

Diffusion of Evidence-based Intensive Care Unit Organizational Practices

A State-Wide Analysis

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Abstract

Rationale: Several intensive care unit (ICU) organizational practices have been associated with improved patient outcomes. However, the uptake of these evidence-based practices is unknown.

Objectives: To assess diffusion of ICU organizational practices across the state of Pennsylvania.

Methods: We conducted two web-based, cross-sectional surveys of ICU organizational practices in Pennsylvania acute care hospitals, in 2005 (chief nursing officer respondents) and 2014 (ICU nurse manager respondents).

Measurements and Main Results: Of 223 eligible respondents, nurse managers from 136 (61%) medical, surgical, mixed medical-surgical, cardiac, and specialty ICUs in 98 hospitals completed the 2014 survey, compared with 124 of 164 (76%) chief nursing officers in the 2005 survey. In 2014, daytime physician staffing models varied widely, with 23 of 136 (17%) using closed models and 33 (24%) offering no intensivist staffing. Nighttime intensivist staffing was used in 37 (27%) ICUs, 38 (28%) used nonintensivist attending staffing, and 24 (18%) had no nighttime attending physicians. Daily multidisciplinary rounds occurred in 93 (68%) ICUs. Regular participants included clinical pharmacists in 68 of 93 (73%) ICUs,

respiratory therapists in 62 (67%), and advanced practitioners in 37 (39%). Patients and family members participated in rounds in 36 (39%) ICUs. Clinical protocols or checklists for mechanically ventilated patients were available in 128 of 133 (96%) ICUs, low tidal volume ventilation for acute respiratory distress syndrome in 54 of 132 (41%) ICUs, prone positioning for severe acute respiratory distress syndrome in 37 of 134 (28%) ICUs, and family meetings in 19 of 134 (14%) ICUs. Among 61 ICUs that responded to both surveys, there was a significant increase in the proportion of ICUs using nighttime in-ICU attending physicians (23 [38%] in 2005 vs. 30 [49%] in 2014; $P = 0.006$).

Conclusions: The diffusion of evidence-based ICU organizational practices has been variable across the state of Pennsylvania. Only half of Pennsylvania ICUs have intensivists dedicated to the ICU. Variable numbers use clinical protocols for life-saving therapies, and few use structured family engagement strategies. In contrast, the diffusion of non-evidence-based practices, including overnight ICU attending physician staffing, is increasing. Future research should focus on promoting implementation of organizational evidence to promote high-quality ICU care.

Keywords: intensive care units; personnel staffing; clinical protocols; multidisciplinary communication; patient-centered care

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There is increasing evidence linking organization factors and protocols to intensive care unit (ICU) patient outcomes. Observational studies have shown that staffing ICUs with nurses with higher levels of training and certification (1–3), higher nurse-to-bed ratios (1, 4), involvement of intensivist physicians in the care of all ICU patients (5–7), daily interprofessional rounds, and use of daily checklists (1, 7–10) are all associated with superior patient outcomes. Randomized clinical trials have demonstrated mortality benefits from clinical protocols for lung-protective mechanical ventilation strategies (11, 12), ventilator liberation (13), and management of sedative medications (13, 14). Several studies have shown the lack of a need for in-hospital nighttime intensivist staffing in closed ICUs (1, 4, 6, 15–17).

The uptake of this evidence base is increasingly supported by professional organizations such as the American College of Critical Care Medicine Task Force (18) and the Leapfrog Group (19, 20), as well as other key stakeholders. However, barriers to uptake have also been identified, including cost, loss of control, lack of leadership, and lack of ramifications for not implementing these structural and protocol changes, resulting in slow uptake, despite knowledge regarding the recommendations (21, 22).

Although there have been ICU-based studies performed (11, 15, 19, 20, 23–26), there have not been systematic attempts to examine diffusion of various ICU organizational practices within a geographically defined region. Therefore,

we examined the patterns and trajectory of uptake across Pennsylvania ICUs so as to identify targets for future systems interventions that may improve care for the critically ill.

Some of the results of this study have been previously reported in the form of an abstract at the 2016 American Thoracic Society international conference (27).

