Twenty-four–Hour Intensivist Presence

A Pilot Study of Effects on Intensive Care Unit Patients, Families, Doctors, and Nurses

Allan Garland[1], Dan Roberts[1], and Lesley Graff[1]

[1]Faculty of Medicine, University of Manitoba, Winnipeg, Manitoba, Canada

***Rationale*: Around-the-clock intensivist presence in intensive care units (ICUs) has been promoted as necessary to optimize outcomes. Little data have addressed how it affects the multiple stakeholders in such care.**

***Objectives*: To assess effects of around-the-clock intensivist presence on intensivists, patients, families, housestaff, and nurses.**

***Methods*: This 32-week, crossover pilot trial of two intensivist staffing models, performed in two Canadian ICUs, alternated 8-week blocks of two staffing models: the standard model, where one intensivist worked for 7 days, taking night call from home; and the shift work model, where one intensivist worked 7 day shifts, while other intensivists remained in the ICU at night.**

***Measurements and Main Results*: Surveys scaled from 0–100 points assessed outcomes for 24 intensivists (primary outcome: burnout); 119 families (satisfaction); 74 nurses (satisfaction with collaboration and communications, role conflict); and 34 housestaff (autonomy, supervision, and learning opportunities). Outcomes for 501 patients included mortality, length of stay, and resource use. Intensivists doing shift work experienced less burnout (−6.9 points; $P = 0.04$). Adjusted hospital mortality (odds ratio, 1.22; $P = 0.44$), ICU length of stay (−6 h; $P = 0.46$), and family satisfaction (0.9 points; $P = 0.79$) did not differ between staffing models. Under shift work staffing, nurses reported more role conflict (9 points; $P < 0.001$), whereas nighttime housestaff reported less autonomy, more supervision, but no difference in learning opportunities.**

***Conclusions*: Shiftwork staffing was better for intensivists and most were receptive once they had experienced it. Although there were no evident negative outcomes for patients or families, further evaluation is needed to clarify how around-the-clock intensivist staffing influences the various stakeholders in ICU care, given power considerations in this study.**

Clinical trial registered with www.clinicaltrials.gov (NCT 01146691).

Keywords: intensive care units; organization and administration; burnout; outcomes assessment

AT A GLANCE COMMENTARY

Scientific Knowledge on the Subject

Although around-the-clock intensivist presence in intensive care units (ICUs) has been promoted as necessary to optimize patient outcomes, few studies have assessed the effects of this intervention on relevant outcomes, and they have all used before versus after study designs with inconsistent results. No published studies have assessed the effect on the broad range of stakeholders in ICU care.

What This Study Adds to the Field

This is the first study to use a more rigorous, alternating crossover study design to address how around-the-clock staffing influences outcomes. Compared with a standard model of intensivist ICU staffing, 24-hour intensivist presence, implemented by shift work, was better for intensivists and had no detrimental effect on outcomes for patients, families, or ICU nurses. This information can assist and inform intensivists, hospital administrators, and policymakers in choosing a model for intensivist staffing.

Considerable debate has occurred regarding whether intensivists, subspecialists in critical care medicine, should be continuously present in intensive care units (ICUs) (1), including opinions that 24/7 intensivist staffing is the "ideal" (2). Moving to such a staffing paradigm could affect various stakeholders including patients, families, physicians, nurses, medical trainees, and society. Increasing numbers of ICUs have implemented such staffing, usually by shift work (1, 3–5). However, the worsening shortage of intensivists (6, 7) makes 24/7 staffing problematic, because it requires more intensivists.

Sparse and inconsistent data exist on this topic. Interventional studies comparing staffing with and without 24/7 intensivist presence have evaluated single ICUs, using historical controls (5, 8). Prior studies have mainly evaluated academic ICUs with housestaff, whereas many ICUs are in community hospitals and lack any overnight physician presence (9). The impact of adding 24/7 intensivist coverage may depend on ICU type, and preexisting nighttime staffing.

We compared the effects of 24/7 intensivist staffing on multiple stakeholders, using an alternating crossover design in two types of ICUs. This pilot study was intended to prepare for a larger national study. We hypothesized that intensivists would experience less burnout while providing 24/7 ICU presence by shift work, compared with the historical, standard type of scheduling (10–13). Some results of this study were previously reported in the form of an abstract (14).

METHODS

This prospective, 32-week study began in October 2008 in two ICUs in Winnipeg, Manitoba, Canada. One was a 10-bed medical ICU in a 753-bed tertiary referral hospital; the other a six-bed medical–surgical ICU in a 231-bed community hospital. Both are closed-model ICUs with

(Received in original form September 26, 2011; accepted in final form December 26, 2011)

Supported by St. Boniface Hospital Foundation, Winnipeg, Manitoba, Canada.

Author Contributions: Conception and design, A.G., D.R., and L.G.; acquisition of data, A.G.; analysis and interpretation of data, A.G. and L.G.; statistical analysis, A.G.; drafting of the manuscript, A.G.; critical revision of the manuscript for intellectual content, A.G., D.R., and L.G.; final approval of version to be published, A.G., D.R., and L.G.; administrative, technical, or material support, A.G., D.R., and L.G.; and supervision, A.G.

Correspondence and requests for reprints should be addressed to Allan Garland, M.D., M.A., Winnipeg Health Sciences Center, 820 Sherbrook Street, Room GF-222, Winnipeg, MB, R3A 1R9 Canada. E-mail: agarland@hsc.mb.ca

This article has an online supplement, which is accessible from this issue's table of contents at www.atsjournals.org

Am J Respir Crit Care Med Vol 185, Iss. 7, pp 738–743, Apr 1, 2012

Originally Published in Press as DOI: 10.1164/rccm.201109-1734OC on January 12, 2012
Internet address: www.atsjournals.org

intensivists rotating on a 1-week schedule, and formal multidisciplinary ICU rounds twice daily, in the morning and afternoon. Intensivists in these ICUs included internists, anesthesiologists, and surgeons. The size of the participating ICUs is comparable with most of those in the United States and Europe (9, 15).

In the tertiary ICU the team included the attending intensivist, an ICU subspecialty fellow, and house officers who took in-hospital overnight call in rotation. The community ICU had no housestaff, and before this study no physicians routinely remained in the ICU overnight. Both ICUs care for the full spectrum of critically ill patients, except that the community ICU lacks capacity for renal dialysis.

We compared two models of intensivist staffing: standard and shift work. Intensivists rotated weekly in both models. In standard staffing, the historical paradigm in both units, one intensivist staffed an ICU for 7 days, was present during daytime, and took calls from home at night, returning to ICU as deemed necessary.

In shift work staffing there was 24/7 intensivist presence. The same pool of intensivists supplied dayshift and nightshift coverage. In any given week, a single intensivist was responsible for all seven dayshifts (08:00–17:30, 08:00–15:00 on weekends), whereas two different intensivists alternated the seven nightshifts. The nightshift intensivist arrived, assumed care, and remained in the hospital until relieved by the dayshift intensivist. Among their duties, nightshift intensivists did initial evaluations of patients admitted at night, and responded to queries from nurses and housestaff. Although all intensivists had full authority for care during their shifts, we aimed to reduce alternations in care by establishing that choices made on the dayshift should not be changed solely because of different preferences of the nightshift intensivist. Although the intensivists were explicitly expected to directly communicate at shift changes, we did not specify the details of how handovers should be conducted. Intensivist on-call rooms with beds were provided at both sites.

The study had four blocks of 8 weeks each. During each block one ICU had standard staffing and the other had shift work staffing; each site alternated three times between the staffing models (*see* Figure E1 in the online supplement). Every effort was made to minimize contamination between the study arms. For the intensivists, each 1-week period of ICU work included just a single model of intensivist staffing, and they were specifically directed to base their survey responses on the experience of the ICU week they had just completed. Patients and families were only included if their ICU experience was contained within a single model of intensivist staffing. The nurse surveys were done at the end of each 8-week block of a single model of intensivist staffing, and they were specifically directed to respond based on the most recent 8-week period. Finally, the 1-month rotations for housestaff were scheduled such that each one included just a single model of intensivist staffing.

