[Editorial]

CHEST

New ICU Team Members

The Effective Inclusion of Critical Care Advanced Practice Providers

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Today, the treatment of critically ill and injured adults involves complex care paradigms that are delivered by interprofessional teams at the time of the day or night when evaluation or management is needed. The need for time-sensitive critical care interventions and the steadily rising numbers of adult critically ill and injured patients have sparked interest in new ways to provide timely and effective treatments. Optimal outcomes for patients with serious infections, coronary artery occlusion, stroke, bleeding victims of blunt or penetrating trauma, and patients with acute respiratory failure require distinct treatments that are time sensitive. The rising need for critical care was accurately predicted from models of the aging dynamics of our population[1] and increasing utilization of critical care with decades of life after adolescence.[2]

The effectiveness of one increasingly common approach is presented in this issue by Janna Landsperger[3] who is an acute care nurse practitioner from Vanderbilt. This important study was inspired by the late Arthur Wheeler, MD. Arthur was a preeminent leader in the field of pulmonary and critical care medicine who understood the power and importance of true interprofessional collaboration. This landmark study addresses one of the most pressing and challenging questions facing the critical care community: How are we going to provide high quality care for all of the critically ill and injured patients who need it?

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The problem of caring for high-acuity patients who require time-sensitive interventions dates to the time that the first ICUs were created. A closer working relationship of physicians, nurses, and other clinical professionals was central to making the cohorting of high-acuity patients an effective and nearly universally accepted care model. Nearly all effective solutions for high-acuity patients involve team care. In the context of critical care medicine, value has been derived from the creation of interprofessional teams with each team member having a defined role and providing a scope of services that is dictated by training, experience, and license. The current study tests the hypothesis that access to high-quality critical care can be increased by creating new types of critical care professionals who are able to prescribe and perform procedures.

In the Landsperger study,[3] acute care nurse practitioners (ACNPs) that had additional critical care specialty training were supervised by critical care specialists. This study was possible by the interprofessional study team that was assembled by Dr Wheeler and the guided experiential training program that they created and implemented at Vanderbilt. This new class of ICU providers was not made up of recent graduates left to unguided task-oriented work assignments; rather, the ACNPs of this study received 4 months of direct critical care specialist supervised, hands-on, and mentored patient care experience. The formal training paradigm included direct supervision of the ability to recognize critical illness, perform initial patient stabilization tasks, broker the admission process, and ensuring that time-sensitive treatments and procedures were performed successfully when they were needed. The effectiveness of ACNP communication skills that are critical for effective intensivist oversight was documented. Importantly, their professional and procedural competencies were reviewed by critical care specialists who completed formal evaluations of their performance.

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The study demonstrated that there was essentially no difference of 90-day mortality for ACNP care team patients compared with resident team patients for teams with equivalent intensivist oversight; the primary study end point. Similarly, secondary end points demonstrated equivalently positive hospital mortality and ICU lengths of stay. Overall, the study demonstrated that nonphysician ICU team members who have adequate training and proper supervision can provide care of comparable quality to the care delivered by a traditional resident model at a highly respected academic medical center.

The finding that ICU teams that include properly trained and supervised advanced practice providers can provide care that is of equivalent quality to that provided by resident staffed teams is consistent with most prior studies.[4-6] Limitations of resident work hours[7] have been associated with the inclusion of nurse practitioners and physician assistants on to an increasing number of critical care teams.[8] Estimates of the inclusion of these provider types from the Medicare and Medicaid databases suggest that their contributions are underestimated from administrative data because the important services of these providers are often outside of professional reimbursement requirements.[9]

The team at Vanderbilt and its late leader, Dr Arthur Wheeler, are to be congratulated for putting together a nonphysician-based care team with a formal, dedicated, mentored, training model that documented proficiency of key critical care delivery skills. The study is important because it supports an increasingly common approach to providing high quality adult critical care.[8] As with most important studies, this work raises interesting new questions. Taken in the context of its predecessor studies, it provides a foundation for defining the scope of practice and training requirements that should be used to grant credentials to advanced practice providers who practice in ICUs. It also raises the question of how the longitudinal educational and professional needs of ICU advanced practice providers should be supported. Unfortunately, there is little to be learned about longitudinal support or the professional needs of advanced practice providers from our experience with ICU residents and fellows. The description of the intervention at Vanderbilt may understate the importance of the encouragement and vision for individual professional growth that Dr Wheeler provided for the advanced practice providers that he mentored.

The accumulated evidence suggests that properly trained and supervised nonphysician prescribing providers can provide high-quality critical care. The question remains: "Where and when should they provide care?" It appears that properly trained advanced practice providers that can effectively communicate with a supervising board-certified intensivist should provide care wherever patient need exists and they are credentialed to provide it.