Methods

Study Design and Population

We invited nurse managers of all 223 adult ICUs in all 169 acute care hospitals in the state of Pennsylvania to participate in a web-based survey.

Instrument Development and Administration

We created a draft instrument on the basis of previous surveys of ICU organization for content (23, 28). We then assembled two separate focus groups of attending and trainee intensivist physicians, with approximately 10 participants in each group, to provide feedback about the content, form, and structure. We further refined the instrument after a pilot test with 10 clinicians, including 6 ICU nurse leaders who would not be otherwise eligible to participate in the survey, 1 physician researcher with experience in survey design, and 3 nurse researchers.

The final instrument included 38 items and could be completed in approximately 10 to 15 minutes (*see* Appendix E1 in the online supplement) using the REDCap

(Research Electronic Data Capture) electronic platform hosted at the University of Pennsylvania (29). Survey questions were divided into five categories: ICU organization, nurse staffing, physician staffing, staffing of other disciplines, and availability of clinical protocols.

We administered the survey from January to March 2014. We sent all eligible participants an invitation letter by mail, which included multiple means to access the survey (quick response code, web address, or request for an email link). Along with the invitation letter, we included a \$20 bill (30). We sent nonrespondents postcards every 2 weeks for a total of 6 weeks after the initial invitation. At 8 weeks, we attempted to contact the nonresponding nurse managers directly by telephone to request their participation.

Additional Data Sources

We obtained hospital-level data from the American Hospital Association Annual Survey Database for fiscal year 2014, including total number of hospital and ICU beds, total number of hospital annual admissions, hospital ownership, affiliation with Accreditation Council for Graduate Medical Education programs, and resident-to-bed ratio. We used rural–urban continuum codes from the United States Department of Agriculture to evaluate urbanicity (31).

Linkage to Historical Survey Data

We linked the survey results to those from a survey in 2005 of hospital Chief Nursing Officers of PA hospitals (Appendix E2)

Table 1. Hospital characteristics of responding and nonresponding intensive care units using external data

Organization Characteristic	Responding ICUs (<i>n</i> = 129)	Nonresponding ICUs (<i>n</i> = 77)	<i>P</i> Value
No. of hospitals*	92	63	—
Total hospital beds, median (IQR)	308 (150–493)	228 (138–382)	0.09
Total hospital annual admissions, median (IQR)	13,136 (5,508–25,201)	10,112 (3,271–18,928)	0.1
Total ICU beds, [†] median (IQR)	34 (12–61)	26 (10–53)	0.3
Hospital ownership, <i>n</i> (%)			0.9
Not for profit	111 (86)	66 (86)	
For profit	18 (14)	11 (14)	
Accreditation Council for Graduate Medical Education programs, <i>n</i> (%)	78 (61)	40 (52)	0.2
Resident-to-bed ratio, median (IQR)	0.07 (0–0.26)	0.01 (0–0.13)	0.07
Metropolitan, <i>n</i> (%)	110 (85)	64 (83)	0.7

Definition of abbreviations: ICU = intensive care unit; IQR = interquartile range.

*Only includes hospitals for which American Hospital Association data were available (129/136 responders, 77/87 nonresponders); 14 hospitals include both responding and nonresponding ICUs and are included in both comparison groups.

[†]Missing: 14 responding ICUs, 8 non-responding ICUs.

(23, 32) to determine longitudinal trends in ICU organization factors. Questions common to the two surveys included those related to ICU capacity, daytime intensivist staffing, overall staffing, and multidisciplinary care. Hospitals that were common between the surveys and reported single ICUs were included for comparison. Hospitals that were common but differed in numbers of ICUs were explored further for types of patients cared for in each ICU. Three authors (R.K., V.M., M.P.K.) came to a consensus as to which ICUs matched between the two studies, excluding those that did not match.

Statistical Analyses

For all ICUs, we compared hospital characteristics between responders and nonresponders using Wilcoxon rank sum tests and chi-square tests as appropriate. For cases in which a single hospital had both responding and nonresponding ICUs, the hospital contributed data to both groups. For responding ICUs, we summarized survey responses using standard summary statistics. For items that were shared among both the 2005 and 2014 surveys, we compared responses using two-sample Student *t* tests and chi-square tests as appropriate.