We assessed outcomes for intensivists, ICU patients, families, nurses, and housestaff (*see* Table E1). Except for patients, outcomes were assessed by self-report surveys, with scores transformed to a common 0–100 scaling (*see* Tables E2–E5). Although all admitted patients were eligible for analysis, to avoid contamination between staffing models we excluded patients (and families) whose ICU stay included time under both models. For patients with multiple ICU admissions, only the first was used.

Work-related personal and emotional burden for intensivists was assessed after each 1-week rotation using four validated survey scales (*see* Table E3): (*1*) job burnout (16), (*2*) work–home imbalance (17), (*3*) role overload (18), and (*4*) role ambiguity (19). For these scales higher scores were more unfavorable. Because no suitable measure was available, we developed three items to assess interactions between intensivists sharing shift work, termed "intensivist role conflict." For this study, the primary outcome was job burnout, specifically the Emotional Exhaustion subscale of the Maslach Burnout Inventory (16). In addition to weekly surveys of intensivists working in the participating ICUs, all intensivists in Winnipeg were surveyed prestudy and poststudy to indicate their preference between the two staffing models.

Clinical information obtained from the regional ICU database for each patient included age; sex; Charlson Comorbidity Index (20); daytime versus nighttime ICU admission; source of ICU admission (emergency department vs. other sources); admission day severity of illness assessed as the Acute Physiology and Chronic Health Evaluation (APACHE) II score (21); and the type of diagnosis necessitating ICU care (categorized as medical, surgical including cardiac and cardiovascular surgery, or cardiovascular). Patient outcomes included mortality and length of stay (LOS) in the ICU and the hospital. We also assessed ICU resource use as the cumulative number of laboratory blood tests (complete blood count, serum creatinine, international normalized ratio, and arterial blood gases); microbiologic cultures (urine, blood, and sputum); imaging tests (chest radiographs, computed tomography, and echocardiography); and blood and colloid product administrations (red blood cells, plasma, albumin, and synthetic starches).

We measured satisfaction among families who visited in ICU and consented to participate, using the Family Satisfaction in the Intensive Care Unit survey (22). This validated instrument has two subscales (Satisfaction with Care and Satisfaction with Decision-Making), which are combined into an overall score; higher scores reflect greater satisfaction (*see* Table E2). For ICU survivors, family surveys were provided as soon as possible after ICU discharge. For patients who died in ICU, surveys were mailed 1 month after death.

We surveyed ICU nurses' perceptions at the end of each 8-week study block. Nurses reported their sociodemographics and work history, and complete five validated scales: (*1*) nurse–physician collaboration (23), (*2*) satisfaction with communications (24), (*3*) nurse–physician understanding (24), (*4*) shift communication (24), and (*5*) role conflict (19) (*see* Table E4).

In the tertiary ICU, we surveyed house officers' perceptions at the end of their 4-week rotations, during each of which they experienced only one staffing model. That survey captured sociodemographics and three domains: (*1*) autonomy, (*2*) supervision, and (*3*) opportunity to learn (*see* Table E5). The first scale is validated (19, 25), and the other two have been used previously (26).

Statistical Methods

For the primary outcome of intensivist burnout, we calculated sample size using an alternate hypothesis that shift work staffing would lower intensivists' burnout scores from 41.1 (the mean normative value for physicians, on the transformed scale) by 1 SD, to 23.1 (16). For $\beta = 0.80$ and $\alpha = 0.05$, this required 32 surveys in each staffing model, leading to the planned study duration of 32 weeks.

Continuous data are presented as mean ± SD, or median and interquartile range (IQR), and categorical data as percentages. Unadjusted comparisons used *t* tests, Mann-Whitney *U* tests, or Fisher exact test. Adjusted comparisons used multivariable regression; logistic regression for binary outcomes, negative binomial regression for resource use, median regression for ICU LOS, and linear regression for other continuous outcomes. Because intensivists and nurses could complete multiple surveys, we analyzed those data using general estimating equations to account for correlated responses (27). Analysis used Stata 11.0 (StataCorp, College Station, TX), with *P* values less than 0.05 considered statistically significant.

This study was approved by the University of Manitoba Health Research Ethics Board.

RESULTS

Physicians

A total of 37 of 39 intensivists completed the prestudy survey; 92% were men, 84% were married, 59% were 41–60 years old, 59% had children living at home, 56% completed their ICU training more than 10 years earlier, and 51% previously experienced shift work ICU staffing. The 24 intensivists who worked in participating ICUs completed 126 weekly surveys (median, 5; range, 1–11), 96 (76%) under shift work staffing, and 63 (50%) from the tertiary ICU. Unadjusted weekly surveys results were consistent across ICUs (*see* Table E6).

Intensivist outcomes were adjusted for workload, study site, and interaction between them. Workload was the weekly average of cumulative daily census, defined as the number of different patients cared for during the day. After adjustment, intensivists doing shift work experienced significantly less burnout, work–home life imbalance, and job overload, but more role uncertainty

(Table 1, *see* Table E7). Compared with standard staffing, only dayshift intensivists experienced less burnout and work–home imbalance, whereas only nightshift intensivists reported more role ambiguity (Table 1).

Weekly surveys during standard staffing revealed that intensivists were awakened a median of two times nightly (IQR, 1–4), and returned to the ICU at night a median of twice weekly (IQR, 1–4). Asked how many times a week shift work intensivists experienced "major disagreement about patient management" with an intensivist on the other shift, 15% indicated this occurred once, 10% said it occurred multiple times, and 12% endorsed that they "often" or "very often" felt frustrated having joint responsibility with another intensivist.

Thirty-five intensivists completed both the prestudy and poststudy surveys. Asked the question "Assuming that the remuneration and the total amount of work was equivalent in both models, which of the 2 intensivist staffing models do you think you would prefer to work in?", 14 (40%) preferred shift work prestudy study, whereas 18 (51%) preferred shift work poststudy ($P < 0.001$). Among the 21 intensivists who worked in the participating ICUs and completed both surveys, the corresponding figures were 9 and 13 (43% vs. 62%; $P = 0.02$).

Patients

Of 605 ICU admissions during the study, 104 were excluded (*see* Figure E2). Characteristics of the 501 included patients were similar for the two staffing models, except for a lower APACHE II score during shift work staffing in the community ICU (Table 2).

The only significant unadjusted difference was a shorter hospital LOS under shift work staffing in the community hospital (Table 2). Regressions of hospital mortality and ICU LOS were adjusted for study site, ICU admission source, day versus night admission, age, sex, comorbidity, ICU diagnosis type, and APACHE II score (*see* Table E8). Interaction terms of staffing model by hospital, and staffing model by day or night admission were not significant (data not shown). Compared with standard staffing, shift work intensivist staffing was not associated with significant differences in hospital mortality (odds ratio, 1.22; 95% confidence interval [CI], 0.73–2.04) or median ICU LOS (difference, −5.8 h; 95% CI, −21.1 to 9.5). The mortality model had a receiver operating characteristic curve area of 0.848, and was well calibrated (Hosmer-Lemeshow goodness-of-fit P value = 0.45).

Regression analyses of ICU resource use were adjusted for the same variables, plus ICU LOS. Although there were no statistically significant differences in the four resource use variables between the intensivist staffing models (*see* Table E9), the trends indicated 8–15% lower usage under shift work staffing.

Families

Of 501 patients, 232 (46%) had an eligible family member. The 119 (51%) respondents who completed surveys (Table 3) had a mean age 52 ± 15 years; 73 (61%) were female; and 52 (44%) lived with the patient. Their relationship with the patient was spouse (42%); child (35%); sibling (12%); parent (6%); and other (5%).