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Outcomes of Nurse Practitioner-Delivered Critical Care

A Prospective Cohort Study

Janna S. Landsperger, ACNP-BC; Matthew W. Semler, MD; Li Wang, MS; Daniel W. Byrne, MS; and Arthur P. Wheeler, MD

BACKGROUND: Acute care nurse practitioners (ACNPs) are increasingly being employed in ICUs to offset physician shortages, but no data exist about outcomes of critically ill patients continuously cared for by ACNPs.

METHODS: Prospective cohort study of all admissions to an adult medical ICU in an academic, tertiary-care center between January 1, 2011, and December 31, 2013. The primary end point of 90-day survival was compared between patients cared for by ACNP and resident teams using Cox proportional hazards regression. Secondary end points included ICU and hospital mortality and ICU and hospital length of stay.

RESULTS: Among 9,066 admissions, there was no difference in 90-day survival for patients cared for by ACNP or resident teams (adjusted hazard ratio [HR], 0.94; 95% CI, 0.85-1.04; $P = .21$). Although patients cared for by ACNPs had lower ICU mortality (6.3%) than resident team patients (11.6%; adjusted OR, 0.77; 95% CI, 0.63-0.94; $P = .01$), hospital mortality was not different (10.0% vs 15.9%; adjusted OR, 0.87; 95% CI, 0.73-1.03; $P = .11$). ICU length of stay was similar between the ACNP and resident teams (3.4 ± 3.5 days vs 3.7 ± 3.9 days [adjusted OR, 1.01; 95% CI, 0.93-1.1; $P = .81$]), but hospital length of stay was shorter for patients cared for by ACNPs (7.9 ± 11.2 days) than for resident patients (9.1 ± 11.2 days) (adjusted OR, 0.87; 95% CI, 0.80-0.95; $P = .001$).

CONCLUSION: Outcomes are comparable for critically ill patients cared for by ACNP and resident teams.

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KEY WORDS: acute care nurse practitioner; critical care; critical care manpower standards; intensive care units; nurse practitioner; outcome assessment (health care); patient care team; physician assistant; quality of health care; retrospective studies

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ABBREVIATIONS: ACNP = acute care nurse practitioner; HR = hazard ratio; PA = physician assistant; UHC = University HealthSystem Consortium

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Despite increasing demand for critical care services, the number of intensivists is constant or declining.[1] Moreover, in academic medical centers, duty hour limitations for residents have diminished a traditional source of ICU manpower.[1,2] To address the resulting shortage, acute care nurse practitioners (ACNPs) and physician assistants (PAs) have been increasingly employed to provide critical care services, but few data exist regarding safety or efficacy of this practice.[1-4] Although in-hospital outcomes of patients for whom ACNPs or PAs provided a portion of the care have been reported, no study has examined the longer term outcomes of critically ill adults continuously cared for by ACNPs.[5-11]

To meet increasing critical care demands, in late 2010, Vanderbilt Medical Center expanded the number of medical ICU beds by more than 50%, which prompted the creation of a continuous in-house ACNP team in addition to two existing in-house resident teams.[12-14] All teams shared a common physical location, staff nurses, equipment, ancillary services, rounding format, and cadre of fellow and attending intensivist physicians. To evaluate the safety and efficacy of this model of care, we compared patient outcomes, including postdischarge survival, of patients admitted over a 3-year period to the ACNP and resident teams. We hypothesized that 90-day survival would be comparable between patients cared for by ACNP and resident teams.

Methods

Study Design

From January 1, 2011, through December 31, 2013, we collected observational data for all admissions to the three critical care teams in the closed, 34-bed medical ICU at Vanderbilt University Hospital. The protocol was approved by the Vanderbilt Institutional Review Board (#110005) with waiver of informed consent. Each of two resident teams was composed of one first-year and one upper-level resident; the nurse practitioner team consisted of one ACNP (e-Figure 1). Coverage models were complex and changed over time. For resident teams, upper level residents worked 24-h shifts and first-year residents worked 16-h shifts allowing for overlapping coverage during morning and evening handoffs. At the time of service implementation, ACNPs worked either 12- or optional 24-h shifts. The ACNP team transitioned to 16-h shifts with a morning overlap of 2 h for rounds and a 5-h evening overlap beginning in 2012 after a workflow analysis showed workload heaviest in the early evening. Critical care fellows and attending physicians rounded with each team twice a day, were onsite most of each day, and were available at night. Each team was responsible for the evaluation and management of their patients including conducting admissions, transfers, and discharges; obtaining and interpreting diagnostic tests; and performing critical care procedures, with supervision by fellows and attending physicians as needed.

