Physician staffing of ICUs has always varied widely, and this has only increased with work hour limitations for physician trainees and the proliferation of staffing models including nonphysician extenders and telemedicine. Staffing options can be framed as a series of questions. Who does it? How many of them are there to do it? What do they do? How do they do it? These questions address the type, training, experience, and other characteristics of physicians, including details of work schedules (e.g., workload, duty hours, shiftwork, and coverage for nights and weekends), details of assigned tasks, and interfaces with nonphysician health-care workers.

Most of the opportunities to improve the performance of ICUs derive from improving the structures and processes of which they consist, including staffing models. Staffing in most ICUs, however, reflects historical precedents and practical necessities rather than what works best based on formal assessment. In the absence of quantitative evaluation, there is no reason to believe that existing staffing models result in optimal outcomes. Further, the optimal ICU staffing model may differ based on ICU type, size, case mix, and other factors.

Herein we review evidence related to intensivists, hospitalists, house officers, telemedicine, and physician extenders, with a focus on that which has appeared within the past 5 years. Although we concentrate on patient outcomes, we consider other outcomes that are important to physicians and society.
such as job satisfaction, length of stay (LOS), and costs.3

INTENSIVISTS

Many studies have assessed whether the outcomes of patients in the ICU are better if intensivists (attending physician specialists in critical care medicine) participate in their care or if patients experience greater exposure to intensivists. A coherent interpretation of this literature is challenging because of the myriad of differences between studies in ICU administration, team composition and function, physician practice, and other variables.4 Nonetheless, we will review the available literature.

OPEN VS CLOSED ICUS

Most studies of intensivist staffing relate to open vs closed ICU structures. Typically, patients in an open ICU are cared for by multiple generalists with or without assistance of intensivists, whereas all patients in a closed ICU are cared for by a single intensivist. In the United States and some other countries, open ICUs are more common,5,7 whereas closed ICUs are more common in other areas.8,9 This classification of ICU structure does not adequately characterize the intensivist staffing model, as numerous variations and intermediate models exist for both types.4,7 Furthermore, many other differences often exist between open and closed ICUs, making it difficult to infer that any benefits of closed-model ICUs are due to the contribution of intensivists; for example, closed ICUs are more common in academic hospitals that typically have residents and ICU fellows working in them.5,7

With these caveats in mind, >30 studies have compared outcomes in open vs closed ICUs. Most were from single ICUs, and most evaluated outcomes after changing from open to closed units. Results have been mixed. A meta-analysis of 27 studies involving 27,000 patients addressed the organizational diversity of ICUs by classifying intensivist involvement into high vs low “intensity.”10,11 Closed-model ICUs and open ICUs in which consultation by an intensivist was mandatory were classified as high intensity. High-intensity intensivist involvement was associated with lower ICU and hospital mortality (unadjusted, pooled risk ratios of 0.61 and 0.71, respectively), shorter ICU and hospital LOS, and lower costs. However, a cross-sectional study using the Project IMPACT database, including 101,000 patients in 123 ICUs,12 found that adjusted hospital mortality was higher for patients with intensivists involved in their care (OR, 1.42; P < .001). The reasons for these conflicting findings are unclear.13

AROUND-THE-CLOCK INTENSIVIST PRESENCE

Around-the-clock intensivist staffing, in which intensivists are present in the ICU 24/7, is common in some European countries.9 It is usually operationalized via shiftwork, wherein different intensivists are present during days and nights. However, variations can include the following: (1) whether the intensivists are required to remain in the ICU, in the hospital, or within a short distance from the hospital; (2) whether they are responsible for a single, geographically restricted ICU, or for patients in the ICU in different locations within a hospital; and (3) the expectation for maximum time from being called to arriving in the ICU. Around-the-clock intensivist staffing is less common in North American ICUs8,14-16 where even the much less rigorous staffing standards promulgated by the Leapfrog Group are rarely met.14,17