We performed all analyses using STATA version 14.1 (StataCorp LP, College Station, TX). The study was approved by the Institutional Review Board of the University of Pennsylvania (Philadelphia, PA). The 2005 survey was approved by the Institutional Review Board of the University of Pittsburgh.

Table 2. General intensive care unit characteristics as reported in the survey

Organization Characteristic	ICUs (n = 136)
ICU operational beds, median (IQR)	12 (9.5–18.5)
ICU annual admissions, median (IQR)	1,050 (500–2,000)
ICU type	
General patients (mixed medical/surgical patients)	78 (57)
General medical patients	25 (18)
Cardiac patients (medical and surgical)	14 (10)
General surgical patients	11 (8)
Specialty patients (neurological, burn, or trauma patients only)	8 (6)
ICU services	
Mechanical ventilation	136 (100)
Vasopressor administration	136 (100)
Targeted temperature management	100 (74)
Continuous renal replacement therapy	93 (68)
Extracorporeal membrane oxygenation	25 (18)

Definition of abbreviations: ICU = intensive care unit; IQR = interquartile range. Data presented as n (%) unless otherwise noted.

Results

Baseline Characteristics

Among 223 eligible ICUs in 154 hospitals, nurse managers completed the survey for 136 (61%) ICUs in 98 (64%) hospitals, compared with 124 of 164 (76%) chief nursing officers in the 2005 survey (32). Among the 141 (92%) hospitals for which American Hospital Association data were available, responding ICUs were more likely to be located in teaching hospitals than nonteaching hospitals, although these differences did not achieve statistical significance (Table 1). Table 2 summarizes the general characteristics of the 136 responding ICUs.

ICU Staffing

Nurse staffing varied across responding ICUs (Table 3). One hundred twenty-one (89%) ICUs reported having dedicated nurse managers. Twenty-eight of 119 (24%) nurse managers managed more than one ICU. Similarly, 30 (22%) ICUs reported regular care from clinical nurse specialists. Six (4%) ICUs used at least one licensed practical nurse and seven (5%) used at least one nurse practitioner, in addition to registered nurses. Seventy-seven (57%) ICUs had at least one nurse with a Master's degree. Only 18 (13%) ICUs had no nurses with critical care certification. A majority of ICUs, 89 (65%), allowed the maximum nurse patient assignment to be three or higher. The typical nurse-to-mechanically

ventilated patient ratio was 1:2 (in 129 [95%] ICUs).

Table 4 summarizes patterns of physician staffing across responding ICUs. One hundred six (78%) ICUs had dedicated physician directors. Sixty-one (45%) ICUs had high-intensity daytime intensivist staffing. An attending physician (either intensivist or nonintensivist) was available during nighttime hours in 75 (55%) ICUs. Twenty-three (17%) ICUs utilized remote patient monitoring, or tele-ICUs, which were staffed by intensivists in 14 (61%), nonintensivist attendings in 7 (30%), and nurses in 16 (70%). Remote monitoring was used during weekday daytime hours in 10 (44%) ICUs, weekday nighttime hours in 11 (48%) ICUs, weekend daytime hours in 8 (35%) ICUs, and weekend nighttime hours in 8 (35%) ICUs. Seventy-nine of 134 (59%) ICUs routinely had fellows or residents participate in patient care.

Table 3. Intensive care unit nurse staffing

ICU Staffing Characteristic	ICUs (n = 136)
Dedicated nurse manager	121 (89)
Clinical nurse specialist provides care regularly	30 (22)
Nursing licensure levels (any present)	
LPN	6 (4)
RN	136 (100)
NP	7 (5)
Nursing education levels	
ADN	123 (90)
BSN	136 (100)
MSN	77 (57)
Nursing specialty certification in critical care	
All nurses	3 (2)
Some nurses	115 (85)
None	18 (13)
Maximum patient assignment*	
2	47 (35)
3	83 (61)
≥4	6 (4)

Definition of abbreviations: ADN = associates degree in nursing; BSN = bachelor of science in nursing; ICU = intensive care unit; LPN = licensed practical nurse; MSN = master of science in nursing; NP = nurse practitioner; RN = registered nurse. Data presented as n (%).