As previously described, the implementation of the ACNP team was a labor-intensive process occurring over the 10 months before the study period.[13] Eight ACNPs were hired, underwent didactic, procedural, and simulation training, developed protocols, and were integrated into the ICU. Training consisted of 4 months of attending physician supervised hands-on patient care that included admitting patients, making differential diagnoses, performing procedures, ordering and interpreting diagnostic studies, ordering medications, interacting with consultants, and discharging patients. Daily informal feedback of the performance of each ACNP trainee was provided by the attending physician and weekly formal evaluations occurred during orientation. Ongoing performance evaluations of ACNPs were conducted every six months. Each ACNP had prior experience as a critical care registered nurse (mean, 7.0 ± 6.7 years) and half had worked previously as an ACNP (mean, 3.3 ± 2.6 years).[12-14]

Patients admitted to the ICU were evaluated by the critical care fellow and assigned to one of the three teams. Consideration was given to each team's census (total number of patients and their acuity of illness) and workload (recent admissions, pending procedures, transfers, and discharges) as well as the provisional diagnosis and acuity of the incoming admission.

Study Population

All patients admitted to a medical ICU team during the 3-year study period were eligible for inclusion in the study. Patients were excluded only if they were not under the care of a medical ICU team or admitted as organ donors after declaration of death (Fig 1). If patients were admitted more than one time during the study period, each admission was included.

Data Collection

Demographic and administrative data for each patient were entered into a secure, online Research Electronic Data Capture database by the medical receptionist at the time of ICU admission and verified using an independently generated hospital administrative database. The composite database included information on patient characteristics (demographics, marital status, residence), admission data (date, time, and source of admission, provisional admitting diagnosis), severity of illness (use of mechanical ventilation and vasopressors, expected hospital mortality), team assignment (ACNP or resident), and outcomes (ICU and hospital length of stay, ICU and hospital mortality). In January 2015, more than 1 year after the date of the last admission, vital status of all patients was added to the database by study personnel unaware of patients' team assignment by review of the electronic health record. When vital status at 90 days could not be determined by review of the electronic health record, study personnel searched legacy.com for the patient's obituary or a relative's obituary listing them as a survivor. If vital status remained in question, a search of ancestry.com, which links to the national death index, was conducted. If a record of death could still not be found, each patient's name and common variants were searched using google.com in an attempt to determine vital status.

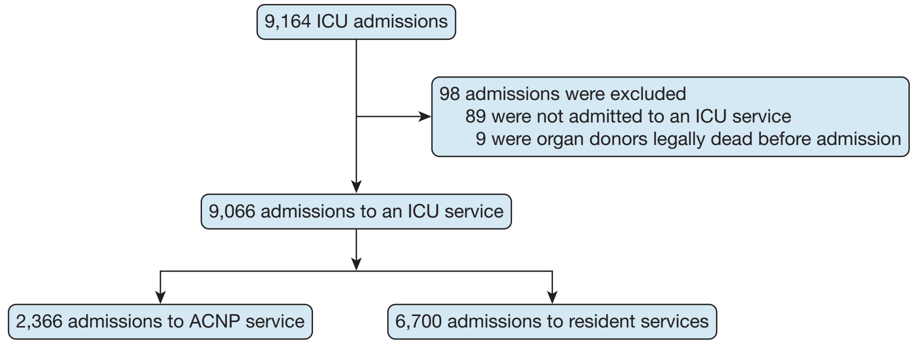
Study Outcomes

The primary end point was 90-day survival, defined as the time from ICU admission to death censored at 90 days. Secondary end points included ICU and hospital length of stay and ICU, hospital, and longer term mortality (with median follow-up of 231 days).

Statistical Analysis

With 6,700 admissions to the resident team and 2,366 admissions to the ACNP team, an accrual interval of 3 years and additional follow-up after the accrual interval of 3 months, and a median survival time on

Figure 1 – *Derivation of the study cohort. All admissions to the ACNP service and resident services were included in analysis. ACNP = acute care nurse practitioners.*



the resident team of 6 months, we had 90% statistical power at an alpha of 0.05 to detect true hazard ratios (HRs) for death of 0.919 or 1.089. Similarly, with a 90-day mortality rate of 28% among admissions to the resident team, we had 90% power at an alpha of 0.05 to detect an absolute difference in mortality between teams of 3.4%.

