An Official American Thoracic Society Systematic Review: The Effect of Nighttime Intensivist Staffing on Mortality and Length of Stay among Intensive Care Unit Patients

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This Joint Statement of the American Thoracic Society (ATS) was adopted by the ATS Board of Directors, December 2016

Background: Studies of nighttime intensivist staffing have yielded mixed results.

Goals: To review the association of nighttime intensivist staffing with outcomes of intensive care unit (ICU) patients.

Methods: We searched five databases (2000–2016) for studies comparing in-hospital nighttime intensivist staffing with other nighttime staffing models in adult ICUs and reporting mortality or length of stay. We abstracted data on staffing models, outcomes, and study characteristics and assessed study quality, using standardized tools. Meta-analyses used random effects models.

Results: Eighteen studies met inclusion criteria: one randomized controlled trial and 17 observational studies. Overall methodologic quality was high. Studies included academic hospitals (n = 10), community hospitals (n = 2), or both (n = 6). Baseline clinician staffing included residents (n = 9), fellows (n = 4), and nurse practitioners or physician assistants (n = 2). Studies included both general and specialty ICUs and were geographically diverse. Meta-analysis (one randomized controlled trial; three nonrandomized studies with exposure limited to nighttime intensivist staffing with adjusted estimates of effect) demonstrated no association with mortality (odds ratio, 0.99; 95% confidence interval, 0.75–1.29). Secondary analyses including studies without risk adjustment, with a composite exposure of organizational factors, stratified by intensity of daytime staffing and by ICU type, yielded similar results. Minimal or no differences were observed in ICU and hospital length of stay and several other secondary outcomes.

Conclusions: Notwithstanding limitations of the predominantly observational evidence, our systematic review and meta-analysis suggests nighttime intensivist staffing is not associated with reduced ICU patient mortality. Other outcomes and alternative staffing models should be evaluated to further guide staffing decisions.

Keywords: intensive care unit; critical care; organization; staffing; administration

Contents

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High-intensity daytime physician staffing in intensive care units (ICUs), in which all patients are primarily managed or comanaged by an intensivist, is associated with reduced mortality and ICU length of stay (LOS) (1, 2), although the finding is not consistent across all studies (3, 4). Whether intensivist staffing at night has additional benefits remains a matter of debate (5). Despite inconsistent data supporting the efficacy of around-the-clock (day and night) intensivist staffing in large observational studies (6, 7) and a randomized controlled trial (8), several groups endorse this staffing model (9), and it has been adopted by many hospitals in the United States (10).

Nighttime intensivist staffing is not without potential negative consequences. First, it may substantially increase health care costs through higher physician salaries and more claims for services provided at night. Second, in academic centers, it may have undesirable impacts on education (11), such as reduced autonomy for postgraduate medical trainees (12). Finally, the nighttime intensivist model may not be feasible, given the strained intensivist physician workforce (13, 14).

Given these tensions, it is important to better understand the effectiveness of nighttime intensivist staffing on patient outcomes. Therefore, the objective of this systematic review, endorsed by the American Thoracic Society (ATS), was to determine the effect of an in-hospital nighttime intensivist staffing model on mortality, ICU LOS, and hospital LOS.

Methods

Development of the Research Question

In 2013, the ATS charged a committee of 14 critical care researchers and clinicians, including physicians, nurses, and clinical pharmacists, with performing a systematic review of the effect of ICU staffing on outcomes of critical illness. Initially, the committee developed a comprehensive list of topics relevant to ICU staffing, then excluded those topics with recently published or ongoing systematic reviews and those with limited evidence, as identified by scoping searches of PubMed and Google Scholar. The committee then formed four subcommittees and developed candidate research questions in the population-intervention-comparison-outcome (PICO) format (15) for four remaining broad topics: physician assistant and advanced practitioner staffing, nurse staffing, staffing of other professions, and organization of staffing. The committee discussed the six PICOs felt to be highest priority (*see* Table E1 in the online supplement), considering potential impact and availability of evidence, and came to consensus that the most important topic was the effect of nighttime intensivist staffing on ICU patient outcomes. The other five topics were excluded because of an inadequate current evidence base to contribute to a systematic review.

Data Sources and Searches

With the aid of a biomedical librarian, we searched PubMed (January 1, 2000–April 4, 2016), Scopus (January 1, 2000–April 4, 2016), Embase (January 1, 2000–April 4, 2016), CINAHL (January 1, 2000–April 4, 2016), and the Cochrane Library (January 1, 2000–April 4, 2016), using controlled vocabulary terms and key words covering concepts related to ICUs, physician staffing, and nighttime and limited to English language articles (*see* online supplement for full details). We did not consider citations before 2000 because preliminary scoping searches identified no studies from that period. We also hand-searched abstracts (2009–2015) from the annual conferences of the ATS, American College of Chest Physicians, International Symposium on Intensive Care and Emergency Medicine, European Society of Intensive Care Medicine, and Society of Critical Care Medicine. Last, we hand-searched reference lists of all studies selected for detailed review. We followed the recommendations from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) for reporting the results of this systematic review (16), and summarize our methodology in Table 1.