*95% reported the typical nurse-to-mechanically ventilated patient ratio during weekday, daytime hours to be 1:2.

Table 4. Intensive care unit physician staffing

ICU Staffing Characteristic	ICUs (n = 136)
Dedicated physician ICU director	106 (78)
Daytime intensivist staffing model	
Primary responsibility for all patients on admission	23 (17)
Primary attending or consults on all patients by ICU policy/guideline	38 (28)
Consults on certain patients by policy/guideline and on other patients only when requested by an attending physician	20 (15)
Consults on patients only when requested by the primary attending physician	21 (15)
No intensivist is available	33 (24)
Tele-ICU	1 (1)
Senior-most clinician available in person overnight	
Intensivist attending physician	37 (27)
Nonintensivist attending physician	38 (28)
Resident, fellow, or other trainee	27 (20)
Advanced practitioner	8 (6)
No physician or physician-equivalent clinician, but physicians from other parts of the hospital	24 (18)
No physician or physician equivalent is available in person	2 (2)
Patient monitoring by tele-ICU	23 (17)
Trainees routinely participate in patient care*	79 (59)

Definition of abbreviation: ICU = intensive care unit.

Data presented as n (%).

*Missing: two ICUs.

In addition to physicians and bedside nurses, care providers who provided care regularly (on at least 3 days weekly) are summarized in Table 5. Daily team rounds at least 5 days weekly occurred in 93 (68%) ICUs. Regular participants in rounds are shown in Figure 1. The patient and/or a family member participated in rounds in 36 (39%) ICUs.

ICU Protocols

Overall, protocols or checklists for mechanically ventilated patients were used in 128 of 133 (96%) ICUs (Figure 2). Automatic triggers for palliative care

consultation were used in 16 (12%) ICUs, and protocols for family meetings were used in 19 (14%) ICUs. Common elements included in family meeting protocols regarded the timing of the first and subsequent family meetings and triggers for the most severely ill patients.

Delirium was routinely measured in 83 of 132 (63%) ICUs. Of these, 70 (84%) used the Confusion Assessment Method for the ICU (33, 34), 2 (2%) used the Nursing Delirium Screening Scale (35), 3 (4%) used the Delirium Detection Score (36), and 7 (8%) used other scales, including the Intensive Care Delirium

Screening Checklist (7%) (37); the remaining ICU reported using the Vanderbilt ABCDE delirium and safety bundle without specifying the delirium scale used (38).

Temporal Trends in ICU

Organization Factors

Data for 61 ICUs were available from both the 2005 and the 2014 surveys. There were no differences in the reported number of operational ICU beds (median, 12 [interquartile range (IQR), 8–16] in 2005 vs. 12 [IQR, 8–16] in 2014; $P = 0.98$), the proportion with daily multidisciplinary rounds (39 of 60 [65%] in 2005 vs. 39 of 61 [64%] in 2014; $P = 0.9$), or the proportion reporting the availability of a case manager (54 [89%] in 2005 vs. 57 [93%] in 2014; $P = 0.3$), palliative care (27 of 59 [46%] in 2005 vs. 31 of 61 [51%] in 2014; $P = 0.6$), or pastoral care (26 of 57 [46%] in 2005 vs. 32 of 61 [52%] in 2014; $P = 0.5$) between the study periods.

There was also no significant change in the role of intensivists in patient care; however, there was increased coverage during nighttime hours by in-hospital physicians, with a shift of coverage from trainees to attending physicians ($P = 0.006$) (Figure 3).