Unadjusted family satisfaction did not differ between staffing models or study sites (Table 3, *see* Table E10). Adjusting for study site, death in ICU, respondents' age, sex, and relationship to the patient, satisfaction did not differ between staffing models (*see* Table E11). On the 0–100 scale, adjusted difference in scores (shift work minus standard staffing) was 1.7 for satisfaction with care (95% CI, −5.3 to 8.6); −0.1 for satisfaction with decision making (95% CI, −7.7 to 7.6); and 0.9 (95% CI, −5.9 to 7.7) for overall satisfaction.

Nurses

Seventy-four nurses completed 189 surveys (median, 3; range, 1–4); 104 (55%) under shift work staffing and 147 (78%) from the tertiary ICU. Of surveyed nurses, 89% were female, 69% were aged 36–60 years, 5% received nursing degrees outside of North America, 41% had less than 5 years as an ICU nurse, and 45% had more than 10 years of ICU experience. Only 23 (31%) worked only or mainly on the dayshift.

More role conflict under shift work staffing was the only significant difference in nurses' outcomes between the two intensivist staffing models, both unadjusted (Table 4) and adjusted for study site, sex, years in ICU nursing, and primarily dayshift work (difference, 9; 95% CI, 4.7–3.3; *see* Table E12). Nurses' responses were similar for those who primarily worked on dayshifts versus those who worked evenings or nights.

Housestaff

Thirty-four residents completed 35 surveys, 16 (46%) under intensivist shift work staffing. Respondents were mostly male (80%); senior residents (11% first-year, 31% second-year, and 58% third-year or higher); who had completed a prior ICU rotation (80%). Their home departments were internal medicine, 13 (37%); anesthesia, 7 (20%); surgery, 5 (14%); and others, 10 (29%).

During daytime, supervision, autonomy, and learning opportunities were similar under the two staffing models (Table 5). However, with a nightshift intensivist present residents reported more supervision and reduced autonomy, but no difference in learning opportunities even after adjusting for residency year, sex, and prior ICU rotations (*see* Table E13).

DISCUSSION

In this pilot study, the main effect of 24/7 intensivist presence in the ICU was on the intensivists; implemented through shift work, intensivists experienced less job and life stresses, but higher uncertainty about their roles and evidence of friction with colleagues working on the other shift. These findings were relative to a model where a single intensivist was responsible an entire

TABLE 1. ADJUSTED INTENSIVIST OUTCOMES BASED ON MULTIVARIABLE GENERAL ESTIMATING EQUATION REGRESSION, REPRESENTING ADJUSTED MEAN DIFFERENCES AMONG GROUPS

Parameter	Shiftwork Staffing (vs. Standard Staffing)	Day Shift in Shiftwork Staffing (vs. Standard Staffing)	Night Shift in Shiftwork Staffing (vs. Standard Staffing)
Burnout	−6.9*	−11.7*	−2.5
Work–home imbalance	−10.1*	−23.6*	1.3
Role overload	−28.4*	−19.7*	−32.9*
Role ambiguity	9.5*	−1.3	20*

Negative values in this table indicate that shift work staffing was associated with less burnout, imbalance, overload, or ambiguity. Positive values indicate the reverse.

*$P < 0.05$.

TABLE 2. PATIENT AND ILLNESS CHARACTERISTICS, ICU RESOURCE USE, AND OUTCOMES OF INITIAL ICU ADMISSIONS, BY STUDY SITE AND INTENSIVIST STAFFING MODEL

	Tertiary ICU		Community ICU		
Parameter	Standard Staffing	Shiftwork Staffing	Standard Staffing	Shiftwork Staffing	All
Number of ICU admissions (persons)	161	150	96	94	501
First 8-wk block	86	62	56	45	249
Second 8-wk block	75	88	40	49	252
Patient and illness characteristics, and medical interventions used in ICU					
Age, yr	54.7 ± 16.5	55.6 ± 17.2	64.4 ± 17.2	65.2 ± 16.3	58.8 ± 17.4
Sex, % males	55.3	56	53.1	52.1	54.5
Charlson Comorbidity Index	2.42 ± 1.97	2.38 ± 2.10	2.51 ± 2.04	2.31 ± 2.16	2.40 ± 2.05
Admitted to ICU at night, %	63.4	61.3	55.2	54.2	59.5
Admitted to ICU from other than emergency department, %	38.5	39.3	31.3	29.8	35.7
APACHE II score	20.6 ± 8.1	19.6 ± 7.5	16.9 ± 8.2	14.5 ± 7*	18.4 ± 8.1
Diagnostic type, %					
Medical	97.5	98	70.8	59.6	85.5
Cardiac	0	0.7	20.9	35.1	11
Surgical	2.5	1.3	7.3	5.3	3.5
Interventions during initial 24 h, %					
Mechanical ventilation	76	71	47	36	61
Intravenous vasoactive drugs	47	42	33	33	40
Renal replacement therapy	13	8	0	0	7
Medical resource use					
# of laboratory tests	28.9 ± 2.3	34 ± 3.8	17.8 ± 1.6	18.4 ± 3	26.4 ± 34
# of microbiologic cultures	2.9 ± 0.3	3 ± 0.4	1.2 ± 0.2	1.5 ± 0.3	2.4 ± 3.5
# of imaging tests	4.9 ± 0.4	5.4 ± 0.5	2.9 ± 0.3	3 ± 0.5	4.3 ± 5.2
# of blood and colloid administrations	4 ± 0.5	5 ± 1.4	1.1 ± 0.2	2.1 ± 0.6	3.4 ± 10.2
Patient outcomes					
ICU mortality, %	18.6	19.3	13.5	9.6	16.2
Hospital mortality, %	26.1	24.7	20.8	17	23
ICU length of stay, d					
Median (IQR)	2.7 (1.2–6)	3 (1.1–7.3)	3.1 (1.6–5.9)	2.2 (1.1–5.1)	2.8 (1.2–6)
Mean ± SD	4.5 ± 4.8	5.6 ± 6.8	4.3 ± 4	4 ± 5	4.7 ± 5.4
Hospital length of stay, d					
Median (IQR)	10.3 (4.2–24.2)	11.8 (5.1–23.2)	10.5 (4.7–25.5)	6.5 (2.8–16.3)*	10.1 (4.2–22.9)

Definition of abbreviations: APACHE = Acute Physiology and Chronic Health Evaluation; ICU = intensive care unit; IQR = interquartile range.
*$P < 0.05$ for difference between standard and shift work intensivist staffing for that ICU.

week, taking call from home 7 days in a row. After intensivists experienced shift work their preference for it increased, with almost two-thirds preferring shift work over standard staffing after the study. Although significant, the difference of 6.9 in intensivist burnout scores was close to but less than the minimally important difference as suggested by Norman and coworkers (28), of 9 for our data. The observed conflict between intensivists under shift work staffing could be influenced by numerous factors; longer experience with shared care could alter expectations and lead to adaptation and a reduction in points of conflict. A long-term analysis of conflict in different staffing models, or a cross-sectional study across ICUs with different models, is needed to resolve this interesting psychosocial question.

Outcomes for patients or families did not differ between staffing models. Although this study was not powered to detect differences for those stakeholders, our findings are similar to those of a prior study (5). It is also relevant that our findings were similar for the ICUs with and without nonintensivist physicians who remained overnight in the ICU.