Characteristics of the study population and outcomes measures are presented using descriptive statistics. Continuous variables are summarized as median and interquartile range; categorical variables as frequency and percentage. Outcomes of admissions to the ACNP and resident teams are compared using the Wilcoxon rank-sum test for continuous variables and Pearson χ^2 test or Fisher's exact test for categorical variables. The primary outcome of 90-day survival was evaluated using a Cox proportional-hazards model adjusting for age, sex, ventilator use, vasopressor use, and nationally benchmarked University HealthSystem Consortium (UHC) expected hospital mortality (Supplemental Methods in e-Appendix 1).[15-17] Age and UHC expected mortality were modeled as nonlinear with respect to the outcome with transformation using restricted cubic splines with three knots. For all analyses, UHC expected mortality was treated as a continuous variable. The effect of admission diagnosis, weekday vs weekend admission, dayshift vs nightshift admission, and number of ICU admissions during the study period on the relationship between admitting team and 90-day survival was examined by including an interaction term between each factor and team assignment in the model. Using all administrative and patient-level data available at the time of ICU admission, we constructed a logistic regression model to predict the propensity for admission to the ACNP vs resident team. We then adjusted for this propensity score in the multivariable Cox proportional-hazards model relating team assignment to 90-day survival. The relationships between treatment assignment and ICU, hospital, and longer term mortality were analyzed with multivariable logistic regression models and ICU and hospital length of stay with multivariable proportional odds models.[18-20]

The primary and secondary analyses performed by the study statistician are available for review in the supplemental Methods in e-Appendix 1. A second statistician unaffiliated with the study was provided access to all of the data and independently replicated all primary and secondary analyses. Statistical analyses were performed using open source R statistical software (version 3.1.2).

Results

Enrollment and Baseline Characteristics

During the 3-year study period, 7,329 unique patients experienced a total of 9,066 ICU admissions (Fig 1). Characteristics for the 2,366 admissions to the ACNP team and 6,700 admissions to the resident teams are shown in Table 1.

Patients admitted to the ACNP team were similar to those on the resident team with respect to age, sex, and race but were more often admitted from in-hospital wards and less often as transfers from another hospital. The most common admitting diagnoses for both the ACNP and resident teams were sepsis, respiratory failure, and GI bleeding (Table 1; e-Table 1). Fewer ACNP patients were receiving vasopressors or mechanical ventilation on the day of ICU admission.

The average 8 AM census for the ACNP team was 6.3 ± 1.7 patients (with one provider) compared with 18.1 ± 4.2 patients for the two resident teams of four providers (4.5 ± 1.0 patients per provider per day).

Patient Outcomes

In unadjusted univariate analysis, admissions to the ACNP team had lower ICU mortality, in-hospital mortality, and 90-day mortality (Table 2). Observed in-hospital mortality was similar to UHC expected in-hospital mortality for the ACNP (10.0% vs 10.4%) and resident (15.9% vs 15.5%) teams. After multivariable analysis adjusting for patient age, sex, ventilator use, vasopressor use, and UHC expected in-hospital mortality, there was no difference between the ACNP and resident teams in the primary outcome of 90-day survival (adjusted HR for death, 0.94; 95% CI, 0.85-1.04; $P = .210$) (Fig 2A).

When a multivariable logistic regression model was developed for the propensity of a patient to be admitted to the ACNP rather than resident team, the baseline factors associated with ACNP team admission were: source of admission ($P < .001$), admitting diagnosis ($P < .001$), body mass index (OR, 0.93; 95% CI, 0.88-0.98; $P = .01$), ventilator use (OR, 0.86; 95%, CI 0.76-0.98; $P = .03$), vasopressor use (OR, 0.84; 95% CI,

TABLE 1] Characteristics of Patients by Admitting Service

Baseline Characteristic	NP (n = 2,366)	Resident (n = 6,700)	*P* Value
Age, y	55.9 [42.1-67.6]	56.7 [43.5-67.2]	.23[a]
Men	51% (1,206)	52% (3,504)	.27[b]
Caucasian	78% (1,844)	76% (5,121)	.002[b]
BMI, kg/m^2	26.0 [22.0-31.4]	26.7 [22.7-32.4]	< .001[a]
Currently married	43% (1,017)	46% (3,098)	.006[a]
Origin of admission			< .001[a]
ED	53% (1,259)	52% (3,483)	
Referring hospital	18% (418)	25% (1,644)	
In-house transfer	20% (462)	16% (1,077)	
Other	10% (227)	7% (496)	
Admitting diagnosis			< .001[b]
Sepsis	19% (446)	26% (1,730)	
Respiratory failure	15% (361)	15% (980)	
GI bleed	13% (307)	12% (800)	
Drug toxicity or ingestion	8% (193)	5% (354)	
Glucose disorder	6% (150)	4% (267)	
Altered mental status	6% (144)	6% (389)	
Other	33% (765)	33% (2,180)	
Mechanical ventilation[c]	28% (654)	37% (2,456)	< .001[b]
Vasopressors[c]	27% (627)	36% (2,424)	< .001[b]
UHC expected mortality	10.4%	15.5%	< .001[a]