Study Selection

We included studies meeting the following criteria: randomized or observational study design with a control group; population or setting, adult ICU; intervention or exposure, in-hospital nighttime intensivist staffing model; and at least one prespecified study outcome reported. Our primary outcome was mortality. For studies that reported more than one mortality point, we used mortality data in the following order: specific time (at least 28-day duration), hospital, ICU. Secondary outcomes were ICU and hospital LOS as measures of resource use, as well as staff satisfaction, patient and family satisfaction, rates of ICU complications and ICU readmission, and ICU processes of care. We limited inclusion to studies with adult patients, as adult clinical practice

Table 1. Methods

	Yes	No
Panel assembly		
Included experts for relevant clinical and nonclinical disciplines	X	
Included an individual who represents the views of patients and society at large	X	
Included a methodologist with appropriate expertise (documented expertise in conducting systematic reviews to identify the evidence base and the development of evidence-based recommendations)	X	
Literature review		
Performed in collaboration with librarian	X	
Searched multiple electronic databases	X	
Reviewed reference lists of retrieved articles	X	
Evidence synthesis		
Applied prespecified inclusion and exclusion criteria	X	
Evaluated included studies for sources of bias	X	
Explicitly summarized benefits and harms	X	
Used Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to report systematic review	X	

and outcomes are sufficiently distinct from pediatric and neonatal intensive care.

Two committee members independently screened all citations retrieved through database searches to select studies potentially meeting our inclusion criteria. We retrieved the full-text manuscript of citations deemed potentially relevant from searches of databases and bibliographies of ultimately included studies. Two committee members independently evaluated these for inclusion. Disagreements were resolved though discussion and by adjudication from a third reviewer as necessary. We calculated kappa (κ) to estimate interrater agreement for inclusion after discussion by reviewer pairs. We excluded secondary studies when more relevant or complete outcomes were reported in other included studies.

For abstracts without full manuscripts published in 2014 or later, two reviewers evaluated the abstract, in consideration that full manuscripts may be in preparation. If needed, we contacted authors of all studies (manuscripts and abstracts) reviewed in detail for inclusion to clarify methodology and request additional data as necessary (17–33).

Data Extraction

We extracted data using a standardized form and entered information into REDCap, a web-based data management platform (34). Each reviewer independently extracted data on study design, setting, population, and results and assessed study quality, using the Cochrane Risk of Bias tool for randomized controlled trials (35) and the Newcastle-Ottawa Scale for observational studies (36). A third reviewer resolved differences in assessments of study quality.

Data Synthesis

Anticipating that many studies would be observational, we determined *a priori* that the primary meta-analysis would include only randomized controlled trials (RCTs) of in-hospital intensivist nighttime staffing compared with any other nighttime staffing model. We planned three secondary analyses: all RCTs, experimental studies, and observational studies in which nighttime intensivist staffing was the only difference between exposed and unexposed groups and providing adjusted estimates of effect; these studies plus additional observational studies (in which nighttime intensivist staffing was the only difference between exposed and unexposed groups) with unadjusted estimates of effect; and all studies, regardless of adjustment, and those with a composite exposure or intervention (e.g., in-hospital nighttime intensivist staffing and other organizational differences, such as allied health professional staffing, availability and use of clinical protocols, and ICU bed number).

To explore potential modifiers of the effect of nighttime intensivist staffing, we planned three subgroup analyses: intensity of daytime physician staffing (high vs. low), ICU type (medical, surgical, mixed, or specialty), and geographic location (North American, European, or other). We defined high-intensity daytime physician staffing as models in which intensivists were primarily responsible for care or in which their input as consultants was mandated for all ICU patients; low intensity included all other models. All subgroup analyses were planned for the primary outcome of mortality. Analyses of the secondary outcomes of ICU and hospital LOS included all studies that reported these outcomes, irrespective of study design or effect adjustment.

We assessed for publication bias by constructing a funnel plot of all studies included in any analysis (37) and using the Egger's regression test (38) and the Macaskill test (39, 40). We assessed study heterogeneity using I^2, the percentage of