Among ICU nurses, the only difference was more role conflict under intensivist shift work staffing; this might relate to the

TABLE 3. FAMILY SATISFACTION WITH ICU CARE, BY INTENSIVIST STAFFING MODEL, UNADJUSTED

Parameter	Standard Staffing	Shiftwork Staffing	*P* Value
Number of respondents, n	60	59	—
Tertiary ICU, n (%)	31 (52)	32 (51)	
Patient died in ICU, n (%)	7 (12)	5 (9)	
Satisfaction with care	76.2 ± 19.2	77 ± 18.3	0.81
Satisfaction with decision-making	69.3 ± 20.1	69 ± 21	0.93
Overall satisfaction	73.3 ± 18.6	73.7 ± 17.9	0.92

Definition of abbreviation: ICU = intensive care unit.
Values are mean ± SD, rescaled to range 0–100.

TABLE 4. NURSES' EXPERIENCES, BY INTENSIVIST STAFFING MODEL, UNADJUSTED

Parameter	Standard Staffing	Shiftwork Staffing	*P* Value
Number of surveys	85	104	—
Nurse–physician collaboration	61.6 ± 19.2	60.7 ± 21.3	0.76
Satisfaction with communications	63.8 ± 13.8	61.4 ± 17.4	0.31
Nurse–physician understanding	64.1 ± 12.4	64.2 ± 13.3	0.97
Shift communication	57.7 ± 16.9	57.5 ± 18.8	0.92
Role conflict	47 ± 19.4	54.2 ± 21	0.02

Values are mean ± SD, rescaled to range 0–100.

TABLE 5. HOUSE OFFICER EXPERIENCES, BY INTENSIVIST STAFFING MODEL, UNADJUSTED

	During Daytime Hours			During Nighttime Hours		
Parameter	Standard	Shiftwork	*P* Value	Standard	Shiftwork	*P* Value
Autonomy	51.2 ± 9.9	52.8 ± 7.6	0.60	61.7 ± 7.4	54.9 ± 8.3	0.02
Supervision	86.8 ± 19.3	76.6 ± 17	0.11	59.2 ± 22.4	76.6 ± 19.3	0.02
Learning opportunity	71.1 ± 17.2	60.9 ± 22.3	0.14	65.8 ± 26.6	56.3 ± 26.6	0.30

Values are mean ± SD, rescaled to range 0–100.

additional physicians they are interacting with, or to intensivist disagreements about care within that model. For housestaff in the academic ICU, intensivist presence at night resulted in less autonomy and more supervision, but no perceived difference in nocturnal learning opportunities, similar to a study that compared resident experiences according to the amount of intensivist involvement in care (26).

Despite opinions that around-the-clock intensivist presence improves patient outcomes (1, 2, 29), data on the topic are sparse and inconclusive. In the United Kingdom, 24/7 intensivist presence reduced severity-adjusted mortality in an academic ICU (8). However, in an academic ICU in the United States, it did not alter mortality rates or ICU LOS, although it was associated with a shorter hospital LOS (5). Our results, although preliminary, mainly support the latter study.

Our study augments and improves on the existing literature. The alternating crossover design obviates concerns about bias inherent in the before versus after designs of all prior interventional studies on this topic (30). Although others have studied the effect of 24/7 intensivist staffing in academic settings, we also evaluated a community ICU. Finally, with one exception (5) prior publications only assessed the effects on patients; ours is the first to concurrently evaluate effects on numerous stakeholders.

Our study also has limitations. First, it was a pilot study in two ICUs, powered to assess outcomes for the intensivists. The lack of differences for patient and family outcomes, either positive or negative, between the two staffing models is not definitive and should be assessed carefully in larger multicenter studies. Second, we did not assess secondary measures, such as processes of care or patient safety events. Although these may have provided further insights, such secondary measures are less important than the patient outcomes evaluated (31). Third, we did not evaluate other important potential consequences of the intensivist shift work intervention, including salary costs for extra intensivists, potential differences in costs of patient care, and the possibility that reducing intensivists' job stress might reduce their tendency for early retirement (7, 32, 33) and increase the number of medical trainees who want to become intensivists (34). Fourth, unvalidated scales were used to assess domains for which validated measures did not exist (i.e., intensivist role conflict, housestaff supervision, and opportunity to learn), and should be further assessed psychometrically before more extensive use. Validated measures were used wherever possible, and measurement development was otherwise guided by clinical and systems knowledge (for content) and measurement theory. Fifth, the differential effects on the intensivists that we observed in this 32-week study might not persist over time; avoiding shift work is the most common reason that emergency medicine physicians leave that field as they age (35). Finally, as for all studies of relationships between medical structures and outcomes, it is an extrapolation to apply our results to ICUs that differ from the ones studied in ICU type, size, duration of intensivist rotations, the way that around-the-clock intensivist coverage is implemented, other differences in baseline structure, characteristics of the intensivists, or patient case mix.

Our study contributes to the literature on the relationship between structure and outcomes in ICU care. Designed to be preparatory to a multicenter study of 24/7 intensivist ICU staffing in Canada, the findings demonstrate that it is possible and relevant to assess how alterations in ICU structure affect multiple stakeholders. This pilot study illustrated that it is practical to evaluate such relationships using an alternating study design that obviates problems inherent in before versus after studies, and will help to inform the design of subsequent studies. The findings regarding intensivist outcomes indicate that there are models of intensivist staffing that provide good patient care and reduce the burden associated with this career choice. This is particularly relevant given the increasingly short supply of this type of specialist, attributed partly to premature retirements and reluctance to enter into this field.

Author disclosures are available with the text of this article at www.atsjournals.org.

References

1. Burnham EL, Moss M, Geraci MW. The case for 24/7 in-house intensivist coverage. *Am J Respir Crit Care Med* 2010;181:1159–1160.
2. Haupt MT, Bekes CE, Brilli RJ, Carl LC, Gray AW, Jastremski MS, Naylor DF, Rudis M, Spevetz A, Wedel SK, *et al.* Guidelines on critical care services and personnel: recommendations based on a system of categorization of three levels of care. *Crit Care Med* 2003;31: 2677–2683.
3. Graf J, Reinhold A, Brunkhorst FM, Ragaller M, Reinhart K, Loeffler M, Engel C. Variability of structures in German intensive care units: a representative, nationwide analysis. *Wien Klin Wochenschr* 2010; 122:572–578.
4. Parshuram CS, Kirpalani H, Mehta S, Granton J, Cook D. The Canadian Critical Care Trials Group. In-house, overnight physician staffing: a cross-sectional survey of Canadian adult and pediatric intensive care units. *Crit Care Med* 2006;34:1674–1678.
5. Gajic O, Afessa B, Hanson AC, Krpata T, Yilmaz M, Mohamed SF, Rabatin JT, Evenson LK, Aksamit TR, Peters SG, *et al.* Effect of 24-hour mandatory versus on-demand critical care specialist presence on quality of care and family and provider satisfaction in the intensive care unit of a teaching hospital. *Crit Care Med* 2008;36:36–44.
6. Ewart GW, Marcus L, Gaba MM, Bradner RH, Medina JL, Chandler EB. The critical care medicine crisis: a call for federal action. A white paper from the critical care professional societies. *Chest* 2004;125: 1518–1521.
7. Angus DC, Kelley MA, Schmitz RJ, White A, Popovich J. Current and projected workforce requirements for care of the critically ill and patients with pulmonary disease. *JAMA* 2000;284:2762–2770.
8. Blunt MC, Burchett KR. Out-of-hours consultant cover and case-mix-adjusted mortality in intensive care. *Lancet* 2000;356:735–736.
9. Angus D, Shorr A, White A, Dremsizov T, Schmitz R, Kelley M, Committee on Manpower for Pulmonary and Critical Care Societies (COMPACCS). Critical care delivery in the united states: distribution of services and compliance with leapfrog recommendations. *Crit Care Med* 2006;34:1016–1024.
10. Embriaco N, Azoulay E, Barrau K, Kentish N, Pochard F, Loundou A, Papazian L. High level of burnout in intensivists: prevalence and associated factors. *Am J Respir Crit Care Med* 2007;175:686–692.
11. Fields AI, Cuerdon TT, Brasseux CO, Getson PR, Thompson AE, Orlowski JP, Younger SJ. Physician burnout in pediatric critical care medicine. *Crit Care Med* 1995;23:1425–1429.

