improved outcomes and decreased costs [10]. Increasing financial pressure by organizations such as the Leapfrog Group will incentivize hospitals to consider intensivist staffing models. Closed unit models benefit the patient by providing high-intensity staffing and generating coordinated care plans, but may not be appropriate in all settings. The shortage of trained intensivists is not expected to change soon [59], so it is not feasible to expect all ICUs to use a 24-h in-house dedicated intensivist model. ICU staffing models may use an ICU effector to provide care during the night and at the weekend. In addition, telemedicine ICU coverage models may improve care, but the technology must be applied with a willingness to allow intensivist intervention and direction of care.

Acknowledgments Disclosure Jacob T. Gutsche and Jesse M. Raiten declare no conflict of interest.

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