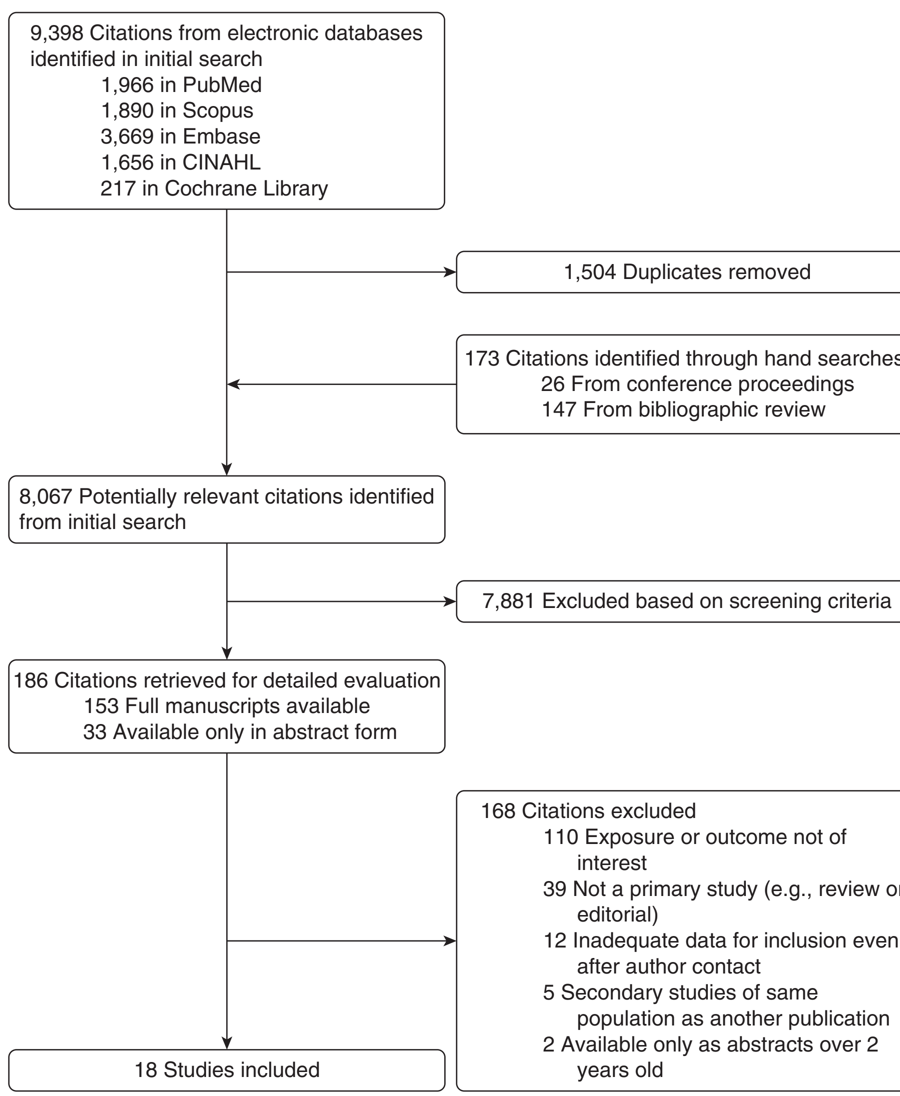

Figure 1. Study selection for systematic review. CINAHL = Cumulative Index to Nursing and Allied Health Literature.

Table 2. Studies of Nighttime Intensivist Staffing

Study	Study Design	Geographical Location	Key ICU Features	Number of ICUs; Number of Patients	Nighttime Staffing: Exposed Group	Nighttime Staffing: Control Group(s)	Severity of Illness Measure Used for Risk Adjustment; OR (95% CI)	Outcomes Measured
Baharoon *et al.*, 2004–2005 (44)	Cohort	Saudi Arabia	Academic, high-intensity staffing, mixed medical and surgical ICU	2; 1,921	In-hospital house staff, ICU hospitalist, and intensivist	In-hospital house staff and fellow or ICU hospitalist; intensivist available on demand	APACHE II; 0.56 (0.38–0.84)	Mortality (hospital, 30-d) LOS (ICU)
Dugar *et al.*, 2011–2012 (28)	Before–after	United States	Community, high-intensity staffing, mixed medical and surgical ICU	1; 598	In-hospital house staff and intensivist	In-hospital house staff; intensivist available on demand	None; 0.64 (0.43–0.98)	Mortality (hospital) LOS (ICU, hospital)
Gajic *et al.*, 2005–2007 (29)	Before–after	United States	Academic, high-intensity staffing, medical ICU	1; 2,641	In-hospital house staff, fellow, and intensivist	In-hospital house staff and fellow; intensivist available on demand	APACHE III; 1.18 (0.93–1.49)	Mortality (ICU, hospital) LOS (ICU, hospital) ICU readmission Processes of care ICU complications Patient/family satisfaction
Garland *et al.*, 2008–2009 (12)	Prospective crossover	Canada	One academic, high-intensity, medical ICU; one high-intensity, community mixed medical and surgical ICU	2; 501	In-hospital intensivist, in addition to usual staffing for each ICU	In-hospital house staff and fellow in academic ICU; no in-hospital physician in community ICU; intensivist available on demand	APACHE II; 1.22 (0.73–2.04)	Mortality (ICU, hospital) LOS (ICU, hospital) Patient/family satisfaction
Gershengorn *et al.*, 2008 (45)*	Cohort	United States	Academic, high-intensity staffing, medical ICUs	2; 590	In-hospital intensivist	In-hospital house staff; intensivist available on demand	MPM_0 III; 0.75 (0.46–1.23)	Mortality (ICU, hospital) LOS (ICU, hospital) Discharge disposition
Kerlin *et al.*, 2001–2008 (6)	Cohort	United States	Mixed academic and community, mixed high- and low-intensity staffing, multiple ICU types	143; 258,655	In-hospital intensivist, not further specified	No in-hospital intensivist, not further specified	MPM_0 III; 1.03 (0.92–1.15)	Mortality (ICU, hospital) LOS (ICU, hospital) MV duration
Kerlin *et al.*, 2011–2012 (8)	RCT	United States	Academic, high-intensity staffing, medical ICU	1; 1,598	In-hospital house staff and intensivist	In-hospital house staff; intensivist available on demand	APACHE III; 1.08 (0.93–1.25)	Mortality (ICU, hospital) LOS (ICU, hospital)
Kumar *et al.*, 2005–2008 (46)†	Before–after	United States	Academic, high-intensity staffing, general surgical and specialty ICUs	2; 1,866	In-hospital intensivist	In-hospital house staff; intensivist available on demand	APACHE II; 0.80 (0.41–1.55)	Mortality (ICU, hospital, 30-d) LOS (ICU, hospital) ICU readmission Processes of care Postoperative complications
Lee *et al.*, 2000–2011 (31)‡	Before–after	United States	Community, both low- and high-intensity staffing, surgical ICU	1; 6,081	In-hospital intensivist, with the addition of advanced practitioners toward end of study period	Not further specified	None; 1.31 (1.07–1.60)	Mortality (ICU) LOS (ICU, hospital) Duration of MV
McMillen *et al.*, 1996–2010 (47)§	Before–after	United States	Academic, high-intensity staffing, general surgical ICU	1; 13,092	In-hospital house staff, physician assistants, and intensivist	In-hospital house staff, intensivist available on demand	None; 1.28 (1.04–1.57)	Mortality (ICU, hospital)

(Continued)

Table 2. (*Continued*)