12. Guntupalli KK, Fromm RE. Burnout in the internist-intensivist. *Intensive Care Med* 1996;22:625–630.
13. Shaman Z, Roach MJ, Marik P, Carson S, Garland A. Job stress and workload among intensivists. *Proc Am Thorac Soc* 2005;2:A597.
14. Garland A. Effects on patients, physicians and families of 24 hour, on-site intensivist coverage in academic and community ICU care. *Am J Respir Crit Care Med* 2011;183:A1024.
15. Depasse B, Pauwels D, Somers Y, Vincent JL. A profile of European ICU nursing. *Intensive Care Med* 1998;24:939–945.
16. Maslach C, Jackson SE, Leiter MP. Maslach burnout inventory manual. Mountain View, CA: CPP, Inc.; 1996.
17. Kopelman RE, Greenhaus JH, Connolly TF. A model of work, family, and interrole conflict: a construct validation study. *Organ Behav Hum Perform* 1983;32:198–215.
18. Bacharach SB, Bamberger P, Conley SC. Work processes, role conflict, and role overload: the case of nurses and engineers in the public sector. *Work Occup* 1990;17:199–228.
19. Peterson MF, Smith PB, Akande A, Ayestaran S, Bochner S, Callan V, Cho NG, Jesuino JC, D'Amorim M, Francois P-H, *et al.* Role conflict, ambiguity, and overload: a 21-nation study. *Acad Manage J* 1995;38: 429–452.
20. Charlson M, Pompei P, Ales K, MacKenzie C. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;40:373–383.
21. Knaus WA, Draper EA, Zimmerman JE. Apache II: a severity of disease classification system. *Crit Care Med* 1985;13:818–829.
22. Wall RJ, Engelberg RA, Downey L, Heyland DK, Curtis JR. Refinement, scoring, and validation of the family satisfaction in the intensive care unit (FS-ICU) survey. *Crit Care Med* 2007;35:271–279.
23. Baggs JG. Development of an instrument to measure collaboration and satisfaction about care decisions. *J Adv Nurs* 1994;20:176–182.
24. Shortell SM, Rousseau DM, Gillies RR, Devers KJ, Simons TL. Organizational assessment in intensive care units: construct development, reliability, and validity of the ICU nurse-physician questionnaire. *Med Care* 1991;29:709–727.
25. Fields DL. Taking the measure of work; a guide to validated scales for organizational research and diagnosis. Thousand Oaks: Sage Publications; 2002.
26. Carson SS, Stocking C, Podsadecki R, Christenson J, Pohlman A, MacRae S, Jordan J, Humphrey H, Siegler M, Hall J. Effects of organizational change in the medical intensive care unit of a teaching hospital. *JAMA* 1996;276:322–328.
27. Hardin J, Hilbe J. General estimating equations. Boca Raton, FL: Chapman & Hall/CRC; 2003.
28. Norman G, Sloan J, Wyrwich K. Interpretation of changes in health-related quality of life: the remarkable universality of half a standard deviation. *Med Care* 2003;41:582–592.
29. Arabi Y. Pro/con debate: should 24/7 in-house intensivist coverage be implemented? *Crit Care* 2008;12:216.
30. Friedman LM, Furberg CD, DeMets DL. Historical controls/data bases. Fundamentals of clinical trials. New York: Springer-Verlag; 1998. pp. 47–51.
31. Garland A. Improving the intensive care unit. Part 1. *Chest* 2005;127: 2151–2164.
32. Brett T, Arnold-Reed D, Hince D, Wood I, Moorhead R. Retirement intentions of general practitioners aged 45–65 years. *Med J Aust* 2009; 191:75–77.
33. Landon B, Reschovsky J, Pham H, Blumenthal D. Leaving medicine: the consequences of physician dissatisfaction. *Med Care* 2006;44:234–242.
34. Lorin S, Heffner J, Carson S. Attitudes and perceptions of internal medicine residents regarding pulmonary and critical care subspecialty training. *Chest* 2005;127:630–636.
35. Hall KN, Wakeman MA, Levy RC, Khoury J. Factors associated with career longevity in residency-trained emergency physicians. *Ann Emerg Med* 1990;21:291–297.

24 Hour Intensivist Presence: A Pilot Study of Effects on ICU Patients, Families, Doctors and Nurses

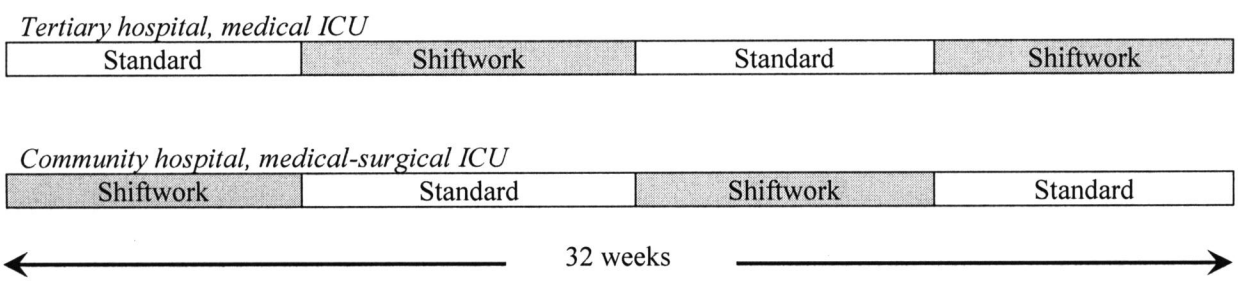
Allan Garland, MD, MA, Dan Roberts MD, and Lesley Graff, PhD

