Nurse Practitioner/Physician Assistant Staffing and Critical Care Mortality

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BACKGROUND: ICUs are increasingly staffed with nurse practitioners/physician assistants (NPs/PAs), but it is unclear how NPs/PAs influence quality of care. We examined the association between NP/PA staffing and in-hospital mortality for patients in the ICU.

METHODS: We used retrospective cohort data from the 2009 to 2010 APACHE (Acute Physiology and Chronic Health Evaluation) clinical information system and an ICU-level survey. We included patients aged ≥ 17 years admitted to one of 29 adult medical and mixed medical/surgical ICUs in 22 US hospitals. Because this survey could not assign NPs/PAs to individual patients, the primary exposure was admission to an ICU where NPs/PAs participated in patient care. The primary outcome was patient-level in-hospital mortality. We used multivariable relative risk regression to examine the effect of NPs/PAs on in-hospital mortality, accounting for differences in case mix, ICU characteristics, and clustering of patients within ICUs. We also examined this relationship in the following subgroups: patients on mechanical ventilation, patients with the highest quartile of Acute Physiology Score (> 55), and ICUs with low-intensity physician staffing and with physician trainees.

RESULTS: Twenty-one ICUs (72.4%) reported NP/PA participation in direct patient care. Patients in ICUs with NPs/PAs had lower mean Acute Physiology Scores (42.4 vs 46.7, $P < .001$) and mechanical ventilation rates (38.8% vs 44.2%, $P < .001$) than ICUs without NPs/PAs. Unadjusted and risk-adjusted mortality was similar between groups (adjusted relative risk, 1.10; 95% CI, 0.92-1.31). This result was consistent in all examined subgroups.

CONCLUSIONS: NPs/PAs appear to be a safe adjunct to the ICU team. The findings support NP/PA management of critically ill patients.

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ABBREVIATIONS: ACGME = Accreditation Council for Graduate Medical Education; APACHE = Acute Physiology and Chronic Health Evaluation; APS = Acute Physiology Score; NP/PA = nurse practitioner/physician assistant

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Given the rising demand for critical care and a shortage of trained intensivists, hospitals are searching for alternative ways to staff the ICU.¹ One model involves the use of nurse practitioners/physician assistants (NPs/PAs).² Since the first acute care nurse practitioner certification examination in 1995³ and the emergence of critical care residencies for physician assistants,⁴ the number of these clinicians providing complex care for patients with critical illness has grown.^{5,6} In the United States, 68% of acute care nurse practitioners⁶ and 24% of physician assistants⁷ presently report working in ICUs.

Materials and Methods

Study Design and Data Sources

We conducted a retrospective cohort study of NP/PA staffing and ICU outcomes from 2009 to 2010. Patient-level hospitalization data were obtained from APACHE (Acute Physiology and Chronic Health Evaluation), a nationally representative, fee-based clinical information system that provides risk-adjusted ICU outcome data to participating hospitals for benchmarking purposes.¹⁴ These data are used for internal quality improvement and ICU outcomes research.¹⁴⁻¹⁷ We linked APACHE data to an ICU-level survey of organizational practices that included in-depth information about staffing patterns. Details of the survey design were previously reported.^{16,17}

Hospitals and Patients

We included ICUs that participate in the APACHE clinical information system and responded to the ICU staffing practices survey. To create a homogenous cohort with which we could adequately control for case-mix differences, we limited the analyses to medical and mixed medical/surgical ICUs. The subspecialty ICUs in this sample (ie, neuro-ICUs, cardiac ICUs) were infrequently staffed by NPs/PAs, and the surgical ICUs in this sample cared for a large number of trauma patients with various severities of illness and mortality rates than mixed medical/surgical ICUs. Limiting to mixed medical/surgical and medical ICUs allowed us to more confidently control for case mix and severity of illness across the two comparison groups. Thus, the final sample is a smaller subset of previously published work.¹⁷

To avoid interdependence of observations, we included only the first ICU admission for each patient. We also excluded patients aged < 17 years and those who were missing data on race (< 5% of the sample).