There are strong proponents of this staffing model,18,19 and it is becoming increasingly common worldwide. The primary rationale for 24/7 intensivist presence is logical: that critically ill patients need expert care during the day and night. Other reasons include references to data suggesting that care and outcomes are worse at night; however, that literature is contradictory, with some studies showing such an effect20-26 and others not.27-33 Finally, 24/7 intensivist presence has also been proposed to provide better end-of-life care and to benefit trainees and nurses.19

Despite copious opinions, data on this topic are limited and largely based on observational studies and/or the use of before vs after designs that use potentially problematic historical controls.34 Among 824 patients in an ICU in the United Kingdom, the standardized hospital mortality ratio declined from 1.11 to 0.81 after changing to the 24/7 staffing model.35 A US study of 4,388 patients in a medical ICU found that such a change was not associated with improved ICU mortality (10.2% vs 10.4%, P = .83), hospital mortality (17% vs 19%, P = .33), ICU LOS (difference, −0.2 days; P = .08) or family satisfaction, although improvements occurred in ICU-acquired complications, processes of care, hospital LOS, and intensivist burnout.36 Notably, in this latter study the standard staffing model had ICU fellows present overnight. The only interventional study that did not use historical control subjects37 used an alternating crossover study design in two closed-model, intensivist-run ICUs, one academic and one in a community hospital without house staff. Including the community ICU was valuable because it is more comparable to most ICUs than are the large, academic units that
are the subject of most ICU research. In this study, 24/7 intensivist presence did not improve patient outcomes or family satisfaction in either ICU. The main effect of the shiftwork model was on the intensivists, who reported reduced job and life stresses. The largest study thus far was a retrospective, cross-sectional analysis of 49 ICUs participating in the Acute Physiology and Chronic Health Evaluation (APACHE) database project. Nocturnal intensivist presence was associated with lower hospital mortality in ICUs in which daytime involvement of intensivists was low intensity (OR, 0.62; \( P = .04 \)) but not in ICUs in which daytime intensivist involvement was high intensity (OR, 1.08; \( P = .78 \)).

These findings underscore that the impact of 24/7 intensivist coverage may depend on ICU type and preexisting staffing. Moreover, 24/7 staffing requires more intensivists, which will be difficult to supply given the worsening intensivist shortage. An analysis limited to direct costs concluded that these were lower with 24/7 intensivists, although only for the sickest patients.

### Intensivist Workload

Staffing and workload are related. Aspects of intensivist workload include the number of hours worked per day, the details of nighttime coverage, the number of days worked per week and month, the details of weekend coverage, the number of patients cared for at a time, and the intensity of intellectual and physical effort while providing care. For the intensivists, staffing models must seek to ensure sustainable job satisfaction. This concern is highlighted by data showing that intensivists suffer from a high rate of job burnout.

But intensivist workload is also relevant to society, as the shortage of intensivists is exacerbated by the fact that trainees are discouraged from entering this subspecialty because they perceive the workload to be high. And, of course, there is concern that patient outcomes may be adversely affected by overtired and overworked intensivists. Although the workload of physician trainees has been progressively limited because of concerns that overwork negatively influences patient and personal outcomes, similar concerns for attending physicians have garnered little attention. Few studies have addressed these issues.

In a preliminary study of 38 intensivists in four academic centers in the United States, hours worked per week and number of nights on call per year did not correlate with job burnout or job distress. But three studies have found that the emotional consequences of being an intensivist are influenced by scheduling. In a cluster-randomized study in five medical ICUs, Ali et al studied the effect of weekend cross-coverage for intensivists doing half-month rotations. Such weekend respite reduced intensivists’ burnout and job distress without adversely affecting mortality or LOS. Two studies of intensivists doing 1-week rotations compared day/night shiftwork to enable around-the-clock intensivist presence, with staffing in which the intensivist was present during daytimes and took call at night from home. Both studies observed lower burnout under shiftwork, without differences in patient outcomes.