Discussion

This study describes the diffusion of recommendations and scientific evidence regarding ICU organizational factors and assesses temporal trends in organizational models across a diverse group of hospitals. Despite the literature linking specific ICU organizational structures with superior patient outcomes, and professional society recommendations from the American College of Critical Care Medicine Task Force (18) and the Leapfrog Group (19, 20), among others, adoption of these structures remains incomplete. Having at least some nurses with critical care certification and high nurse-to-patient ratio for mechanically ventilated patients has been nearly universally adopted. However, nearly one-third of ICUs have no regular availability of intensivists. A quarter of ICUs have no dedicated clinical pharmacists, despite studies demonstrating a reduction in medication errors (39)

Table 5. Multidisciplinary care

ICU Clinician	Clinicians Providing Care on a Regular Basis (≥ 3 d weekly) (n = 136)
Respiratory therapists	133 (98)
Social workers and/or case managers	129 (95)
Physical therapists and/or occupational therapists	121 (89)
Nutritionists	115 (85)
Clinical pharmacists	102 (75)
Advanced practitioners	77 (57)
Pastoral care	74 (54)
Palliative care	71 (52)

Definition of abbreviation: ICU = intensive care unit.

Data presented as n (%).

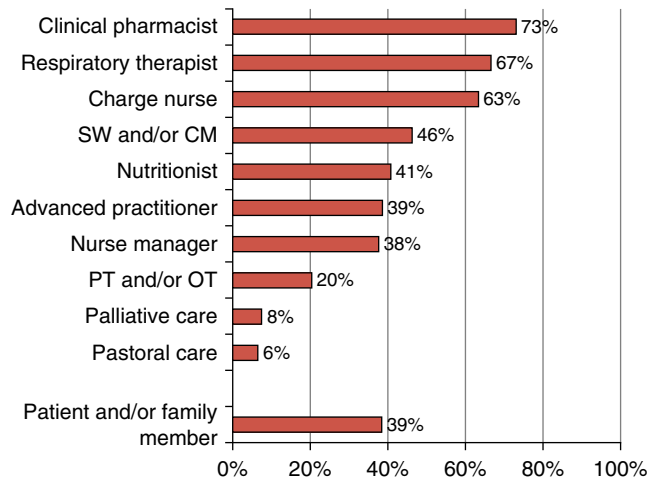


Figure 1. Participants present on daily team rounds (in addition to physician and bedside nurse) (n = 93). CM = case manager; OT = occupational therapist; PT = physical therapist; SW = social worker.

and downstream benefits to patient outcomes (40). Fewer than half of ICUs have clinical protocols for lung-protective ventilation (12) and prone positioning in ARDS (41).

Policies for structured family engagement are also uncommon. Only a quarter of ICUs engage patients and family members in daily team rounds, and even fewer have guidelines regarding

family meetings. Although the evidence of benefit from family engagement is limited (42), family engagement is consistent with principles of autonomy and patient-centered care and expert recommendations for patient and family support in the ICU (43).

The most notable change in ICU organization over the past 10 years is in nighttime physician coverage. Compared

with 2005, the same ICUs in 2014 more commonly used physicians in the ICU at night. These changes occurred despite evidence suggesting that nighttime intensivist staffing does not improve patient survival or perhaps other outcomes (1, 6, 16, 23, 44).

Why is there incomplete adoption of some evidence-based organizational practices and guideline recommendations but at the same time increases in some practices against high-quality evidence? This question remains unanswered, but there may be several factors at play. Previous literature cites high costs, lack of leadership, and lack of accountability as barriers to evidence uptake, particularly to what may be perceived to be large organizational changes (21, 22). On the other hand, although acknowledging that nighttime intensivists do not save lives on a population level, in the era of patient safety, hospitals may be willing to invest in this staffing practice to save the individual marginal lives, using the principle of “rule of rescue” rather than utilitarianism. In addition, anecdotes of poor outcomes may compel health systems to intervene despite the lack of benefit in the literature, or hospital administrators may be compelled to compete with their local markets in being able to advertise the most “advanced services.” Future work should seek to better understand these and other drivers of organizational decisions (22), methods to overcome barriers to evidence uptake, and alternative staffing solutions that may be as effective (45).