Variables

The primary exposure variable was admission to an ICU with NPs/PAs participating in direct patient care, defined as the response to the survey question, "Besides physician and nurses, which clinicians also routinely provide direct patient care in the ICU? (check all that apply)," with the option to select respiratory therapists, clinical pharmacists, nutritionists, and NPs/PAs. The primary outcome variable was in-hospital mortality. As in prior work, we classified patients discharged to hospice as dead upon discharge.¹⁷

We measured patient-level and ICU-level covariates believed a priori to be associated with both NP/PA staffing and mortality as potential confounders.^{14,15} Patient-level covariates available from the APACHE dataset included age, race (grouped as black, white, and other), sex, emergency surgery before ICU admission (yes or no), presence of mechanical ventilation on day 1 of admission (yes or no), Acute Physiology Score (APS) on day 1 of ICU admission (scored from 0 to 252,

Despite the expansion of this workforce, it remains unclear how NPs/PAs affect the quality of care in the ICU. Single-center studies examining the relationship between NP/PA staffing and outcomes either show no difference in outcomes^{2,8} or demonstrate improvements on select outcomes,⁹⁻¹³ and multicenter studies are lacking. To better understand how NPs/PAs affect patient outcomes, we conducted a retrospective cohort study of NP/PA use in a large cohort of US ICUs. We sought to compare organizational characteristics of ICUs with and without NP/PA staffing and to understand the association between admission to an ICU with NP/PA staffing and in-hospital mortality in adult patients in the ICU.

with a higher score representing higher illness severity), transferred from an outside hospital (yes or no), pre-ICU length of stay (in days), and presence of individual comorbid conditions (AIDS, myeloma, lymphoma, diabetes, metastatic cancer, cirrhosis, and liver failure [treated as indicator covariates]).

ICU-level covariates available from the APACHE dataset included annualized ICU volume¹⁵ (treated as a continuous variable), physician trainee participation in care (categorized as either present or absent at the unit level),^{18,19} and type of physician staffing model.²⁰ We defined physician staffing as either high intensity (ie, a mandatory intensivist physician consult or a closed unit) or low intensity (ie, an optional intensivist physician consult or the absence of available intensivists).²⁰

Analysis

We assessed using χ^2 tests and *t* tests as appropriate the bivariate relationships between ICU and patient characteristics in ICUs with and without NPs/PAs. We assessed the multivariable relationship between NP/PA staffing and mortality using relative risk regression²¹ with generalized estimating equations and robust variance estimators to account for ICU-level clustering.²² We used relative risk regression instead of logistic regression because the incidence of the primary outcome exceeded established thresholds for which the OR approximates the relative risk.^{23,24} We used generalized estimating equations (Stata command *xtgee*) with a normal (Gaussian) distribution and a log link. In this model, the exponentiated regression coefficients are interpreted as relative risks.²⁵

We assessed the robustness of the findings by performing subgroup analyses in four groups: patients on mechanical ventilation, patients in the highest quartile of APS (> 55), patients in ICUs with low-intensity physician staffing, and patients in ICUs with physician trainees participating in direct patient care. We examined the association of NP/PA staffing among patients on mechanical ventilation and patients with the highest quartile of APS because these represent a high-severity cohort that may be most affected by NP/PA care. We examined the relationship of NP/PA staffing in ICUs with low-intensity physician staffing and ICUs with trainees because we posited that differential effects of NP/PA staffing based on the availability of physicians, trainees, or both might exist.

We also performed a sensitivity analysis in which we included patients discharged to hospice as alive upon discharge. The goal of this analysis was to assess the degree to which our definition of in-hospital mortality influenced the results.

Because the outcome variable was in-hospital mortality rather than 30-day mortality, we also assessed for potential discharge bias if patients in one group were preferentially transferred to post-acute care facilities, thereby shifting the mortality burden.²⁶⁻²⁸ We compared discharge disposition of patients in ICUs with and without NPs/PAs using a Fisher exact test of significance. We categorized discharge disposition

into five groups: discharge to home, dead, transfer to another acute care hospital, transfer to a post-acute care facility (ie, skilled nursing facility, inpatient rehabilitation facility, long-term acute care hospital), and discharge to hospice.

All analyses were performed using Stata 12.0²⁹; all tests were two tailed, and we set significance at $P < .05$. This study used deidentified data and was exempt from review by the University of Pittsburgh Institutional Review Board.