Dara and Afessa studied patient outcomes as they related to intensivist workload among 2,492 patients admitted to a medical ICU over an 18-month period in which the ratio of beds per intensivist varied from 7.5 to 15. They found that ICU LOS was longer when the ratio was 15, whereas hospital LOS and mortality rates did not differ. Although it had methodologic limitations, an observational study suggested better patient outcomes when intensivists worked 12-h rather than 8-h shifts. Despite limited data, the European Society of Intensive Care Medicine has stated that the optimal size of an ICU is 8 to 12 beds.

### Nonintensivist Attending Physicians

The shortage of intensivists assures us that nonintensivists will continue to act as primary attending physicians for most patients in the ICU in the United States. Although this includes physicians trained in numerous areas, most attention has centered on emergency physicians or hospitalists, for whom pathways to formal certification as intensivists have been established or are under discussion, respectively.

Hospitalists are attending physicians who specialize in the care of hospitalized patients. Hospitalists already participate in ICU care in many US hospitals. This can take a variety of forms, ranging from only responding to cardiopulmonary arrests and other emergencies, to routine off-hours coverage, to complete around-the-clock staffing. Two studies have assessed outcomes related to hospitalist participation. An observational study compared outcomes in two adult medical ICUs, one staffed by intensivists and the other by hospitalists supported by an intensivist-led consultation service. After adjustment for large differences in case mix, the hospitalist-led ICU had similar hospital mortality (OR = 0.80, \( P = .22 \)), ICU mortality (OR = 0.80, \( P = .41 \)), and ICU LOS (mean difference, −0.3 days; \( P = .32 \)). The second study compared outcomes when night coverage was provided by residents vs hospitalists in an intensivist-led pediatric ICU using a before vs after design. ICU mortality (OR = 0.36, \( P = .01 \)) and ICU LOS (mean difference, −21 h; \( P = .01 \)) were lower when care was provided by hospitalists.
Emergency physicians already routinely provide initial care to critically ill patients. In many community hospitals in the United States they are also expected to leave their EDs and attend to unstable patients in the ICU.\textsuperscript{58} We were unable to find any data on outcomes related to this latter role.

**Telemedicine**

ICU telemedicine has been implemented in several hundred hospitals in the United States.\textsuperscript{59} In telemedicine, ICU physicians and/or nurses remotely provide real-time care; this may be nighttime only or around the clock. The remote clinicians can electronically access telemetry, diagnostic tests, information from ventilators and other devices, electronic medical records, and computer order entry.\textsuperscript{60} Some telemedicine software continuously analyzes the data stream for early identification of worrisome trends. Telemedicine clinicians view patients via live video feeds and talk to ICU personnel by telephone or intercom; some have a robotic presence in the ICU.\textsuperscript{61} The remote physicians may or may not have ordering authority.

Several studies, most often assessing the Philips VISICU eICU system, have evaluated how ICU telemedicine affected mortality, LOS, and complications;\textsuperscript{62-65} with conflicting results. A meta-analysis of 13 studies including 35 ICUs and >41,000 patients\textsuperscript{66} identified the limitations of this literature: (1) before vs after study designs, (2) modest study quality, (3) large heterogeneity in baseline ICU structures and telemedicine implementation, and (4) potential for bias due to vendor involvement or support.\textsuperscript{66} Based on the meta-analysis, ICU telemedicine was associated with lower ICU mortality (OR = 0.80, \(P = .01\)) without concomitant changes in hospital mortality or LOS.

The initial and ongoing costs of ICU telemedicine systems are substantial, and there are conflicting data about the cost effectiveness of these systems.\textsuperscript{67,68} In addition, ICU telemedicine requires the ability to hire and retain the necessary ICU clinicians in addition to on-site providers who are available, at the very least, to perform procedures such as intubations. Of possible relevance to the lives of eClinicians, the psychosocial aspects of doing ICU telemedicine work differ considerably from those of bedside work, including different types of relationships, interpersonal encounters, and physical and mental stressors.\textsuperscript{69}

**House Officers**

Working under supervision as an extension of attending physicians, house officers have been an important component of ICU staffing in teaching hospitals, especially at night. Only a few studies have assessed how ICU staffing by residents or critical care fellows affects patient outcomes.