Study	Study Design	Geographical Location	Key ICU Features	Number of ICUs; Number of Patients	Nighttime Staffing: Exposed Group	Nighttime Staffing: Control Group(s)	Severity of Illness Measure Used for Risk Adjustment; OR (95% CI)	Outcomes Measured
Netzer *et al.*, 2004–2008 (48)[‖]	Before–after	United States	Academic, high-intensity staffing, medical ICU	1; 3,687	In-hospital house staff and intensivist	In-hospital house staff; intensivist available on demand	Multiple variables; 0.74 (0.62–0.88)	Mortality (ICU, hospital) LOS (ICU, hospital) Duration of MV Processes of care
Ramaswamy *et al.*, 2009–2011 (54)	Cohort	United States	Mixed academic and community, mixed high- and low-intensity staffing, cardiothoracic ICUs	43; 29,449	In-hospital intensivist, not further specified	No-hospital intensivist, not further specified	None; 0.70 (0.51–0.96)	Mortality (7-d) LOS (ICU)
Sakr *et al.*, 2007 (49)	Cohort	International	Mixed academic and community, mixed high- and low-intensity staffing, multiple ICU types	1,265; 13,796	In-hospital intensivist, not further specified	No-hospital intensivist, not further specified	SOFA; 0.69 (0.47–1.01)	Mortality (hospital)
Soares *et al.*, 2013 (50)[¶]	Cohort	Brazil	Mixed academic and community, high-intensity staffing, multiple ICU types	78; 59,693	In-hospital intensivist, not further specified	No-hospital intensivist, not further specified	SAPS 3, SOFA; 1.04 (0.78–1.37)	Mortality (hospital) LOS (ICU, hospital)
Trivedi *et al.*, 2013–2014 (51)	Before–after	United States	Academic, high-intensity staffing, medical ICUs	2; 2,818	In-hospital house staff, fellow, and intensivist	In-hospital house staff; fellow in-hospital until 2 am, and then on-demand	APACHE II; not performed	LOS (ICU) Duration of MV ICU complications
van der Wilden *et al.*, 2008–2010 (52)	Before–after	United States	Academic, high-intensity staffing, general surgical ICU	1; 2,829	In-hospital house staff, fellow, and intensivist	In-hospital house staff and fellow; intensivist available on demand	APACHE II; 0.87 (0.65–1.16)	Mortality (ICU, hospital) LOS (ICU, hospital) Duration of MV ICU readmission Processes of care ICU complications
Volkert *et al.*, 2004–2005 (53)**	Before–after	Germany	Academic, low-intensity staffing, surgical ICU	2; 1,182	In-hospital intensivist	Not specified	None; not performed	LOS (hospital) ICU complications
Wallace *et al.*, 2009–2010 (7)	Cohort	United States	Mixed academic and community, mixed high- and low-intensity staffing, multiple ICU types	49; 65,752	In-hospital intensivist, not further specified	No-hospital intensivist, not further specified	Acute physiology score; 1.02 (0.73–1.41)	Mortality (hospital)

Definition of abbreviations: APACHE = Acute Physiology and Chronic Health Evaluation (58–60); CI = confidence interval; ICU = intensive care unit; LOS = length of stay; MPM_0 III = mortality probability model (61); MV = mechanical ventilation; OR = odds ratio; RCT = randomized controlled trial; SAPS 3 = Simplified Acute Physiology Score, version 3; SOFA = sequential organ failure assessment.

Odds ratio is for the effect of the exposure on mortality, adjusted as reported in the study. When no adjustment is performed, unadjusted estimate is reported.

*Exposed ICU staffed by nurse practitioners and physician assistants during daytime; unexposed ICU staffed by house staff continuously.

†Transition from care of cardiac surgery patients in a general surgical ICU to a dedicated cardiac surgery ICU, including multiple organizational and process changes; creation of ICU of exposed group was in response to regional restructuring and increase in surgical volume and fast-track postoperative care. The postintervention period also included an expansion of beds and closure of a step-down unit.

‡Multicomponent exposure, including nighttime intensivist staffing, change in physical location, size of ICU, change in respiratory therapist–patient ratio, and incorporation of full-time clinical pharmacy support.

§Included only trauma patients (not all patients) admitted to study ICU; control group included changes in daytime staffing and implementation of new protocols.

‖Organizational changes during study period included daytime physician and advanced practitioner staffing and training.

¶Included patients aged 16 years and older. "Community" hospitals in Brazil include both private for-profit and public hospitals without academic affiliations.

**Limited to cardiac surgery patients; description of patient populations in each study group otherwise limited; study of cost outcomes.

Table 3. Assessment of Study Quality of Observational Studies, using the Newcastle-Ottawa Scale

Study	Selection (Maximum, 4)	Comparability (Maximum, 2)	Outcome (Maximum, 3)	Total (Maximum, 9)
Baharoon *et al.* (44)	4	2	2	8
Dugar *et al.* (26)	3	0	2	5
Gajic *et al.* (29)	4	2	3	9
Garland *et al.* (12)	4	2	2	8
Gershengorn *et al.* (45)	3	2	3	8
Kerlin *et al.* (6)	4	2	3	9
Kumar *et al.* (46)	3	2	2	7
Lee *et al.* (29)	3	2	2	7
McMillen *et al.* (47)	4	0	2	6
Netzer *et al.* (48)	3	2	3	8
Ramaswamy (54)	4	1	3	8
Sakr *et al.* (49)	3	2	2	7
Soares *et al.* (50)	4	0	3	7
Trivedi *et al.* (51)	4	2	3	9
van der Wilden *et al.* (52)	3	0	3	6
Volkert *et al.* (53)	3	0	2	5
Wallace *et al.* (7)	4	2	3	9

