Improving the Efficiency of ICU Admission Decisions*

Colin R. Cooke, MD, MS
Division of Pulmonary and Critical Care Medicine
University of Michigan
Ann Arbor, MI; and
Center for Healthcare Outcomes and Policy
University of Michigan
Ann Arbor, MI

Over the last three decades, the United States has witnessed unprecedented growth in critical care beds (1). On one hand, expansion in ICU bed supply may be viewed as beneficial because it helps us meet the needs of our increasingly older and sicker patient populations, effectively allowing hospitals to reduce detrimental delays in ICU admission and providing patients greater access to aggressive care. Through more aggressive care, hospitals may be able to achieve better patient outcomes (2). On the other hand, expansion in bed supply may further exacerbate existing inefficiencies in the use of critical care services leading to overuse and escalating costs (3, 4). For example, regional differences in an individual's likelihood of ICU admission is driven by the number of available ICU beds, independent of regional differences in disease prevalence, disease severity, or patient preferences (3, 6). Intensivists also now recognize that more care does not necessarily represent better care. In many circumstances, it only reflects unnecessary, or worse, unwanted care (7–9). Balancing patients' needs for critical care ("the demand") with the available critical care resources ("the supply") is one of critical care policymakers' greatest challenges.

Policymakers are not alone in their struggle to best match supply with demand. Every day, intensivists and other providers confront triage decisions about who should occupy or vacate available ICU beds. Like policymakers, providers have little evidence to turn to when seeking guidance about which patients are most likely to benefit from critical care (10). In most circumstances, providers are able to make an informed triage decision by considering their patient's need for life-sustaining interventions and their ability to benefit from critical care. But providers are highly sensitive to bed availability (8). Without triage protocols or guidelines to promote efficient bed use, many will admit even those with very low risk of death or, at the opposite end of the spectrum, rely on the "rule of rescue" and admit the sickest and often most terminally ill patients (11, 12). These two groups are among the least likely to benefit from the ICU. Efficient triage decisions are further complicated by financial incentives for physicians to use more critical care, and by the somewhat unpredictable nature of day-to-day fluctuations in the numbers of critically ill patients in the hospital.

In this issue of Critical Care Medicine, Yang and colleagues (13) provide an important addition to this literature by developing a model that aims to better match bed supply with demand in a single ICU. Utilizing data on over 600 admissions to a single tertiary-care cardiothoracic ICU, the authors developed and compared three queuing and simulation-based models to determine the best way to allocate ICU beds to incoming postoperative patients. As is standard for most queuing problems, the authors included three variables in their models: the daily number of ICU beds needed (i.e., operations performed that day), the service time (i.e., patient length of stay), and the number of beds in the ICU. These factors then determined the outcomes of the model: the average and maximum waiting times for patients whose surgery was cancelled due to unavailable beds, stratified by operation type. The authors determined that a dynamic model—one that prioritized operations (followed by ICU admission) for patients with longer waiting times and with lower expected lengths of stay—struck the optimal balance between maintaining high throughput and shortening wait times for all individuals. Maximum wait times in the dynamic model were reduced by up to 38% (4 days) for some patients compared to the status quo, although this reduction varied slightly by surgery type and average wait times were minimally reduced.

The authors are smart to choose the cardiothoracic ICU to study ICU admission practice. This ICU type may provide the optimal environment to begin to study and improve the efficiency of ICU bed management. Typically in these units the demand for beds is not only quantifiable, it is highly predictable; the primary source of admissions derives from the scheduled operative cases. Due to postoperative arrhythmias, labile hemodynamics, or need for mechanical ventilation, most patients undergoing cardiothoracic operations will require critical care services. ICU admission decisions are therefore largely driven by protocol rather than the physician's discretion or individual patient preferences.

Although the study provides important insights into ways to improve the ICU admission efficiency in the unit studied, it is less clear whether the results can be generalized to other ICUs. The aforementioned features of this particular ICU that make it receptive to study and amenable to improvement are not shared across all ICUs. Variability in the case-mix of patients served by the ICU, such as the proportion of thoracic vs.
cardiac cases, the ratio of emergent to elective cases, or the rate of ICU readmissions, may dramatically influence the predictability of admissions. Hospitals also likely vary in the extent to which cardiothoracic surgery patients are managed in a dedicated cardiothoracic ICU instead of a general medical/surgical ICU. As the need for intensive care on any given day becomes less predictable for bedside clinicians and operating room managers, the results of this analysis will become less useful. These limitations suggest that cardiothoracic ICUs or hospital leaders hoping to apply this model should first ensure that it is prospectively validated in novel settings prior to its use. Adapting the reported queuing models to noncardiothoracic ICUs will require much more tailoring of the model inputs to data that better reflects the ICU’s practice (14), and better considers the consequences of delaying ICU admission.

This study also provides several reminders regarding the contributions that queuing models can and cannot offer toward improving the efficiency of ICU admission decisions. In addition to proving insights on how to optimize cardiothoracic surgery cancellations, these models have advanced our ability to predict bed utilization, bed occupancy (14), and optimal bed capacity for a given demand (15). But these models will never fully realize large gains in the efficiency of ICU admission processes because they rely on a flawed assumption: that all patients who are admitted to the ICU will benefit from critical care services. The greatest inefficiencies in the admission process lie in the hands of providers who admit patients to the ICU that are unlikely to benefit particularly when beds are readily available (8), the hospitals that may foster this culture of overuse (5), and regions of the country that address an increase in ICU admission rates through bed expansions. Only when we address these complexities underlying ICU demand and accurately prioritize admission for individuals most likely to benefit from critical care, will we then be ready to realize the full potential of queuing models to improve the efficiency of the ICU admission process.

REFERENCES