Results

The final sample included 39,541 patients in 29 ICUs across 22 hospitals (Fig 1). Twenty-one ICUs (72.4%) reported NP/PA participation in direct patient care. No significant differences were found in ICU characteristics between units with and without NP/PA staffing (Table 1). Trainees participated in direct patient care in 76.2% of the ICUs with and in 50.0% of those without NP/PA staffing, although this difference was not statistically significant. Most ICUs were mixed medical/surgical (95.2% of ICUs with NPs/PAs and 75.0% of ICUs without NPs/PAs) rather than medical. Physician staffing models, nighttime coverage, and the presence of multidisciplinary rounds were also similar between study groups.

A total of 30,254 patients (76.5%) received care in ICUs with NPs/PAs, whereas 9,287 (23.5%) received care in ICUs without NPs/PAs (Table 2). Patients in ICUs with NPs/PAs tended to have lower severity of illness (APS, 42.4 vs 46.7; $P < .001$) and lower

frequency of mechanical ventilation (38.8% vs 44.2%, $P < .001$). We identified small, but statistically significant differences in age, race, primary diagnosis, and select comorbidities between ICUs with and without NP/PA staffing.

Unadjusted mortality was similar in ICUs with and without NP/PA staffing (13.7% vs 14.4%, $P = .10$) (Table 2). Adjusting for patient covariates (Table 3), no differences were found in relative risk of death between study groups either in the main analysis (adjusted relative risk, 1.10; 95% CI, 0.92-1.31) or in any prespecified subgroup. The sensitivity analysis modeling patients discharged to hospice as alive instead of dead revealed similar results (adjusted relative risk, 1.16; 95% CI, 1.01-1.34).

We found no evidence of discharge bias through differential discharge location by NP/PA staffing (Fig 2). There were no significant differences in the percentage of patients transferred to an acute care facility (5.8% vs 4.5%),

Figure 1 – Inclusion and exclusion criteria.

TABLE 1 Characteristics of APACHE ICUs With and Without NP/PA Participation in Direct Patient Care

Characteristic	NP/PA (n = 21)	No NP/PA (n = 8)	P Value
Hospital beds	502 ± 198.9	585.4 ± 333.0	.41
ICU beds			.97
< 10 beds	6 (28.6)	2 (25.0)	
11-15 beds	3 (14.3)	1 (12.5)	
> 15 beds	12 (57.1)	5 (62.5)	
Annualized ICU volume	966.3 ± 513.4	741.4 ± 499.1	.29
Intensivist staffing			.47
High (mandatory consult or closed unit)	10 (47.6)	5 (62.5)	
Low (optional consult)	11 (52.4)	3 (37.5)	
Trainees participate in patient care	16 (76.2)	4 (50.0)	.17
ICU type			.11
Medical	1 (4.8)	2 (25.0)	
Mixed medical/surgical	20 (95.2)	6 (75.0)	
Providers present in the ICU at night			.98
Nonintensivist physician	3 (14.3)	1 (12.5)	
Intensivist physician	5 (23.8)	2 (25.0)	
Resident/fellow	9 (42.8)	4 (50.0)	
NP/PA	1 (4.8)	0 (0)	
No clinician at night ^a	3 (14.3)	1 (12.5)	
Daily multidisciplinary rounds	17 (80.9)	8 (100)	.18

Data are presented as mean ± SD or No. (%). Percentages may not equal 100% due to rounding. APACHE = Acute Physiology and Chronic Health Evaluation; NP/PA = nurse practitioner/physician assistant.

^aNo clinician at night is defined as no medical provider (physician, NP/PA) present in the ICU, but instead, ED physicians or hospitalists are available for emergencies.

to a postacute care facility (22.1% vs 17.5%), and to hospice (2.3% vs 1.7%) in ICUs without NPs/PAs compared with ICUs with NPs/PAs (Fisher exact test $P = 0.92$).