Data are presented as median [25th-75th percentile] or percentage (number). A complete list of diagnoses classified as "other" is provided in e-Table 1 of the e-Appendix 1. Glucose disorder includes diabetic ketoacidosis, hyperosmolar hyperglycemic nonketotic syndrome, and hypoglycemia. NP = nurse practitioner; UHC = University HealthSystem Consortium.
[a]Wilcoxon test.
[b]Pearson χ^2 test.
[c]Mechanical ventilation and vasopressors were not necessarily present at the time of ICU admission but when employed were initiated within 24 h of ICU admission in 90% and 80% of cases, respectively.

0.74-0.96; $P = .007$), UHC expected length of stay (OR, 0.91; 95% CI, 0.86-0.95; $P < .001$), and UHC expected in-hospital mortality (OR, 0.89; 95% CI, 0.84-0.94; $P < .001$) (e-Figure 2, e-Table 2). C-index for the propensity score model was 0.615, suggesting that diagnosis, ventilator or vasopressor receipt, and expected risk of mortality were only weakly predictive of team assignment. After adding the propensity for admission to the ACNP team to the previous multivariable model, the HR for death was 0.89 with 95% CI, 0.80-0.98 ($P = .02$) (e-Table 3). A sensitivity analysis removing all covariates except team assignment and the propensity score showed similar results (HR, 0.89; 95% CI, 0.81-0.99).

We observed no differences in 90-day survival between the ACNP and resident teams in admission subgroups of day vs night, weekday vs weekend, or admitting diagnosis; except for slightly higher survival on the ACNP team with glucose disorders and on the resident team with altered mental status (Fig 2B). Mortality was similar between the ACNP and resident teams over the full range of UHC expected in-hospital mortality (Fig 3). No significant difference in the rate of ICU readmission between the ACNP and resident teams was observed (Table 2).

Discussion

In this large, prospective cohort of consecutive admissions to a closed, academic, tertiary-care medical ICU, we found comparable 90-day survival among patients cared for by ACNP and resident teams. This observation was robust, with similar outcomes for ACNP and resident team patients admitted during the day and at night, on weekdays and weekends, across the most common admitting diagnoses, and along the full spectrum of UHC expected mortality. After adjusting for

TABLE 2] Patient Outcomes by Admitting Service

	ACNP (n = 2,366)	Resident (n = 6,700)	*P* Value	Adjusted OR	95% CI	*P* Value
Mortality						
ICU mortality	6.3% (149)	11.6% (777)	< .001	0.77	0.63-0.94	.01
Hospital mortality	10.0% (236)	15.9% (1,065)	< .001	0.87	0.73-1.03	.11
UHC expected mortality	10.4%	15.5%				
Observed in-hospital deaths	235	1,048				
Expected in-hospital deaths	239.5	1,021.7				
O:E ratio, in-hospital deaths	0.981	1.026				
90-d mortality	21.6% (510)	28.3% (1,896)	< .001	0.94	0.83-1.07	.36
Longer term mortality	38.3% (906)	43.0% (2,881)	< .001	1.03	0.92-1.14	.65
Length of stay						
ICU length of stay, d	3.4 (3.2-3.5)	3.7 (3.6-3.8)	< .001	1.01	0.93-1.1	.81
Hospital length of stay, d	7.9 (7.4-8.4)	9.1 (8.8-9.3)	< .001	0.87	0.8-0.95	< .001
UHC expected length of stay, d	7.6	9.0				
ICU disposition						
Transfer to hospital ward	56.3% (1,250)	69.7% (4,126)	< .001			
Discharge from hospital	43.6% (967)	30.3% (1,797)	< .001			
ICU readmission						
Before hospital discharge	3.5% (83)	4.4% (297)	.06	0.92	0.72-1.19	.53
Within 30 d of hospital discharge	5.5% (129)	5.3% (352)	.75	1.04	0.84-1.28	.75