ONLINE SUPPLEMENTAL MATERIALS

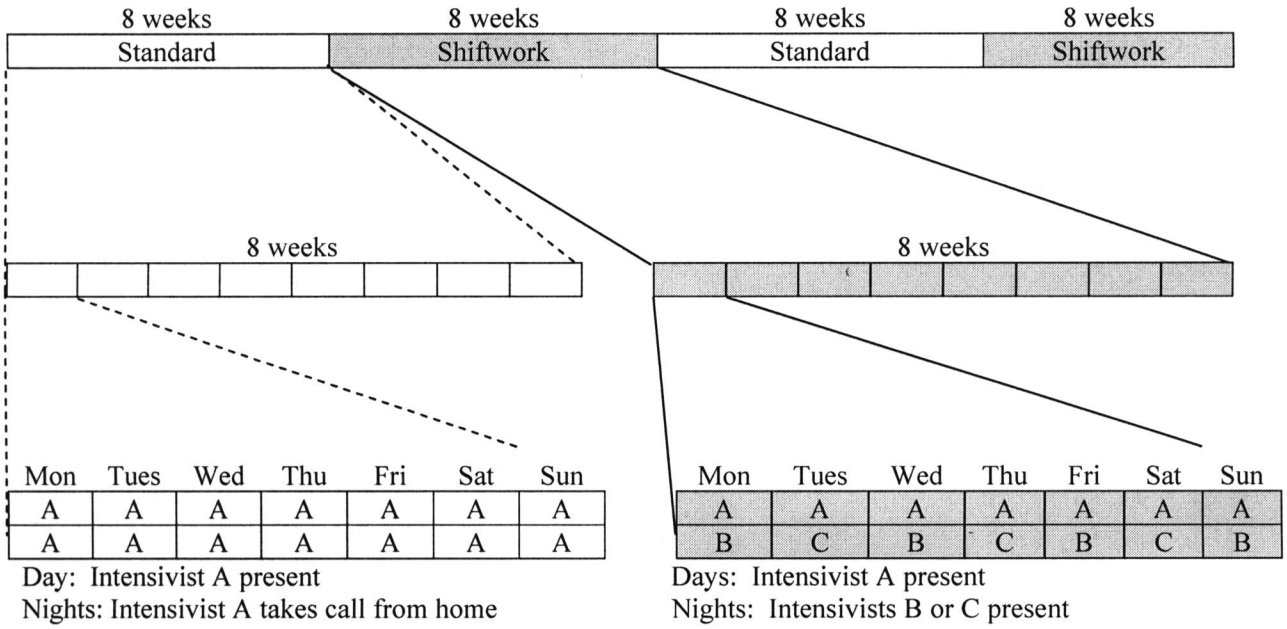
CONTENTS

eFigure 1: Study Design

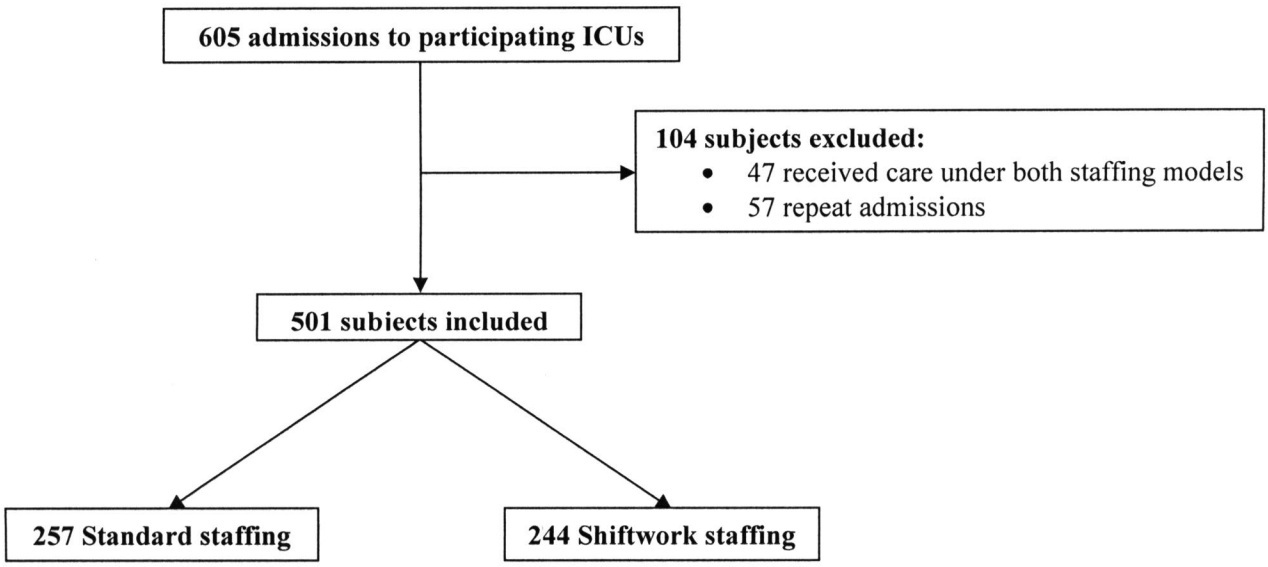
A. Alternating, 8 week blocks of Standard or Shiftwork intensivist staffing



B. Staffing structure within 8 week blocks, tertiary hospital



eFigure 2: Patient flow during study



eTable 1. Outcomes assessed for each stakeholder group.

Stakeholder group	*Outcomes*	*Data source*
Intensivists	-Burnout, emotional exhaustion subscale [a] -Work-home imbalance [b] -Role overload [c] -Role ambiguity [d] -Intensivist role conflict	Self-report surveys
ICU patients	-ICU mortality -Hospital mortality -ICU length of stay -Hospital length of stay -# Laboratory blood tests -# Microbiologic cultures -# Imaging tests -# Blood and colloid administrations	regional ICU clinical database
Families of ICU patients	-Satisfaction with care [e] -Satisfaction with decision-making [e] -Overall satisfaction [e]	Self-report surveys
ICU Nurses	-Nurse-physician collaboration [f] -Satisfaction with communications [g] -Nurse-physician understanding [g] -Shift communication [g] -Role conflict [d]	Self-report surveys
ICU house officers	-Autonomy [h] -Supervision [i] -Opportunity to learn [i]	Self-report surveys

[a] Maslach C, Jackson SE, Leiter MP. *Maslach Burnout Inventory Manual*. 3rd ed Mountain View, California: CPP, Inc.; 1996.

[b] Kopelman RE, Greenhaus JH, Connolly TF. A Model of Work, Family, and Interrole Conflict: A Construct Validation Study. *Organizational Behavior and Human Performance*. 1983;32:198-215.

[c] Bacharach SB, Bamberger P, Conley SC. Work Processes, Role Conflict, and Role Overload: The Case of Nurses and Engineers in the Public Sector. *Work and Occupations*. 1990;17(2):199-228.

[d] Peterson MF, Smith PB, Akande A, al e. Role Conflict, Ambiguity, and Overload: A 21-Nation Study. *Academy of Management Journal*. 1995;38(2):429-452.

[e] Wall RJ, Engelberg RA, Downey L, Heyland DK, Curtis JR. Refinement, scoring, and validation of the Family Satisfaction in the Intensive Care Unit (FS-ICU) survey. *Critical Care Medicine*. 2007;35(1):271-279.

[f] Baggs JG. Development of an instrument to measure collaboration and satisfaction about care decisions. *Journal of Advanced Nursing*. 1994;20(1):176-182.

[g] Shortell SM, Rousseau DM, Gillies RR, Devers KJ, Simons TL. Organizational assessment in intensive care units: Construct development, reliability, and validity of the ICU nurse-physician questionnaire. *Medical Care*. 1991;29(8):709-27.

[h] Fields DL. Taking the Measure of Work; A Guide to Validated Scales for Organizational Research and Diagnosis Thousand Oaks: Sage Publications; 2002.

[i] Carson SS, Stocking C, Podsadecki R, et al. Effects of organizational change in the medical intensive care unit of a teaching hospital. *JAMA*. 1996;276(4):322-328.

eTable 2. Survey questions for the two domains assessed for family members of ICU patients

• Satisfaction with care (1-5 Likert scale, ratings from *Excellent* to *Poor*)

1. Concern and Caring by ICU Staff: The courtesy, respect and compassion your family member
2. (the patient) was given.
3. Symptom management: How well the ICU staff assessed and treated your family member's pain.
4. Symptom management; How well the ICU staff assessed and treated your family member's breathlessness.
5. Symptom management: How well the ICU staff assessed and treated your family member's agitation.
6. How did we treat you: Consideration of your needs: How well the ICU staff showed an interest in your needs.
7. How did we treat you: Emotional support: How well the ICU staff provided emotional support.
8. How did we treat you: Co-ordination of care: The teamwork of all the ICU staff who took care of your family member.
9. How did we treat you: Concern and Caring by ICU Staff: The courtesy, respect and compassion you were given.
10. Nurses: Skill and Competence of ICU Nurses: How well the nurses cared for your family member.
11. Nurses: Frequency of Communication With ICU Nurses: How often nurses communicated to you about your family member's condition.
12. Physicians (all doctors including residents): Skill and Competence of ICU doctors: How well the doctors cared for your family member.
13. The ICU: Atmosphere of the ICU was?
14. The Waiting Room: The atmosphere in the ICU waiting room was?
15. Some people want everything done for their health problems while others do not want a lot done. How satisfied were you with the LEVEL or amount of health care your family member received in the ICU?