The Newcastle-Ottawa scale is a measure of study quality of cohort studies (details available at http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp), in which a score is assigned to each of three categories: selection, comparability, and outcome. Selection refers to how the study population is selected and its representativeness of the actual population (maximum, 4 points). Comparability refers to how well the exposed and unexposed cohorts can be compared, based on the design or analysis (maximum, 2 points). Outcome refers to the quality of the assessment of the outcome (maximum, 3 points). The total score is the sum of the scores assigned to each category.

variability across studies attributable to heterogeneity rather than chance (41). We calculated pooled odds ratios (ORs) for mortality and mean differences for LOS, both with 95% confidence intervals (CIs), using DerSimonian and Laird random effects models (42). We included adjusted ORs for mortality when reported or provided by authors. When results of primary studies were stratified because of a hypothesized interaction, we included the results reported for the entire cohort and the stratified results as a sensitivity analysis. We used unadjusted values of the mean and standard deviation for LOS results and estimated those that were reported as median and interquartile range (43). All statistical analyses were performed using Stata 14.0 (StataCorp LP, College Station, Texas) and R 3.2.0 (R Foundation for Statistical Computing, Vienna, Austria).

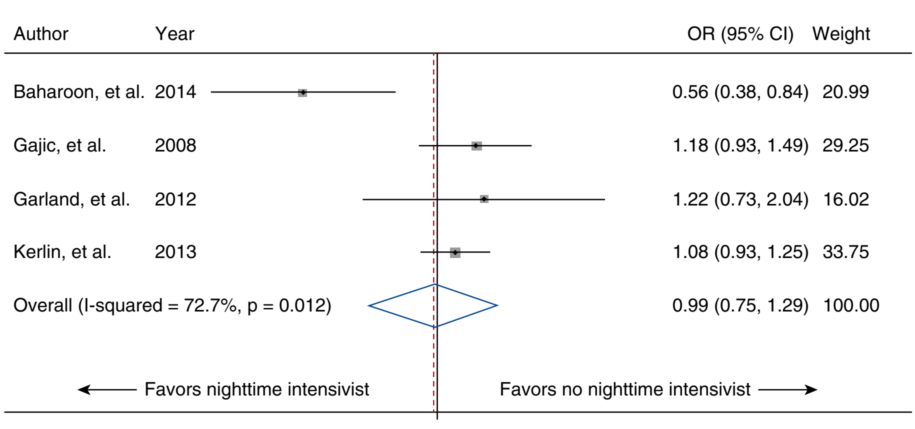

Figure 2. Association of nighttime intensivist staffing with mortality. The analysis uses a random effects model and includes all studies with an intervention or exposure restricted to nighttime intensivist staffing and a control group with any other nighttime physician staffing model and reporting adjusted estimates of association (8, 12, 29, 44). Weight is the contribution of each study to the overall effect. The *squares* represent the weight assigned to the study, the *solid diamonds* represent the ORs for mortality according to the individual study, and the *error bars* represent the 95% CI of the ORs. The *red dashed line* represents the pooled OR, with the *lateral tips of the blue diamond* representing the 95% CI of the pooled OR. CI = confidence interval; OR = odds ratio.

Role of the Sponsor

The study was sponsored by the ATS. The sponsor was provided the documents for peer review and, after review and satisfactory revision, forwarded them to the ATS Board of Directors for final approval. Potential conflicts of interest were disclosed and managed in accordance with the policies and procedures of the ATS.

Results

Study Selection and Characteristics

Database and manual searching yielded 8,067 unique citations, of which 18 studies (6–8, 12, 28, 29, 31, 44–54) met inclusion criteria (Figure 1). Interreviewer agreement on study inclusion was high (kappa = 0.93; 95% CI, 0.85–1.00).

Studies reporting mortality included one RCT (8) and 17 nonrandomized studies, comprising one prospective crossover study (12), seven multi-ICU cohort studies (6, 7, 44, 45, 49, 50, 54), and seven before–after studies (28, 29, 31, 46–48, 52) (Table 2). We also included two additional observational studies that did not report mortality but reported LOS, for a total of 17 nonrandomized studies (51, 53). Studies were heterogeneous in the numbers and types of ICUs included, sample size, and types of exposure and control groups. Ten studies included ICUs only in academic hospitals (8, 29, 44–48, 51–53), two included ICUs in community hospitals (28, 31), and six included both academic and community hospital ICUs (6, 7, 12, 49, 50, 54). In four studies, the exposure included other organizational differences in addition to nighttime intensivist staffing, such as differences in daytime staffing, availability and use of clinical protocols, number of ICU beds, and ratios of patients to respiratory therapists (further detailed in Table 2) (31, 45, 46, 48). In 11 studies, the exposure included

Table 4. Difference in ICU and Hospital LOS with Nighttime Intensivist Staffing

Study	Mean Difference in LOS (*d*) (95% CI)	
	ICU	Hospital
Baharoon *et al.* (44)	0.41 (0.32 to 0.50)	Not reported
Gajic *et al.* (29)	−0.15 (−0.23 to −0.08)	−0.13 (−0.20 to −0.05)
Garland *et al.* (12)	0.10 (−0.07 to 0.28)	−0.10 (−0.27 to 0.08)
Gershengorn *et al.* (45)	−0.08 (−0.24 to 0.08)	0.09 (−0.07 to 0.25)
Kerlin *et al.* (8)	0.04 (−0.06 to 0.14)	0.08 (−0.02 to 0.18)
Kumar *et al.* (46)	0.07 (−0.03 to 0.16)	−0.26 (−0.35 to −0.16)
Netzer *et al.* (48)	0.12 (0.05 to 0.19)	−0.01 (−0.08 to 0.05)
Ramaswamy *et al.* (54)	0.13 (0.10 to 0.16)	−0.03 (−0.06 to 0.003)
Soares *et al.* (50)	0.04 (0.03 to 0.06)	0.08 (0.06 to 0.09)
Trivedi *et al.* (51)	0.08 (0.02 to 0.14)	Not reported
van der Wilden *et al.* (52)	0.00 (−0.07 to 0.07)	0.00 (−0.07 to 0.07)
Volkert *et al.* (53)	−0.03 (−0.14 to 0.08)	Not reported