ICU, hospital, 90-d, and longer term mortality are presented as percentage (frequency) and were compared between ACNP and resident teams using the Pearson χ^2 test. Longer term mortality is death at any point during follow up (median duration of follow up, 231 d). UHC expected mortality, observed in-hospital deaths, expected in-hospital deaths, and O:E ratio are given for the 2,309 ACNP and 6,581 resident patients with available UHC expected mortality data. ICU and hospital length of stay are presented as mean (bootstrap estimate of 95% CI for the mean) and were compared between ACNP and resident teams using the Wilcoxon rank-sum test. The proportion of patients transferred from an ICU room to the hospital ward vs discharged directly from the ICU room to home, a skilled nursing facility, inpatient rehabilitation, hospice, inpatient psychiatric care, or jail is compared among survivors to ICU discharge on the ACNP (n = 2,217) and resident (n = 5,923) teams using the Pearson χ^2 test. The proportion of patients readmitted to the ICU before hospital discharge and within 30 d of hospital discharge is compared between ACNP and resident services using the Pearson χ^2 test. Binary logistic regression and proportional odds models were fit to estimate the group difference for binary and ordinal outcomes, respectively, adjusting for age, sex, ventilator use, vasopressor use, and UHC expected mortality. Compared with patients cared for by residents, ACNP patients had similar odds of a longer ICU stay (odds ratio, 1.01) and lower odds of a longer hospital stay (odds ratio, 0.87). ACNP = acute care nurse practitioner; O:E = ratio of observed in-hospital deaths to expected in-hospital deaths. See Table 1 legend for expansion of other abbreviation.

potential confounders, patients cared for by the ACNP team were less likely to die in the ICU and had a shorter hospital length of stay. In-hospital mortality of patients cared for by the ACNP team was similar to nationally benchmarked UHC expected hospital mortality. These findings are important given the ongoing physician intensivist shortage and increasing use of nonphysician providers in critical care.

Our study differs from prior descriptions of advanced practice providers in critical care in several significant respects. Unlike prior studies in which care was provided by ACNPs or PAs during the day and by fellow or attending physicians at night,[6,7] patients in our study were cared for continuously by ACNPs throughout their entire ICU stay. The absence of cross-contamination by nocturnal or weekend physician coverage permits clearer inferences about the association between the ACNP's care and patient outcomes. Similarly, although our findings are compatible with ICU-level analyses of units staffed with and without ACNPs,[8] inability to define the role ACNPs played in patient care in those studies limits direct comparison.

Another important element of our study is patient follow-up beyond hospital discharge. It has become increasingly clear that the impact of critical illness does not end at hospital discharge and the effect of ICU care on longer term patient outcomes is important to understand.[21,22] This is particularly true when evaluating ICU providers who themselves influence not only ICU care, but the timing and location of ICU disposition and postdischarge planning. Demonstrating for the first time that outcomes are similar for patients