Discussion

In a national sample of ICUs, we found that NP/PA staffing was common, with 72.4% of ICUs reporting that NPs/PAs directly participate in care. We found that NP/PA staffing was not associated with observable differences in risk-adjusted mortality either overall or in several high-risk subgroups. These findings were not attributable to discharge bias. We found small, non-significant differences in discharge location between groups, and discharge to other health-care facilities was, if anything, slightly higher in the group without NPs/PAs. If those patients experienced early postdischarge mortality, including those deaths would tend to move the results closer to the null, thus strengthening the negative findings. Together, these data suggest that NPs/PAs are a safe adjunct to the ICU care team, supporting an expanded role for NPs/PAs in the ICU as a response to the growing demand for critical care services.⁴

Historically, use of NPs/PAs in health care originated from a need in the 1960s for more primary care providers to meet the demand for outpatient and preventive services.⁶ NPs/PAs began to play an increasingly important role in acute and critical care delivery in the 1990s because the Accreditation Council for Graduate Medical Education (ACGME) resident duty hour reform constrained the role of physician trainees in acute care.^{4,30} More recently, the ACGME implemented more restrictive duty hour limits.⁴ This action, combined with increases in patient acuity in US hospitals, amplified existing ICU staffing challenges and led to the increased use of NPs/PAs in ICUs.^{13,31} Indeed, another survey found that 27% of academic medical centers report ACGME guidelines as the primary reason for employing NPs/PAs in the acute care setting.⁹ This change is part of a larger trend in which the scope of nursing practice is broadening, allowing nurse practitioners to offset physician workforce shortages.³²

The present results are consistent with single-center studies in which the addition of NPs/PAs to a medical ICU was not associated with a higher risk of death.^{8,33,34}

TABLE 2 Characteristics of Patients Cared for in APACHE ICUs With and Without NP/PA Participation in Direct Patient Care

Characteristic	NP/PA (n = 30,254)	No NP/PA (n = 9,287)	P Value
Age, y	61.4 ± 17.1	62.8 ± 17.3	< .001
Male sex	16,188 (53.5)	5,038 (54.3)	.21
Race			< .001
White	26,153 (86.4)	7,489 (80.6)	
Black	2,736 (9.0)	1,224 (13.2)	
Other	1,365 (4.5)	574 (6.2)	
APS, d 1 of ICU admission, 0-252	42.4 ± 25.7	46.7 ± 28.4	< .001
Mechanically ventilated on day 1 of ICU admission	11,751 (38.8)	4,106 (44.2)	< .001
Emergency surgery	912 (3.0)	339 (3.7)	.002
Pre-ICU length of stay, d	0.97 ± 11.4	1.08 ± 5.4	.37
In-hospital mortality	4,147 (13.7)	1,335 (14.4)	.10
Primary diagnosis group			< .001
Cardiac	4,764 (15.8)	1,022 (11.0)	
Medicine	4,447 (14.7)	1,419 (15.3)	
Neurosurgery	851 (2.8)	228 (2.5)	
Postarrest	1,057 (3.5)	322 (3.5)	
Respiratory	4,843 (16.0)	1,385 (14.9)	
Sepsis	3,117 (10.3)	1,387 (14.9)	
Trauma	1,598 (5.3)	522 (5.6)	
Surgery	4,260 (14.0)	1,428 (15.4)	
Other	5,317 (17.6)	1,574 (16.9)	
Comorbidities			
AIDS	77 (0.3)	70 (0.8)	< .001
Cirrhosis	856 (2.8)	310 (3.3)	.01
Diabetes	9,511 (31.4)	3,041 (31.1)	.49
Liver failure	350 (1.2)	138 (1.5)	.01
Immunosuppression	1,688 (5.6)	826 (8.9)	< .001
Lymphoma	205 (0.7)	75 (0.8)	.19
Leukemia/multiple myeloma	278 (0.9)	115 (1.2)	.007
Tumors with metastasis	1,263 (4.2)	406 (4.4)	.41

Data are presented as mean ± SD or No. (%). Percentages may not total 100% due to rounding. APS = Acute Physiology Score. See Table 1 legend for expansion of other abbreviations.

Similarly, we did not find that admission to an ICU with NP/PA staffing confers a survival benefit. It is plausible that NPs/PAs facilitate an increased use of evidence-based guidelines^{35,36} and enhance communication and collaboration across the ICU medical and nursing teams.³⁷ However, these potential benefits of NP/PA involvement did not translate into a survival benefit in the present study. One reason may be the heterogeneity of NP/PA roles within the sample. To the degree that NPs/PAs are used to offset physician trainee absences rather than augment existing physician staffing, out-

comes might be expected to be similar between groups. Larger studies that examine NP/PA care activities in more detail are needed to distinguish between these differing roles.