Peets et al\textsuperscript{70} evaluated the impact of ICU fellows in two closed-model medical-surgical ICUs that always had junior house staff but only had fellows half the time. This study found no differences in mortality or LOS associated with the presence/absence of the fellows.

The level of training of ICU residents was associated with outcome in two studies. In Taiwan, a study of 2,274 patients in two open-model ICUs that were covered by a single surgical resident\textsuperscript{71} found that hospital mortality of patients cared for by first-year residents was higher than those cared for by more advanced residents (25\% vs 18\%, \(P = .002\)). In another study of 16 pediatric ICUs, patients cared for by first- and second-year residents had higher mortality than those cared for by third-year residents, and higher mortality was seen earlier in the educational year for each resident level.\textsuperscript{72}

Increasingly stringent limits in many countries on duty hours for house officers have had important consequences for ICU staffing in such hospitals, including lowering continuity of care.\textsuperscript{47} The use of hospitalists and nonphysician providers has increased in teaching hospitals to fill these gaps.\textsuperscript{47} Although a study in two ICUs found that first-year residents working reduced hours had a lower rate of serious errors in association with more weekly sleep and fewer attention failures during work,\textsuperscript{73,74} in an evaluation of 104 ICUs, severity-adjusted mortality did not change after the 2003 duty hour limits were implemented in the United States.\textsuperscript{75}

**Nonphysician Providers**

Acting as physician extenders, nurse practitioners (NPs) and physician assistants (PAs) are increasingly involved in the care of ICU patients.\textsuperscript{15,76,77} These two types of providers differ with respect to their background and training\textsuperscript{76} but often assume similar roles in the ICU.

With a bachelor’s degree in nursing as a prerequisite, acute care NP programs in the United States last 1.5 to 5 years, culminating in a master’s or doctorate-level degree, and usually include training in procedural skills. In most states, NPs have prescription-writing privileges and do not require physician supervision agreements. In contrast, starting with college-level coursework, PAs study for approximately 2 years to gain a bachelor’s or master’s degree. They have prescription-writing privileges but must obtain procedural skills on the job, and their practice requires physician supervisory agreements in all states.
NPs and PAs have been integrated into house staff-based ICU teams\textsuperscript{70-81} or used to staff separate ICUs.\textsuperscript{82,83} NPs have been used in specialty-based teams that remain involved in care of patients who enter the ICU\textsuperscript{84-87} and as outcomes managers to provide unit-based care.\textsuperscript{88-90}

A number of studies have assessed the impact of NPs and PAs. With an NP acting as outcomes manager, hospital mortality, hospital and ICU LOS, duration of mechanical ventilation, complications, and costs were reduced.\textsuperscript{88,90} Adherence to clinical practice guidelines was greater when an NP was added to an open-model surgical ICU.\textsuperscript{89}

Several studies attest to the comparability of nonphysician providers and house officers in adult ICUs. An older study using historical control subjects found that mortality rates were similar for medical ICU patients cared for by house officers as compared with PAs.\textsuperscript{91} Two more recent studies each compared a medical ICU staffed by house officers to another staffed by NPs/PAs operating simultaneously in a single academic institution. These reported similar outcomes, including lengths-of-stay, mortality, and hospital discharge destination.\textsuperscript{82,83} Finally, comparison between ICU fellows and NPs in a subacute ICU showed no differences in mortality, LOS, duration of mechanical ventilation, or ICU readmissions.\textsuperscript{90,92}

The use of nonphysician providers in the ICU may lead to other benefits. First, unlike rotating house officers, these providers become a consistent workforce, which may reduce practice variation and improve communication between ICU staff members and, consequently, ICU culture and safety.\textsuperscript{93,94} Second, since procedural proficiency increases with practice,\textsuperscript{95-97} nonphysician providers have greater opportunity to hone these skills than do transient house officers. And third, over time these nonphysician providers can be expected to attain high-level expertise in ICU care by virtue of having repeated exposure to ICU-specific interventions and the nuances of diagnosis and management of critically ill patients.