• Satisfaction with decision-making (1-5 Likert scale, ratings from *Excellent* to *Poor*)

1. Information needs: Frequency of Communication With ICU Doctors: How often doctors communicated to you about your family member's condition.
2. Information needs: Ease of getting information: Willingness of ICU staff to answer your questions.
3. Information needs: Understanding of information: How well ICU staff provided you with explanations that you understood.
4. Information needs: Honesty of information: The honesty of information provided to you about your family member's condition.
5. Information needs: Completeness of information: How well ICU staff informed you what was happening to your family member and why things were being done.
6. Information needs: Consistency of information: The consistency of information provided to you about your family member's condition (Did you get a similar story from the doctor, nurse, etc.)

eTable 3. Survey questions for the five domains assessed for the intensivists

• Role Ambiguity (1-5 Likert scale from *Strongly disagree* to *Strongly agree*)

1. I had clear goals and objectives for my work..
2. I knew exactly what was expected of me.
3. I knew what my responsibilities were.
4. I felt certain about how much responsibility I had.
5. My responsibilities were clearly defined.

• Role Overload (1-4 Likert scale from *Definitely false* to *Definitely true*)

1. I didn't have time to finish my job.
2. I was rushed in doing my job.
3. I had a lot of free time on my job.

• Burnout, Emotional Exhaustion subscale (0-6 Likert scale, asking how often the following were experienced, ratings from *None of the time* to *All of the time*).

1. Emotionally drained from my work.
2. Used up at the end of the work day or shift.
3. Fatigued when I got up and had to face another day or shift on the job.
4. That working with people all day or shift was really a strain for me.
5. Burned out from my work.
6. Frustrated by my job.
7. That I was working too hard on my job.
8. That working with people directly put too much stress on me.
9. That I was at the end of my rope.

• Work-home life imbalance (1-5 Likert scale, from *Strongly disagree* to *Strongly agree*).

1. After work, I came home too tired to do some of the things I'd like to have done.
2. On the job, I had so much work to do that it took away from my personal interests.
3. My family/friends disliked how often I was preoccupied with my work while I was at home.
4. My work took up time that I'd liked to have spent with my family/friends.
5. Because my work is demanding, at times I was irritable at home.
6. The demands of my job made it difficult to be relaxed all the time at home.
7. My work schedule often conflicted with my personal life.
8. My job made it difficult to be the kind of spouse, parent or friend that I'd like to be.

• Role Conflict

1. I experienced major disagreement related to patient management with the other intensivist(s):
   0 times 1 time 2 times 3-5 times >5 times

   Next two items on 1-5 Likert scale, asking how often the following were experienced, rated from *Not at all or very rarely*, to *Very often or all of the time*):
2. I agreed with the other intensivists' medical management.
3. I felt frustrated having joint patient care responsibility with the other intensivist(s)

eTable 4. Survey questions for the five domains assessed for the ICU nursing staff

• Nurse-physician collaboration (1-7 Likert scale, from *Strongly disagree* to *Strongly agree*)

1. Nurses and physicians plan together to make the decision about care for patients.
2. Open communication between physicians and nurses took place as decisions were made for patients.
3. Decision-making responsibilities for patients were shared between nurses and physicians.
4. Physicians and nurses co-operated in making decisions.
5. In making decisions, both nursing and medical concerns about patients' needs were considered.
6. Decision making for patients was co-coordinated between physicians and nurses.

• Satisfaction with communication (1-5 Likert scale, from *Very dissatisfied* to *Very satisfied*).

1. How satisfied are you with the physician-to-physician communications?
2. How satisfied are you with the communication between patients' families and ICU physicians?
3. How satisfied are you with the communication between patients and ICU physicians?
4. Overall, how satisfied are you with the communication between nurses and physicians?

• Nurse-physician understanding (1-5 Likert scale, from *Strongly disagree* to *Strongly agree*).

1. Nurses have a good understanding of physician goals.
2. Nurses have a good understanding of physicians' treatment plans.
3. Physicians are readily available for consultation.
4. Physicians have a good understanding of nursing objectives.
5. Nursing care plans are well understood by physicians in this unit.
6. There is effective communication between nurses and physicians across shifts.
7. Physicians associated with the unit are well informed regarding events occurring on other shifts.
8. I look forward to working with the physicians on this ICU each day.

• Physician communication across shifts (1-5 Likert scale, from *Strongly disagree* to *Strongly agree*).

1. There is effective communication between physicians across shifts.
2. Physicians associated with the unit are well informed regarding events occurring on other shifts.

• Role conflict (1-5 Likert scale, from *Strongly disagree* to *Strongly agree*).

1. I was often involved in situations in which there were conflicting plans for patient management.
2. I received incompatible instructions from different attending physicians.
3. I had to do things that should be done differently.

eTable 5. Survey questions for the three domains assessed for the ICU housestaff

• Autonomy (1-7 Likert scale)

1. How much autonomy was there for you in this ICU block? That is, to what extent were you permitted to decide on your own how to go about doing the work?
2. The job gave me considerable opportunity for independence and freedom in how I did the work.
3. The job denied me any chance to use my personal initiative or judgment in carrying out the work (reversed item).

• Supervision (1-5 Likert scale, rated from *Very poor* to *Very good*).

1. Supervision by more senior physicians during *daytime* hours.

• Opportunity to learn (1-5 Likert scale, rated from *Very poor* to *Very good*).

1. Opportunity to learn during *daytime* hours.

eTable 6. Unadjusted intensivist outcomes, comparing the two intensivist staffing models, by site.

Parameter	*Tertiary ICU*			*Community ICU*		
	Standard Staffing	Shiftwork staffing	p-value	Standard Staffing	Shiftwork Staffing	p-value
Burnout	33.2 ± 20.2	28.8 ± 16.1	0.44	28.1 ± 26.4	22.9 ± 15.3	0.87
Work-home imbalance	55.6 ± 32.1	48.2 ± 21.8	0.19	55.3 ± 35.6	44.7 ± 23.4	0.25
Role overload	65.2 ± 31.1	33.7 ± 24.0	0.001	54.7 ± 30.6	22.6 ± 21.6	0.0003
Role ambiguity	14.3 ± 18.9	26.3 ± 22.6	0.048	6.3 ± 10.7	24.3 ± 22.6	0.002

Values are mean ± SD, rescaled to range 0-100.

eTable 7. Linear GEE regression model results for intensivist outcomes. Values are coefficients (95% C.I.), representing mean differences.

Variable	Burnout	Home-work Imbalance	Role overload	Role ambiguity
Shiftwork staffing (vs. standard staffing)	-6.9 * (-13.5, -0.3)	-10.1 * (-19.5, -0.7)	-28.4 † (-37.7, -19.1)	9.5 * (2.2, 16.7)
Community ICU site (vs. tertiary site)	-11.8 (-78.5, 54.9)	-16.2 (-110.9, 78.4)	6.7 (-87.3, 100.6)	-54.8 (-127.8, 18.2)
Cumulative daily patient census	2.5 (-1.1, 6.0)	2.7 (-2.3, 7.7)	7.1 † (2.1, 12.0)	-2.9 (-6.7, 1.0)
Interaction term between site and patient census	3.7 (-5.0, 12.5)	4.9 (-7.5, 17.3)	3.6 (-8.7, 16.0)	6.8 (-2.7, 16.3)

* $p<0.05$, † $p<0.01$

eTable 8. Regression model results for hospital mortality, and median ICU length of stay.