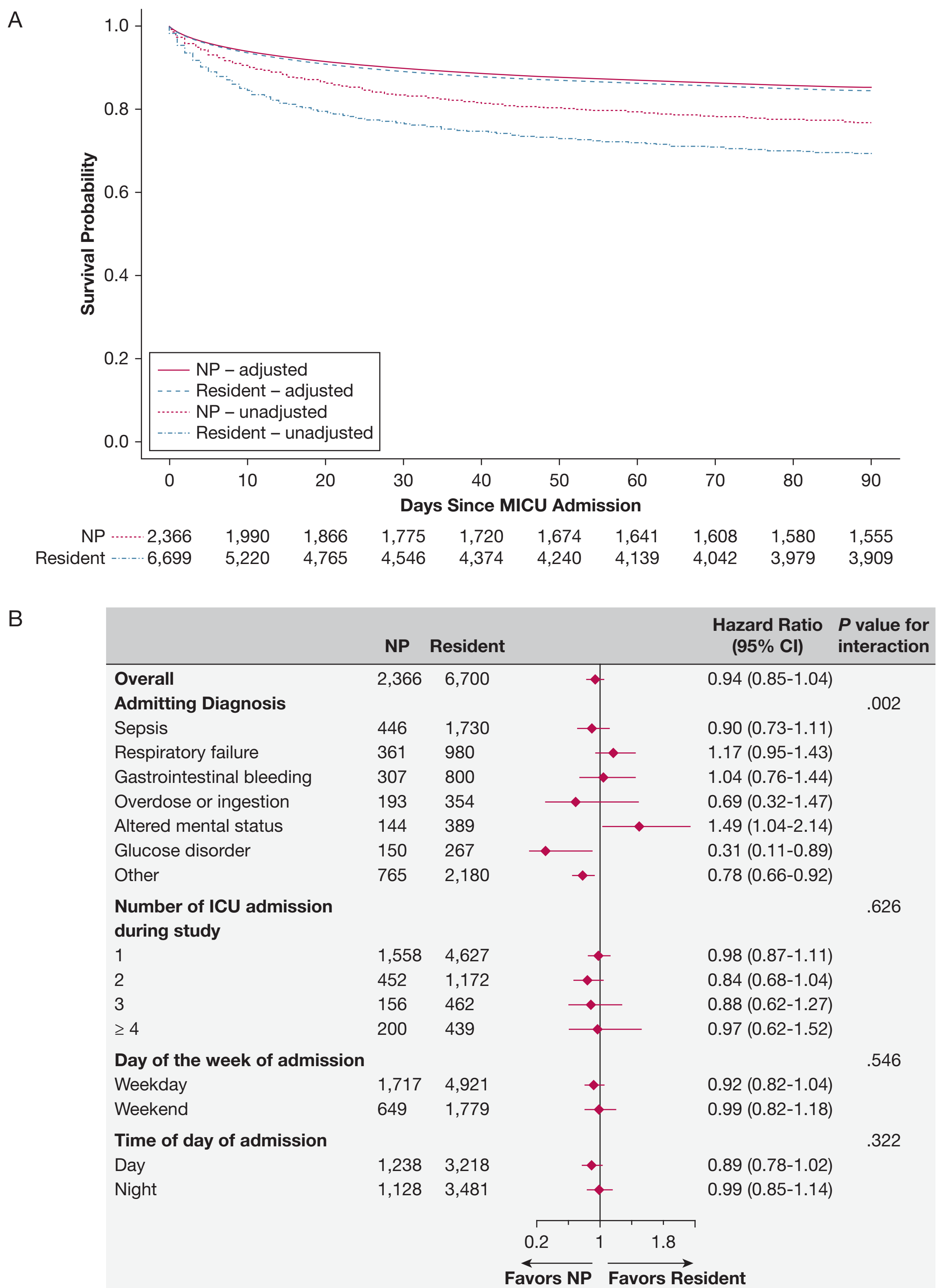


Figure 2 – *Survival by admitting service. (A) In a Cox proportional-hazards regression analysis adjusting for age, sex, ventilator use, vasopressor use, and University HealthSystem Consortium expected mortality, there was no difference between the NP and resident services in the primary outcome of 90-day survival. (B) The hazard ratio for death in the first 90 days was similar between services in subgroups defined by admitting diagnosis, number of ICU admissions during the study period, day of the week on which the admission occurred, and time of day of the admission. There was a suggestion of improved survival within the admitting diagnosis of glucose disorders on the NP service and with altered mental status on the resident service. Glucose disorder includes diabetic ketoacidosis, hyperosmolar hyperglycemic nonketotic syndrome, and hypoglycemia; weekday refers to Monday-Friday; daytime refers to 7 AM through 7 PM. NP = nurse practitioner.*