This study has several limitations. The sample was not a random representation of US ICUs; instead, it was a self-selected group of mixed medical/surgical and medical ICUs that participate in the APACHE clinical information system. However, the sample was diverse with respect to ICU and hospital structural characteristics, strengthening the generalizability of the findings. The

TABLE 3] Relative Risks (e⁸) Estimating the Effect of NP/PA Participation on In-Hospital Mortality for All Patients and Subgroup Analyses

Group	Unadjusted	Adjusted for Patient and ICU Characteristics ^a
All patients (n = 39,541)	1.03 (0.81-1.31)	1.10 (0.92-1.31)
Patients receiving mechanical ventilation (n = 15,857)	1.15 (0.92-1.42)	1.07 (0.94-1.23)
Highest quartile of APS (n = 9,737)	1.14 (0.93-1.39)	1.06 (0.95-1.89)
Low-intensity physician staffing (n = 22,218)	1.27 (0.94-1.72)	1.10 (0.82-1.47)
ICUs with trainees (n = 23,850)	0.91 (0.69-1.22)	1.12 (0.86-1.44)

Data are presented as relative risk ratio (95% CI). Models account for clustering of patients within ICUs. See Table 1 and 2 legends for expansion of abbreviations.

^aAdjusted models control for ICU characteristics (ICU physician staffing intensity, annualized ICU volume, and trainee participation) and patient characteristics (age, APS on ICU admission day 1, primary diagnosis, comorbidities, race, sex, indicator for emergency surgery, transfer status, and length of stay before ICU admission).

study included only medical and mixed medical/surgical ICUs, and the relationship between NP/PA staffing and subspecialty ICUs remains unclear. Additionally, we defined NP/PA staffing at the level of the unit, not the patient, so we were unable to link NP/PA care to individual patients in the cohort and, thus, could not examine the impact of direct care by an NP/PA. However, a patient-level analysis would introduce new selection bias because patients receiving care from NPs/PAs would likely be different from other patients in unobservable ways. That said, the results should be interpreted as the effect of staffing the ICU with NP/PAs not as the effect of direct care by an NP/PA. Statistically, our log-linear modeling approach may have potential problems in relation to bounding.³⁸⁻⁴⁰ Alternative approaches would be a log-binomial model or traditional logistic regres-

sion. However, log-binomial models often fail to converge, and logistic regression can produce ORs that are not numerically similar to the relative risk ratios in some circumstances.^{23,24} Our chosen approach represents the best compromise of feasibility and interpretability of the results.

As in all observational studies, there are unmeasured patient- and unit-level variables that could confound the results. For example, ICUs with NP/PA staffing may have other organizational characteristics (ie, a positive unit culture) compared with ICUs without NP/PA staffing, and these differences could affect any survival benefit that may be seen. We also did not examine other outcomes, such as family or patient satisfaction, provider burnout, or long-term patient outcomes, that may

Excludes 4523 patients with missing values for discharge disposition. P-value for Fisher's exact test for differences between groups = 0.92 NP = nurse practitioner; PA = physician's assistant

Figure 2 – Discharge disposition by NPPA participation in direct patient care.

be influenced by NP/PA participation in direct patient care. Although we are able to identify whether NPs/PAs participate in direct patient care, we do not know the tasks or specific care that they are providing; thus, we cannot be certain that the NPs/PAs in this sample are being used to the fullest extent of their scope of practice or even that they are being used in a similar manner in all the study ICUs.

Overall, this study provides important new evidence suggesting that NPs/PAs are a safe adjunct to the ICU

care team. The findings support a growing role for NPs/PAs in patient care management in the ICU setting. The Institute of Medicine and other health-care leaders call for greater effort to ensure that nurses, including nurse practitioners, work to the fullest extent of their scope, license, and education.^{41,42} More work is needed to understand the optimal role that NPs/PAs can offer in the critical care setting and to identify ways to remove barriers that prohibit expansion of NP/PA use in ICUs and other care settings.

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