	Logistic regression of hospital mortality			Median regression of ICU length of stay, in hours		
Variable	Odds ratio	p-value	95% CI	Coefficient (hours)	p-value	95% CI
Shiftwork staffing (vs. standard staffing)	**1.22**	**0.44**	**0.73, 2.04**	**-5.8**	**0.46**	**-21.1, 9.5**
Community ICU site (vs. tertiary site)	1.38	0.30	0.75, 2.52	-4.0	0.67	-22.3, 14.3
Admitted from other than Emergency	2.07	0.008	1.21, 3.54	15.3	0.15	-5.6, 36.3
Admitted to ICU at night (vs. day)	0.82	0.45	0.49, 1.38	1.7	0.83	-14.3, 17.8
Age (per decade)	1.09	0.31	0.92, 1.30	1.25	0.64	-4.0, 6.5
Male sex (vs. female)	1.34	0.27	0.80, 2.25	7.2	0.34	-7.5, 21.8
Charlson Comorbidity Index (per point)	1.06	0.36	0.94, 1.20	3.8	0.12	-1.0, 8.5
Type of ICU admission diagnosis	--	--	--	--	--	--
Medical (reference)	--	--	--	--	--	--
Cardiovascular	0.80	0.75	0.21, 3.12	-7.3	0.64	-37.3, 22.8
Surgical	0.70	0.62	0.18, 2.82	-20.5	0.73	-67.7, 26.6
APACHE II score (per 10 points)	6.72	<0.001	4.34, 10.40	-2.9	0.73	-19.5, 13.7

eTable 9. Negative binomial regression model results of ICU resource use variables. Values are rate ratios (95% C.I.)

Variable	Laboratory tests	Cultures	Imaging	Blood and colloid administrations
Shiftwork staffing (vs. standard staffing), value (95% C.I.)	**0.92 (0.82-1.02)**	**0.85 (0.70-1.02)**	**0.90 (0.80-1.01)**	**0.88 (0.62-1.24)**
Community ICU site (vs. tertiary site)	0.78 †	0.71 †	0.71 †	0.51 †
Admitted from other than Emergency	1.01	1.192	1.010	1.479 *
Admitted to ICU at night (vs. day)	1.03	0.968	0.969	0.839
Age (per decade)	1.02	1.000	1.054 *	0.948
Male sex (vs. female)	0.99	0.858	0.890	1.045
Charlson Comorbidity Index (per point)	1.02	0.962	1.018	1.174 †
Type of ICU admission diagnosis				
Medical (reference group)	--	--	--	--
Cardiovascular	0.80 *	0.28 †	0.74 *	0.70
Surgical	1.12	0.48 *	0.81	2.44
APACHE II score (per 10 points)	1.23 †	1.21 †	1.12 *	2.31 †
ICU length of stay (per day)	1.16 †	1.13 †	1.13 †	1.15 †

* p<0.05, † p<0.01

eTable 10. Family Satisfaction with ICU Care, by ICU, unadjusted. Values are mean ± SD, rescaled to range 0-100.

	Tertiary ICU	Community ICU	p-value
Number of respondents	63	56	--
Satisfaction with care	78.4 ± 18.7	74.6 ± 18.6	0.18
Satisfaction with decision-making	70.8 ± 20.6	67.3 ± 20.3	0.30
Overall score	75.2 ± 18.2	71.5 ± 18.2	0.23

eTable 11. Linear regression model results of family satisfaction outcomes, rescaled to range 0-100. Values are coefficient (95% C.I.)

Variable	Overall satisfaction	Satisfaction with care	Satisfaction with decision-making
Shiftwork staffing (vs. standard staffing)	**0.91 (-5.89, 7.70)**	**1.65 (-5.32, 8.63)**	**-0.05 (-7.70, 7.59)**
Community ICU site (vs. tertiary site)	-5.09 (-12.12, 1.94)	-5.32 (-12.55, 1.90)	-4.83 (-12.74, 3.09)
Patient died in ICU	-2.15 (-13.74, 9.45)	-3.24 (-15.15, 8.66)	-0.52 (-13.57, 12.52)
Respondent of male sex	-0.61 (-7.75, 6.54)	-1.42 (-8.76, 5.92)	0.48 (-7.56, 8.52)
Respondent age (per 10 years)	-0.02 (-0.27, 0.23)	0.00 (-0.25, 0.26)	-0.05 (-0.33, 0.23)
Respondent's relationship to patient			--
spouse (reference group)	--	--	--
child	1.33 (-7.13, 9.80)	-0.70 (-9.40, 7.99)	4.17 (-5.35, 13.69)
sibling	0.62 (-10.66, 11.90)	1.80 (-9.78, 13.39)	-0.65 (-13.34, 12.04)
parent	-16.02 (-31.87, -0.18) *	-16.19 (-32.47, 0.08)	-16.14 (-33.97, 1.69)
other	-8.36 (-24.42, 7.70)	-10.70 (-27.19, 5.80)	-5.06 (-23.13, 13.02)

* $p<0.05$

eTable 12. Linear GEE regression model of ICU nurse outcomes, rescaled to range 0-100. Values are coefficients (95% C.I.)

Variable	Nurse-physician collaboration	Satisfaction with communications	Nurse-physician understanding	MD-MD communication across shifts	Role conflict
Shiftwork staffing (vs. standard staffing)	**-0.12 (-4.54, 4.30)**	**-2.53 (-6.01, 0.95)**	**0.63 (-1.75, 3.01)**	**0.49 (-3.51, 4.50)**	**9.01 * (4.68, 13.34)**
Community ICU site (vs. tertiary site)	-9.39 * (-18.65, -0.14)	-6.15 (-13.63, 1.33)	-10.32 * (-16.05, -4.58)	-9.33 * (-16.86, -1.81)	14.83 * (6.80, 22.86)
Works mostly day shifts	-1.09 (-8.41, 6.23)	-0.63 (-6.36, 5.10)	0.86 (-3.29, 5.01)	-3.81 (-10.01, 2.39)	-2.12 (-8.72, 4.47)
Male sex	-0.32 (-12.62, 11.98)	2.28 (-7.67, 12.23)	0.61 (-7.05, 8.26)	6.27 (-3.80, 16.34)	12.10 * (1.34, 22.86)
Years as ICU nurse					
< 3 (ref, group)	--	--	--	--	--
3-5	0.56 (-10.15, 11.27)	-2.16 (-10.78, 6.45)	-2.19 (-8.61, 4.23)	-3.51 (-12.49, 5.46)	-12.33 * (-21.93, -2.74)
6-10	-4.95 (-16.82, 6.91)	-2.19 (-11.71, 7.33)	-2.17 (-9.29, 4.95)	0.88 (-9.04, 10.80)	4.43 (-6.18, 15.04)
11-20	-8.12 (-18.55, 2.32)	-8.15 (-16.56, 0.25)	-7.86 * (-14.20, -1.53)	-14.32 * (-22.92, -5.71)	6.79 (-2.47, 16.05)
> 20	-7.86 (-18.77, 3.05)	-3.79 (-12.62, 5.04)	-6.65 (-13.38, 0.08)	-6.95 (-16.05, 2.15)	-4.74 (-14.36, 4.89)

* p<0.05

eTable 13. Linear regression model of ICU housestaff outcomes, rescaled to range 0-100. Values are coefficients (95% C.I.)

Variable	Autonomy	Supervision	Learning opportunity
Nights/days, and staffing model			
days, standard staffing (reference)	--	--	--
nights, standard staffing	10.53 (5.43, 15.63) †	-27.63 (-34.87, -20.40) †	-5.26 (-17.63, 7.11)
days, shiftwork staffing	2.30 (-2.99, 7.59)	-8.85 (-22.55, 4.85)	-11.55 (-26.41, 3.30)
nights, shiftwork staffing	4.38 (-0.91, 9.67)	-8.85 (-22.55, 4.85)	-16.24 (-31.10, -1.39) *
Residency year	2.07 (-0.28, 4.42)	2.03 (-6.14, 10.19)	-5.09 (-12.64, 2.45)
Had done prior ICU rotations	1.13 (-1.23, 3.48)	-7.40 (-14.94, 0.14)	9.98 (2.66, 17.31) †
Male sex	-3.26 (-7.88, 1.36)	3.33 (-12.24, 18.90)	-8.93 (-23.42, 5.57)

* p<0.05, † p<0.01