Strengths and Limitations

This study has several strengths. It includes a large and organizationally diverse population of ICUs. The response rate is high compared with other studies of health care providers (46–49). Although there were some differences among responders and nonresponders, there was an overrepresentation of academic ICUs, which are more likely to have dedicated intensivists and interprofessional rounds. Therefore, the prevalence of these organizational factors, if anything, is overestimated. As the prevalence of these staffing practices was still quite low compared with the universal recommendations, the true proportions may be even lower than our findings suggest. To our knowledge, this is the first

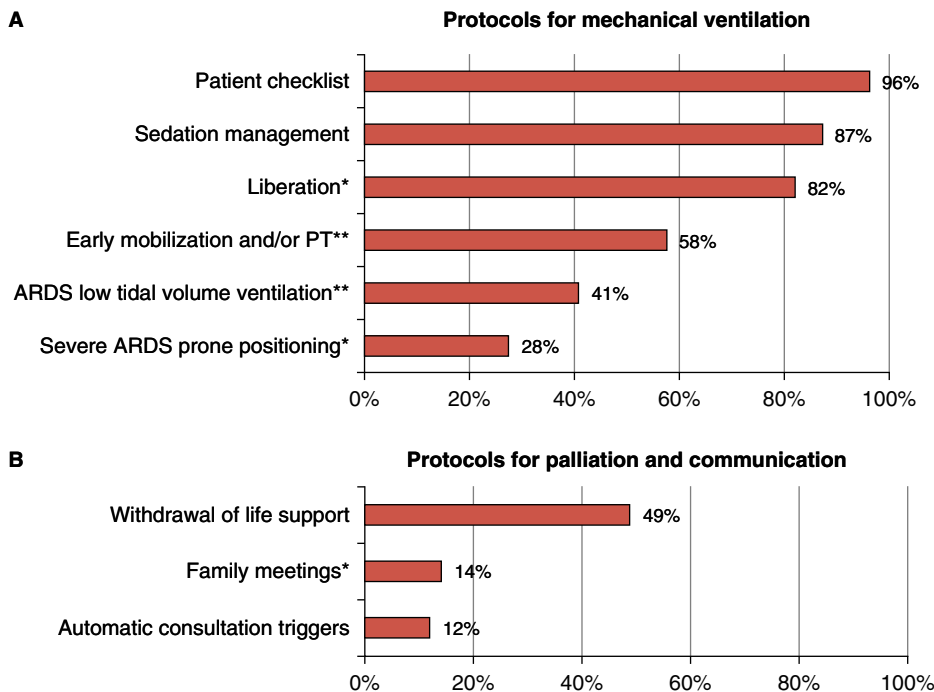


Figure 2. Presence of intensive care unit protocols (n = 133). *n = 134; **n = 132. ARDS = acute respiratory distress syndrome; PT = physical therapist.