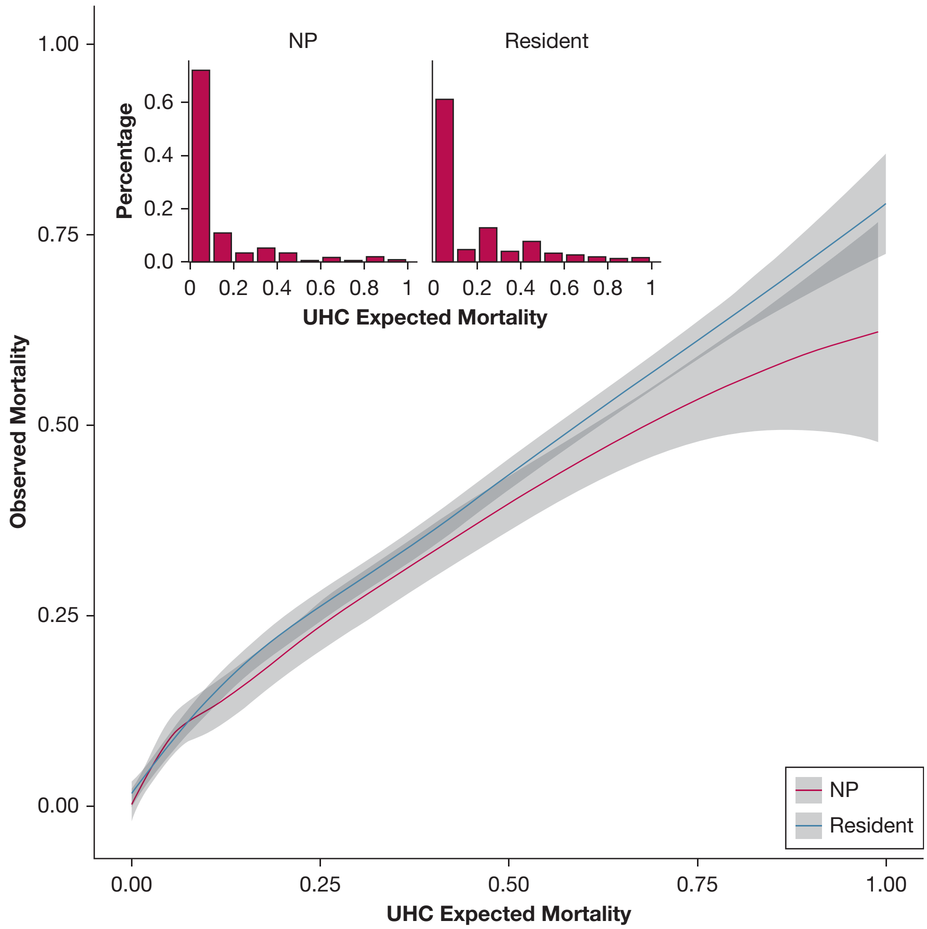


Figure 3 – *Observed relative to expected mortality by admitting service. For the acute care nurse practitioner (ACNP) service (red) and residents services (blue), the proportion of admissions that died before hospital discharge (mean and 95% CI) is displayed at each rate of expected in-hospital mortality as estimated by the UHC national data. Histograms display the distribution of expected mortality rates for patients admitted to each service. UHC = University HealthSystem Consortium. See Figure 2 legend for expansion of other abbreviation.*

on ACNP and resident teams not only at hospital discharge, but at 90 days and beyond, strengthens our conclusions about the quality of ACNP care in the ICU.

A thought-provoking finding of our study relates to the observed ICU and hospital lengths of stay. ICU length of stay was similar between teams but hospital length of stay was shorter for ACNP patients. This difference appeared to arise from more patients on the ACNP team being discharged from the hospital directly from their ICU room rather than being transferred to a ward bed. Whether this represents differences in admitting diagnoses, patient social or economic circumstances, or provider practice patterns is unknown. Importantly, the earlier hospital discharge for patients on the ACNP team did not come at the cost of longer ICU stay, increased ICU readmissions, or higher postdischarge mortality.

Although we observed a higher patient to provider ratio for the ACNP service, we are cautious about making claims of enhanced efficiency in a non-randomized study, given differences in patient characteristics between resident and ACNP services. In addition, attending physicians on the ACNP service on average saw fewer patients per day.

Despite strengths including large size, comprehensive patient inclusion, prospective data collection, objective end points, longer term follow-up, and independence of the ACNP and resident teams, our study has limitations. Patient allocation was not randomized, and there were baseline imbalances between patients assigned to the ACNP and resident teams. We attempted to account for these differences using multivariable and propensity score analysis. Although a C-index of just 0.615 suggests that admitting diagnosis, ventilator and vasopressor use, and expected mortality were not strongly influential in deciding team assignment, other important confounders may have been missed. The accuracy with which the composite predictor of UHC expected in-hospital mortality independently identified risk of death, however, may have mitigated the importance of any remaining unmeasured confounders. Although in one respect the fact that patient team assignment was not randomized may be viewed as a limitation, because advanced practice providers are adopted as a part of critical care clinical practice, patient assignment is unlikely to be at random. The current study can directly inform the outcomes to be expected from such a model of care.

Our study was conducted in a closed, academic, tertiary-care adult medical ICU using highly trained ACNPs (e-Table 4), with intensivist attending physician oversight and critical care fellow availability. We caution against generalizing our results to open ICUs, nonteaching hospitals, nonmedical ICUs, pediatric ICUs, or units without intensivists.[23,24] Importantly, our data do not suggest that intensivists can be replaced by ACNPs. The care of every patient in our study involved an attending intensivist and a critical care fellow, both of which have been previously associated with better patient outcomes. ICUs with intensivists have been shown to have lower mortality rates, shorter length of stay, and less time on a ventilator—and units in institutions with fellowship programs have lower mortality rates.[25-29] Our study does suggest that, at a time of worsening intensivist and resident shortages, a continuous ACNP service developed by careful ACNP selection, thorough training, attending physician oversight, and hospital support can provide an alternative ICU staffing model without detriment to short- or longer term patient outcomes.

In conclusion, our study demonstrates that in an academic adult medical ICU longer term outcomes are comparable for critically ill patients cared for by ACNP and resident teams, and observed in-hospital mortality for both services is similar to nationally benchmarked UHC expected mortality.

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Additional information: The e-Appendix, e-Figures, and e-Tables can be found in the Supplemental Materials section of the online article.

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