The use of nonphysician providers in the ICU may have downsides, which should also be considered. First, NPs and PAs receive less formal in-school education on the pathophysiology, evaluation, synthesis, and presentation of complex medical cases than do medical school graduates. Thus, they often require a substantial investment of time and resources for on-the-job training.\textsuperscript{70,81} Second, as permanent ICU staff members, nonphysician providers may be similar to intensivists and ICU nurses in being at high risk for job burnout.\textsuperscript{98} Finally, employment of nonphysician providers is expensive, since their salaries are nearly twice that of residents,\textsuperscript{99,100} although some of this increased cost may be offset by cost savings associated with nonphysician provider-based care.\textsuperscript{95}

### Discussion and Conclusions

Overall, the current evidence regarding physician staffing of ICUs does not yet provide a coherent view of the optimal model to use. Baseline differences between ICU\textsuperscript{5} and use of differing end points makes it hard to compare across studies and may explain some of the conflicting findings to date. Wide study heterogeneity and narrow focus hinders the ability to generalize and draw conclusions. Most existing studies suffer from serious limitations: single-center designs; use of historical controls; focus on large, academic ICUs, rather than community ICUs of more modest size where most critically ill patients receive care\textsuperscript{94,96}; and evaluation limited to short-term patient outcomes, ignoring longer-term impact and outcomes relevant to the other stakeholders in ICU care.\textsuperscript{3}

The topic with the most data relating to patient outcomes is the intensity of intensivist involvement in care. Despite persistent arguments for closed-model ICUs,\textsuperscript{82} the evidence is inconsistent.\textsuperscript{10,12} Even if closed-model ICUs ultimately produce better outcomes, we do not know which specific elements of that multifaceted organizational paradigm are responsible for improvement. Similarly, current evidence does not strongly support the superiority of models with around-the-clock intensivist presence.\textsuperscript{35-37,90} The other topic with substantial (but still limited) data is use of nonphysician providers. This literature indicates that care provided by teams including NPs or PAs appears to be safe and comparable to that provided by other staffing models.

Although the best way to staff our ICUs is unknown, the landscape of ICU physician coverage will continue to change under the stresses of shortages of intensivists and increasing duty hour limitations for trainees. Nonphysician providers, innovative physician staffing models, telemedicine, and other technologies will be increasingly used to cope with these realities. This evolution makes it more important than ever to study how staffing affects outcomes.

As only quantitative evaluation can tell us whether one staffing model is better than another,\textsuperscript{1} we need more research from multiple sites to develop a consistent and integrated understanding of this complex topic.\textsuperscript{2} Research on this subject is complicated by several factors. First, optimal ICU staffing may depend on ICU characteristics such as type, size, and case mix. Second, designing and conducting studies on this topic is extremely challenging. Although interventional studies using cluster randomization or alternating crossover designs are feasible, it is difficult to obtain funding and buy-in from ICU physicians for this kind of research.\textsuperscript{2} Investigators should be open to other study designs, such as comparative effectiveness approaches.\textsuperscript{101} A third challenge is evaluating the
range of relevant outcomes for patients, health-care workers and society.³

A final comment derives from recognizing that all staffing models are composed of numerous elements that interact in complex ways with the other structures and processes involved in providing patient care. Accordingly, changing to a different staffing model is a complex intervention that results in numerous alterations in how an ICU functions. Finding superiority of one staffing model over another leaves unanswered the important question of whether this was due to the effects of a small number of essential elements or instead resulted from numerous elements of the better model and how they interacted with the specific structures existing in the ICU studied. Identifying such essential elements of ICU staffing, if they exist, might simplify the chance of replicating the intervention in other ICUs with full expectation of replicating the benefits. Although a worthy goal, identifying the essential or minimal elements of ICU staffing required to achieve superior outcomes adds an additional layer of difficulty to assessing the way we should be staffing our ICUs.

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