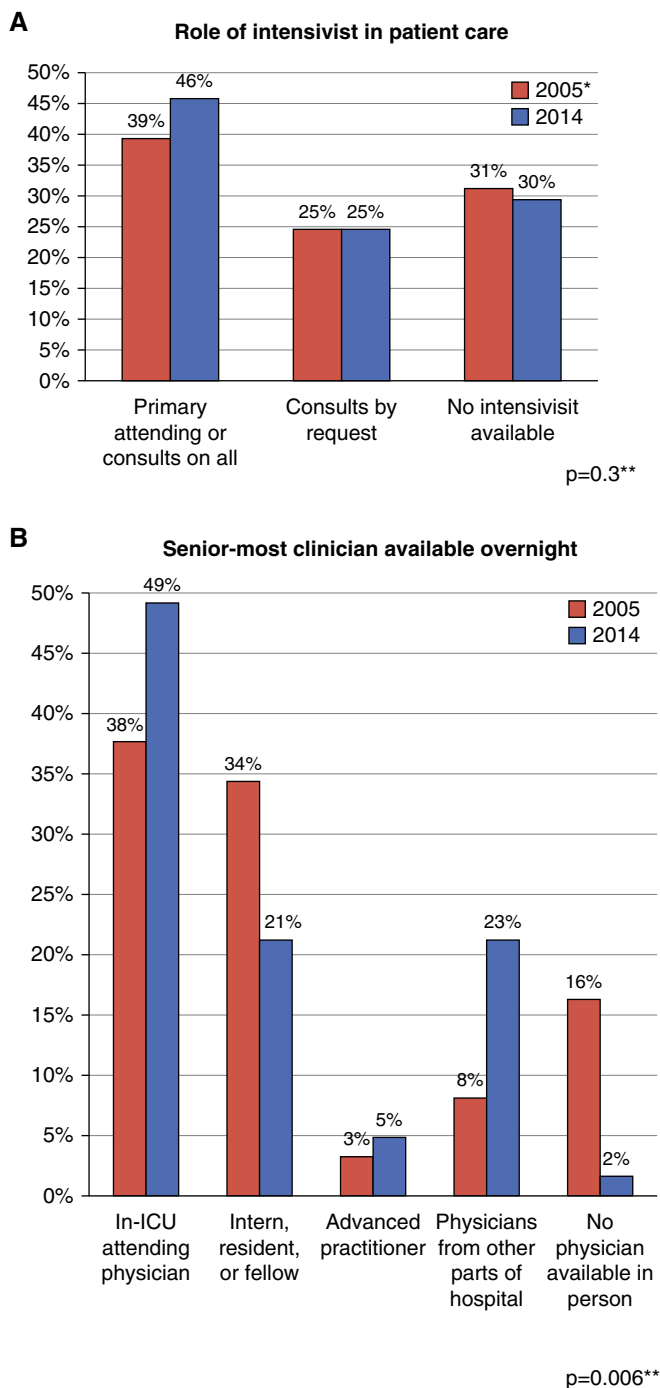


Figure 3. Temporal trends in intensive care unit (ICU) physician staffing. *5% reported “Other”; **chi-square test.

study to evaluate temporal trends of organizational practices in a diverse group of ICUs.

However, the results must also be interpreted in the context of the study limitations. First, data from the 2014 survey reflect the views of ICU nurse managers. As

shown in a prior study, nurse managers and physicians often answer the same objective and subjective questions differently (50).

Furthermore, regardless of respondent, there is always a risk that survey responses may not reflect actual practice (51, 52). However, surveys are more feasible

than other means (such as direct observation or site visits) to obtain these data on a large population of hospitals, and prior organizational research has utilized similar methods (1, 2, 7). We chose to study this population specifically because there were dedicated nurse managers in the vast majority of ICUs and because these were the most consistent staff present in these ICUs (21).

Second, the 2014 survey elicited information on the presence of clinical protocols but did not specify what is contained in them, how they are operationalized, and how they are followed. However, we did not believe that any data we could obtain on protocol adherence by self-report would be reliable (51, 52). Third, the question regarding nursing licensure captured the presence of any single nurse with a particular licensure in that ICU rather than the proportion of nurses with each licensure, which has different implications for outcomes and organizational practices.

Finally, in our longitudinal comparison, questions were asked of different populations (ICU nurse managers in the 2014 survey vs. chief nursing officers of the hospitals surveyed in 2005), using different phrasing and survey questions, and were limited to a subset of the ICUs in the surveys, making comparability and applicability limited. However, we avoided comparing subjective measures and focused on objective measures between the two studies.

Even in light of these limitations, we believe the information in this study is still of vital importance. Despite prior ICU-based studies evaluating individual organizational practices (15, 19, 20, 23–26), all of the research to date has not increased evidence-based ICU management, and we do not yet understand why. Our study highlights this point across a wide geographical and diverse population for a broad range of organizational practices. Perceptions of clinician leaders are fundamental to understanding these barriers to evidence implementation to subsequently enact change. In addition, the longitudinal data provide novel insights into ICU organizational practices and highlight areas to focus future studies.

Conclusions

At a time when evidence and recommendations support the use of intensivist-led multidisciplinary ICU care, the diffusion of these ICU organizational practices has been variable and lacking. Only half of Pennsylvania ICUs have intensivists dedicated to the ICU; one-third do not have regular team rounds,

clinical protocols for life-saving therapies are limited, and structured family engagement is rare. In contrast, the diffusion of non-evidence-based practices, including overnight ICU attending physician staffing, is increasing.

Future research should focus on better understanding barriers to implementation of evidence-based

organizational practices, contributors to implementing non-evidence-based practices, testing strategies to improve evidence uptake, and consideration of alternative staffing practices (45), to promote high-quality ICU care. ■

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

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