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The Search for the Optimal Intensive Care Unit Triage Model

If you fly frequently, there's a good chance you've found yourself "bumped" from an overbooked flight.

Airlines overbook to boost occupancy rates. Higher occupancy rates maximize profits (Figure 1A) because a flight's costs are generally fixed, based mainly on the price of fuel. An empty seat is a missed opportunity for revenue (1). When a flight is overbooked, many airlines use a "first come, first served" model. The first passengers to check in for the flight are guaranteed seats, while stragglers are vulnerable to bumping.

Conversely, the hotel industry believes that 100% occupancy counterintuitively diminishes profits. A hotel's costs are not as fixed as an airplane's, as costs are tied directly to the number of rooms used. More rooms used means more staff is needed. Also, a hotel can more easily adjust staffing at times of high or low occupancy than an airline. Research from the hotel industry indicates that, on average, an occupancy rate of 75% is optimal because higher occupancy rates strain efficiency and decrease profits (Figure 1B) (2). Thus, hotels deliberately avoid reaching full capacity and need not be bound by a first come, first served policy, and whether you check into your room early or late makes little difference to them.

For both the airline and hotel industries, the ultimate goal is to maximize profits. Yet, to do so, each follows a different path. An intensive care unit (ICU), like an airplane or hotel, has a finite capacity. But rather than seeking to maximize profits, an ICU's goal is to provide the best quality of care for critically ill patients. Which model, then, should intensivists use when deciding which patients are "critically ill" enough to receive care? Should ICUs operate like airlines, viewing an empty bed as a missed opportunity and thus maximizing occupancy on a first come, first served basis? Or should ICUs operate like hotels, identifying an inflection point at which too little occupancy is wasteful but too high occupancy strains the system, resulting in poor quality of care for patients and burnout for clinicians (3, 4)?

Several metrics aim to measure this inflection point, which is the balance between ICU bed supply and ICU demand—more technically known as ICU capacity strain (3). The term "capacity

strain" sounds as if it was ripped straight from the handbook of a hospital administrator. So why should a clinician care about capacity strain? Numerous studies have demonstrated that capacity strain impacts how we use the ICU and the quality of care we provide (3). What we have lacked is consensus on the best way to measure capacity strain—by the number of available ICU beds, by how sick an ICU's patients are, etc.

In this issue of *AnnalsATS*, Anesi and colleagues (pp. 1328–1335) provide key contributions toward identifying the best way to measure capacity strain (5). The investigators took four metrics commonly used to quantify strain—ICU occupancy, ICU turnover, ICU acuity, and ward occupancy—and examined which ones were predictive of ICU admission. For each of the four metrics, greater strain made it less likely that a patient would be admitted to the ICU. This is not surprising, given what we know about how capacity strain influences the way we use the ICU. However, after accounting for patient characteristics, only ICU occupancy was independently predictive of ICU admission.

The authors also sought to evaluate the impact of ICU occupancy on quality of care, as measured by mortality. They found that higher ICU occupancy was predictive of increased mortality among ward patients, but not ICU patients, with sepsis. The authors offered several hypotheses for this finding—most concerning that perhaps under high-occupancy conditions, patients who might benefit from ICU care are instead triaged to the general ward. As exemplified in Figure 1C, ICU occupancy could impact quality of care in several ways, positively or negatively. This study depicts the association between ICU occupancy and quality of care as replicating the blue or gray lines, suggesting that higher ICU occupancy leads to lower quality of care.

The authors also demonstrated that when the ICU occupancy rate was greater than 70% (or fewer than five open ICU beds), the odds of ICU admission decreased linearly. This finding illustrates how sensitive we intensivists are to ICU bed availability. When several ICU beds are available, we may admit patients to the ICU who are not critically ill—our threshold for ICU admission may be too low. When there are few beds available, we may refuse admission to patients who are critically ill—our threshold may be too high (6). This study highlights that we have yet to determine which patients are particularly vulnerable to these system-level influences on ICU triage. Which patients would be admitted to the

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Figure 1. Occupancy and value among airlines, hotels, and intensive care units (ICUs). (A) Profits increase linearly with occupancy rates for the airline industry. (B) Profits for the hotel industry increase until occupancy rates reach approximately 75% occupancy, at which point more staffing is required and profits decrease. (C) Four hypothesized examples of how ICU occupancy may influence the quality of care delivered to critically ill patients. Red dashed line: if an ICU always provides the highest-quality care in a hospital, then maximizing ICU occupancy improves quality of care. Gray dashed line: increasing ICU occupancy results in less attention for each additional patient. Blue dashed line: at a given point, ICU occupancy becomes overwhelming and quality of care suffers. Black dashed line: in an ICU with flexible staffing, the ICU provides close attention at low occupancy; at high occupancy, the ICU increases staffing to meet demand, but at medium occupancy, the ICU maintains staffing as if occupancy were low, resulting in poor quality of care.

ICU under low-strain conditions but refused ICU care under high-strain conditions? Is ICU care best for these patients? Existing studies conflict regarding this so-called “discretionary” use of the ICU, with some revealing no difference in mortality while others suggest a benefit (7, 8).