Definition of abbreviations: CI = confidence interval; ICU = intensive care unit; LOS = length of stay.
Mean difference in LOS is defined as (LOS [exposed] – LOS [unexposed]).

staffing by resident physicians (i.e., postgraduate medical trainees) during nighttime hours (in addition to intensivists) (8, 12, 28–30, 44, 45, 47, 48, 51, 52); fellow physicians (i.e., critical care specialty trainees) in four studies (12, 29, 51, 52); and advanced practitioners (nurse practitioners or physician assistants) in two studies (31, 47). Twelve studies included patient-level risk adjustment for severity of illness (6–8, 12, 29, 44–46, 48–50, 52). Six studies (Table E2) provided descriptive details regarding the intervention of nighttime intensivist staffing (8, 12, 29, 44, 46, 52).

The single RCT (8) was assessed as low risk for bias, using the Cochrane Risk of Bias Tool (unblinded, but objective outcome [mortality]; low risk for bias in other domains of selection, attrition, and reporting bias). The methodological quality of the 17 observational studies (6, 7, 12, 28, 29, 31, 44–54) was assessed as high, according to the Newcastle-Ottawa score (median, 8; range, 5–9; Table 3).

Association of Nighttime Intensivist Staffing with Outcomes

Only one RCT (8) met our inclusion criteria for the primary meta-analysis; the study reported no effect of nighttime intensivist staffing on mortality (adjusted OR, 1.08; 95% CI, 0.93–1.25). Secondary analyses similarly showed no association between nighttime staffing and mortality: one RCT (8) and three observational studies (12, 29, 44) reporting adjusted ORs, and with nighttime intensivist staffing as the only intervention or exposure (OR, 0.99; 95% CI, 0.75–1.29; Figure 2); these four studies and two others with unadjusted estimates (28, 52) (OR, 0.91; 95% CI, 0.73–1.14; Figure E2); and all studies, including those with a combined exposure (6–8, 12, 28, 29, 31, 44–49, 52) (OR, 0.95; 95% CI, 0.83–1.08; Figure E3). When adjusted estimates from stratified analyses of two cohorts within a single study (7) were included individually in this latter analysis, results remained unchanged (OR, 0.92; 95% CI, 0.82–1.04; Figure E4).

Twelve studies reported ICU LOS, and nine studies reported hospital LOS (Table 4). The pooled mean difference (nighttime intensivist staffing − control) was 0.06 days (95% CI, 0.01–0.12 d) for ICU LOS, and −0.03 days (95% CI, −0.10 to 0.04 d) for hospital LOS. Three studies reported rates of ICU readmission at any point during the hospitalization (29, 52, 55); none found any significant difference. Four studies reported ICU or postoperative complications (29, 46, 52, 53). Although one study reported a reduction in renal failure with nighttime intensivist staffing (53), statistical testing was not performed. Another study reported a small decrease in a composite outcome of any ICU complication (venous thromboembolism, bleeding, ventilator-associated pneumonia, or reintubation) (29). No other study demonstrated any significant difference in individual complications, including hospital-acquired infections (46, 52), reintubation (52), or new organ failures (46). Four studies reported on various processes of care (29, 46, 48, 52). One study reported overall reduction in sedative use (48), and two studies reported decreased transfusion of blood products (46, 52), although one included a multicomponent exposure of nighttime intensivist staffing and other organizational differences (46). No other differences in process of care were found.

Two studies reported on patient and family satisfaction and staff satisfaction (12, 29). Although both studies used different measurement instruments, neither found differences in patient and family satisfaction. Both found decreased perception of physician burnout and increased staff satisfaction with nighttime intensivist staffing.

Subgroup Analyses

Subgroup analyses based on intensity of daytime staffing (Figure 3) and ICU type (Figure 4) showed no association between nighttime intensivist staffing and mortality. We did not perform the subgroup analysis by geographic location because there were only single studies in locations other than North America.

Heterogeneity and Publication Bias

We found moderate to substantial heterogeneity (41) for all meta-analyses of mortality (I^2 = 64–80%) and substantial heterogeneity for ICU and hospital LOS (I^2 = 91% ICU LOS; I^2 = 92% hospital LOS). We found no evidence of publication bias, assessed by the funnel plot and statistical tests (Figure E1; Egger's test *P* value = 0.133; Macaskill's test *P* value = 0.345).

Discussion

In this systematic review and meta-analysis of one randomized and 17 nonrandomized studies, we found no association between in-hospital nighttime intensivist staffing and mortality. This finding was consistent across multiple sensitivity and subgroup analyses and in subgroups defined by intensity of daytime intensivist staffing and ICU type (specialty vs. mixed). In addition, we found no association with hospital LOS, minimal association with ICU LOS (with substantial heterogeneity among studies), and minimal or association with other patient outcomes, processes of care, and satisfaction measures.