This study presents several important questions that must be considered. First, how generalizable are these results to other ICUs? Although this was a multicenter study, all three hospitals were part of the same university hospital system, and prior studies have revealed that the prevalence (and likely the effects) of strain can differ substantially based on the clinical environment (9). Even within Anesi and colleagues’s study, ICU admission practices varied among the three hospitals. What, at the hospital or clinician level, motivates these differences remains uncertain. Second, what role should non-ICU care locations or care models play to reduce capacity strain? In this hospital system, intermediate care played a relatively minor role, and the extent to which ward-based critical-care consultations (e.g., involving rapid response teams) were used was unclear. Finally, the authors concluded that ICU occupancy is the most robust strain metric for future use, but the use of a single metric may inadequately capture the concept of strain. For instance, you might imagine situations where even though there are several open ICU beds, one or two extremely sick patients dominate the attention of the ICU clinicians and influence triage decisions regarding potential patients.

This study highlights what is perhaps another key difference between the airline and hotel industries: how unanticipated events are perceived. A customer getting bumped from a flight has become an everyday occurrence, with an expectation that the customer will be compensated and will wait for the next flight. For hotels, however, a customer with an existing reservation having no place to sleep may become a public relations nightmare. Where on this spectrum does refusal of ICU admission lie? For the intensivist, should refusing ICU care to a patient who might benefit be a routine part of the job, and what is an acceptable number of “bumped” patients?

Recent guidelines recommend that ICU triage be based on a patient’s potential to benefit from ICU care (10). This remains

difficult to implement, for several reasons. First, there are no good ways to estimate ICU benefit. Second, clinicians are imperfect prognosticators (11). Third, intensivists face great uncertainty related to patient queuing—it is difficult to predict on a given day how many patients will be admitted, when they will arrive, or how critically ill they will be. For these reasons, ICUs tend to fill up like an overbooked airplane, on a first come, first served basis. Yet, this study underscores that the first come, first served model may be particularly prone to influence by factors such as capacity strain.

The search for the optimal ICU triage model continues. This model must take into account the relative value that we intensivists place on maintaining an empty bed (sometimes casually referred to as a “code bed”) versus providing ICU care to a patient who may or may not benefit from it (12). Perhaps the optimal ICU triage model could help us avoid “bumping” the wrong patient. ■

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The Difficulty of Predicting Intensive Care Unit Mortality in Resource-limited Settings

Intensive care medicine is growing in availability and scope throughout the world, and while many countries have resource limitations, in some countries these limitations are pronounced. These include a severely reduced number of intensive care unit (ICU) beds, fewer ICU-trained providers per capita, less availability of critical technologies such as mechanical ventilation and laboratory and imaging modalities, and shortages of important medications such as antibiotics and vasopressors (1–3). Medical record systems may also be more rudimentary, limiting the information available to researchers and treating physicians. Despite these limitations, ICU care is a critical part of any health system and can provide life-saving interventions, as evidenced in the paper by Lalani and colleagues (pp. 1336–1343) published in this issue of *AnnalsATS* (4).

Using a retrospective chart review, Lalani and colleagues sought to accomplish three aims: describe for the first time ICU outcomes in a public hospital in Kenya, validate the Mortality Probability Admission Model II (MPM₀-II) in this population, and identify factors associated with increased mortality in this cohort. The authors examined outcome data (including ICU discharge and 30-d mortality) from a national referral hospital in western Kenya. This was an important and impressive undertaking, as almost a third of the charts were unavailable, highlighting the difficulty of performing research in such setting.

ICU mortality has not been previously described for a public hospital in Kenya, and Lalani and colleagues found an overall ICU mortality of 53.6%, which is notably higher than that predicted by the MPM₀-II model (21.4%). Although there was excess mortality at all deciles, this difference was especially pronounced at the lowest deciles of risk. This study is an important addition to the critical care literature, and publication in this well-read journal brings the

issues surrounding critical care research in a resource-limited setting to the attention of critical care researchers around the world.

The study by Lalani and colleagues highlights several issues involving risk prediction modeling in resource-poor nations. Accurate predictions of ICU mortality are important for research (e.g., comparing dissimilar cohorts), clinical care (allocation of resources and counseling), planning, and increasing ICU capacity. To be useful, such models must use easily available data. The Acute Physiology and Chronic Health Evaluation IV score requires dozens of inputs, including clinical, laboratory, and demographic data. Manual extraction of these data is time-intensive, and in practice its use requires a sophisticated electronic medical record using automated data extraction. The Simplified Acute Physiology Score requires far fewer inputs but relies on laboratory tests that may not be immediately available in a resource-limited setting. As such, the authors used the older model, MPM₀-II, because it does not require laboratory results and thus is more easily applied in resource-limited settings (5). Unfortunately, the reliability (calibration) of this model is limited by its regional specificity (the model was developed and validated at four academic centers in the northeastern United States) as well as its age (it was first published in 1993).

Prediction models are highly context dependent. In general, their accuracy degrades over time as current clinical practice become less reflective of the practices in use when the model was created (6). They are also most useful in populations and case mixes similar to those used during model building. Although some prediction models have sought to capture a wide breadth of patient, regional, and clinical variations (Acute Physiology and Chronic Health Evaluation IV analyzed data from more than 131,000 patients and 104 ICUs, and Simplified Acute Physiology Score III included more than 19,000 patients from Australia, Central and