The effect of nighttime intensivist staffing on patient or health system outcomes has relevance to ICU staffing policies, workforce planning, and healthcare resource planning and costs. A recent survey of academic ICUs in the United States

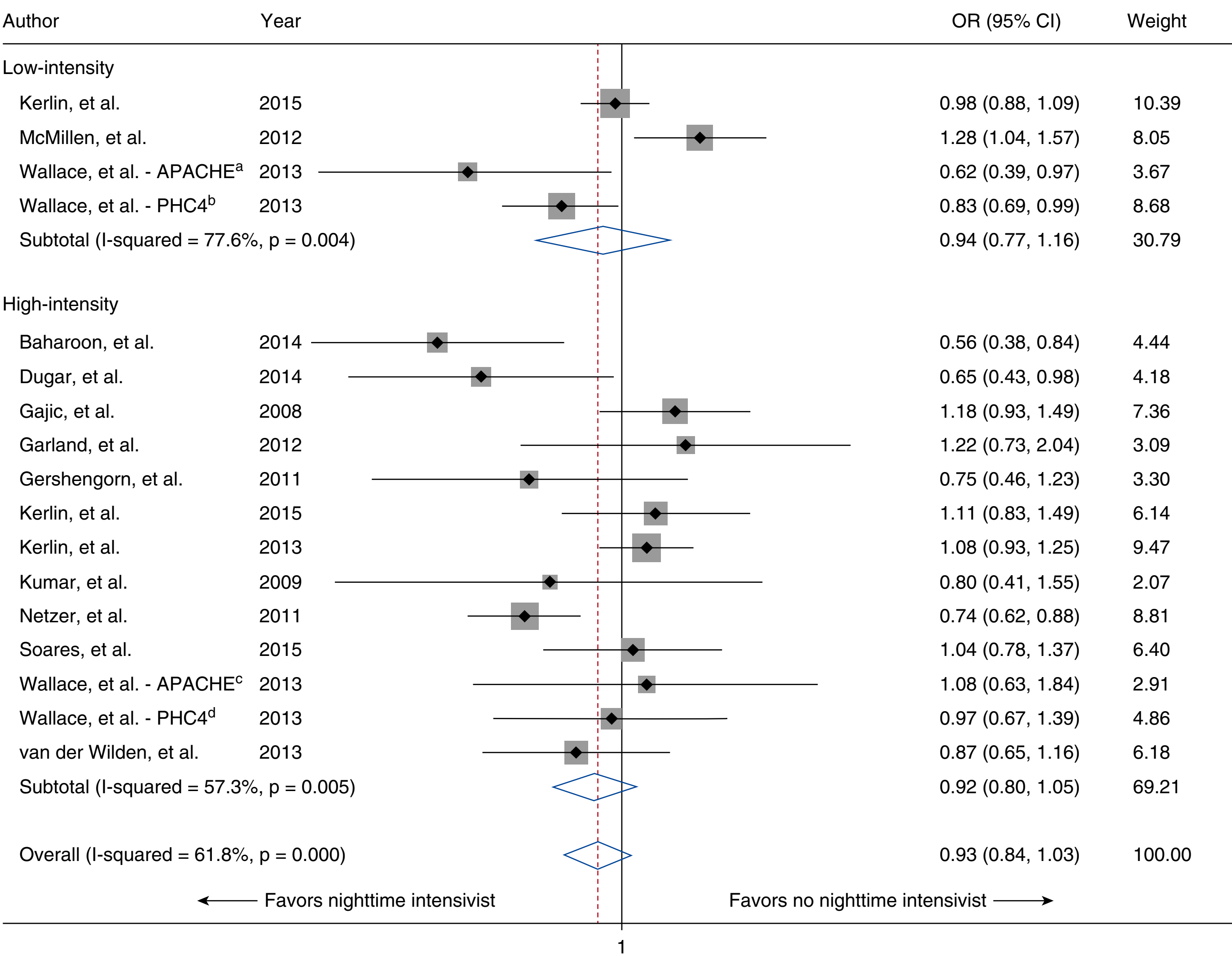

Figure 3. Association of nighttime intensivist staffing with mortality, stratified by intensity of daytime physician staffing. Analyses use random effects models and include all studies with any intervention or exposure with nighttime intensivist staffing (including composite exposures) and a control group with any other nighttime physician staffing model. Adjusted ORs are reported where available (6–8, 12, 28, 29, 44–46, 48, 52). Weight is the contribution of each study to the overall effect. The *P* value for subgroup interaction was 0.80. [a]Cohort of low-intensity daytime staffing ICUs from APACHE clinical registry. [b]Cohort of low-intensity daytime staffing ICUs from PHC4 hospital discharge database. [c]Cohort of high-intensity daytime staffing ICUs from APACHE clinical registry. [d]Cohort of high-intensity daytime staffing ICUs from PHC4 hospital discharge database. The *squares* represent the weight assigned to the study, the *solid diamonds* represent the ORs for mortality according to the individual study, and the *error bars* represent the 95% CI of the ORs. The *lateral tips of the blue diamonds* represent the 95% CIs of the pooled ORs. The *red dashed line* represents the overall pooled OR. APACHE = Acute Physiology and Chronic Health Evaluation (58–60); CI = confidence interval; ICU = intensive care unit; OR = odds ratio; PHC4 = Pennsylvania Health Care Cost Containment Council.

reports that one-third have adopted 24-hour in-hospital intensivist coverage (56). Given the results of our systematic review, one conclusion might be that ICU physicians would be more usefully deployed in centers that lack daytime intensivist staffing, which has been associated with improved outcomes (1, 2). Given perceived shortages in the intensivist workforce (13, 14), consideration and rigorous evaluation of alternative nighttime staffing models, such as advanced nonphysician practitioners (45, 57) and hospitalist physicians (58, 59), is warranted. ICU directors may also consider adopting other organizational strategies that optimize patient care around the clock, such as clinical protocols to promote evidence-based practices and interprofessional care delivery models (3), which may partially make up the mechanism for improved patient outcomes with intensivist-led care.

The results of this systematic review and meta-analysis must be interpreted with caution, considering the heterogeneity among results of included studies (60). Critically ill patients vary in terms of disease process and severity of illness, both within and across ICUs. Although we did not identify benefits from the presence of a nighttime intensivist on average, we were unable to perform an individual patient-level meta-analysis to explore heterogeneity in the effect of nighttime intensivist staffing. Stratified analyses in one study showed no effect of nighttime intensivist staffing on mortality, regardless of severity of illness (8);

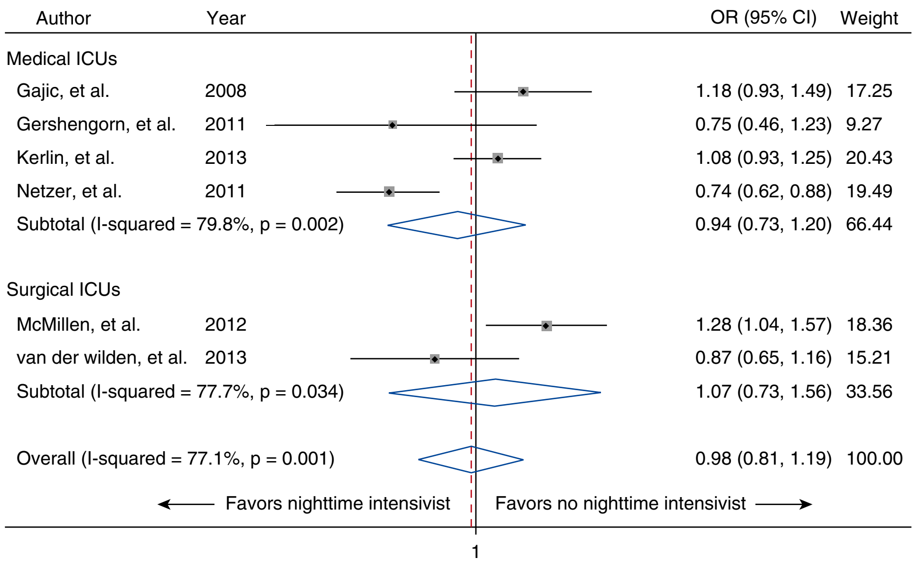

Figure 4. Association of nighttime intensivist staffing with mortality, stratified by ICU types. Analyses use random effects models and include all studies with any intervention or exposure with nighttime intensivist staffing (including composite exposures) and a control group with any other nighttime physician staffing model. Adjusted ORs are reported where available (8, 29, 45, 48, 52). Weight is the contribution of each study to the overall effect. The *P* value for subgroup interaction was 0.79. The *squares* represent the weight assigned to the study, the *solid diamonds* represent the ORs for mortality according to the individual study, and the *error bars* represent the 95% CIs of the ORs. The *lateral tips of the blue diamonds* represent the 95% CIs of the pooled ORs. The *red dashed line* represents the overall pooled OR. CI = confidence interval; ICU = intensive care unit; OR = odds ratio.

however, further study is needed to determine the effect of nighttime intensivist staffing on select patient populations presumed to be at higher risk, such as those with uncommon and highly complex conditions (such as extracorporeal support).

This review has several strengths. The literature search was comprehensive. We used methods to minimize bias and random error, including multiple reviewers to independently screen abstracts, review studies, and extract data. We used an established method to assess quality of observational studies (36) and considered adjusted estimated of effect, where available. In addition, we contacted primary study authors to obtain additional data or clarifications when needed.

This review also has limitations. First, studies were almost exclusively observational, and therefore cannot establish causality. Despite this limitation, observational study quality scores were moderate to high. Second, most studies were small and conducted in single North American academic centers, and we could not perform subgroup analyses of any other regions, limiting generalizability. However, results were consistent with findings of large multicenter international studies. Third, only a few studies provided details regarding the nighttime staffing intervention. In addition, studies may have differed with regard to other organizational factors, such as nursing and allied health staffing, clinical protocols, and interprofessional rounds, all of which may influence patient outcomes. Our inability to explore all sources of heterogeneity allows for the possibility of specific organizational contexts in which nighttime intensivists are beneficial. Last, we selected mortality and LOS as outcomes because they are widely reported and easily synthesized. However, nighttime staffing may have effects on other outcomes that are variably defined and reported, yet still important, including patient and family satisfaction (29), costs and resource use (61), ICU staff satisfaction (62), medical education (63), and physician burnout (64). We reported such outcomes to the extent possible, but could not synthesize the limited data.

In conclusion, current evidence suggests that in-hospital nighttime intensivist staffing is not associated with ICU patients' mortality or ICU or hospital LOS. However, this evidence must be interpreted with caution, given the largely observational nature and substantial heterogeneity of existing studies and the very limited descriptions of nighttime staffing models. Furthermore, evidence for other relevant outcomes, such as triage decision-making or new complications, has been almost nonexistent. Given that ICUs are heterogeneous with respect to both patient and structural characteristics, delivery of high-quality patient care requires organizational approaches tailored to the ICU. Future research should focus on understanding the effects of nighttime intensivist staffing on other outcomes and on identifying and understanding alternative nighttime staffing models to fully inform individual ICU staffing decisions and policies. ■

This official systematic review was prepared by the ATS *Ad Hoc* Committee on ICU Organization.

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