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The impact of intensive care unit physician staffing change at a community hospital

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Abstract

Objectives: A high-intensity staffing model has been defined as either mandatory intensivist consultation or a closed intensive care unit in which intensivists manage all aspects of patient care. In the current climate of limited healthcare resources, transitioning to a closed intensive care unit model may lead to significant improvements in patient care and resource utilization.

Methods: This is a single-center, retrospective cohort study of all mechanically ventilated intensive care unit admissions in the pre-intensive care unit closure period of 1 October 2014 to 30 September 2015 as compared with the post-intensive care unit closure period of 1 November 2015 to 31 October 2016. Patient demographics as well as outcome data (duration of mechanical ventilation, length of stay, direct costs, complications, and mortality) were abstracted from the electronic health record. All data were analyzed using descriptive and inferential statistics. Regression analyses were used to adjust outcomes for potential confounders.

Results: A total of 549 mechanically ventilated patients were included in our analysis: 285 patients in the pre-closure cohort and 264 patients in the post-closure cohort. After adjusting for confounders, there was no significant difference in mortality rates between the pre-closure (40.7%) and post-closure (38.6%) groups (adjusted odds ratio = 0.82; 95% confidence interval = 0.56–1.18; $p = 0.283$). The post-closure cohort was found to have significant reductions in duration of mechanical ventilation (3.71–1.50 days; $p < 0.01$), intensive care unit length of stay (5.8–2.7 days; $p < 0.01$), hospital length of stay (10.9–7.3 days; $p < 0.01$), and direct hospital costs (US $16,197–US $12,731; $p = 0.009$). Patient complications were also significantly reduced post-intensive care unit closure.

Conclusion: Although a closed intensive care unit model in our analysis did not lead to a statistical difference in mortality, it did demonstrate multiple beneficial outcomes including reduced ventilator duration, decreased intensive care unit and hospital length of stay, fewer patient complications, and reduced direct hospital costs.

Keywords

Closed unit, critical care/emergency medicine, epidemiology/public health, intensive care unit, mechanical ventilation, respiratory medicine

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Introduction

Each year an average of five million patients are admitted into an intensive care unit (ICU) with estimated mortality rates of 10%–20%.[1] Critical care costs in the United States equate to roughly 1% of the gross domestic product and between 5.2% and 11.2% of national healthcare expenditures.[2] The organization of a critical care unit and, in particular, its physician staffing directly impacts patient outcomes and resource utilization.[3–5] Despite evidence to support a high-intensity staffing (HIS)

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model, it is estimated that less than one-third of adult ICU patients are cared for by an intensivist.[6] Previous retrospective and observational analyses have demonstrated benefits of an intensivist-led staffing model. Young and Birkmeyer[7] found a potential reduction in mortality with an intensivist model. In 2002, a systematic review compared HIS versus low-intensity staffing in ICUs and reported that intensivist-led models are associated with reduced mortality, ICU length of stay (LOS), and hospital LOS.[8] Despite robust data supporting a high-intensity ICU staffing model, very few studies exist comparing a mandatory intensivist consultation model with a closed-ICU model. A special letter to the editor was published in Critical Care Medicine in 2012 urgently seeking answers to the concerns of ICU organization in the community setting.[9] In October 2015, we converted our ICU from a mandatory intensivist consultation model to a closed services ICU model. The goal of this analysis was to examine patient outcomes prior to and after closure of a community ICU.

Objective

Our objective was to identify whether a closed-ICU staffing model improves patient outcomes, resource utilization, decreases costs, and prevents complications in a community ICU.

Methods

Single-center, retrospective cohort study of all consecutive patients requiring intubation and mechanical ventilation (MV) during ICU admission from 1 October 2014 to 30 September 2015 compared with 1 November 2015 to 31 October 2016. We compared 12-months pre- and 12 months post-ICU closure (October 2015 was excluded, as it was a transition month to a closed unit). No formal sample size calculation was performed. The study protocol was approved by the Robert Wood Johnson University Hospital Somerset Institutional Review Board on an expedited basis (IRB#17-25). Waiver of consent was granted on the basis that no prospective intervention or alteration of therapy was performed and existing data were used. Demographics, comorbidities (Charlson Comorbidity Index),[10] and electronic Sequential Organ Failure Assessment (eSOFA) scores were abstracted from the medical record along with outcomes such as duration of MV, ICU LOS, hospital LOS, complications, and mortality. Patients' acuity of illness was measured with eSOFA due to ease of retrospective abstraction.[11,12] Complications were defined as the composite of venous thromboembolism (VTE), ventilator-associated pneumonia (VAP), central line-associated blood stream infection (CLABSI), catheter-associated urinary tract infection (CAUTI), and *Clostridium difficile* colitis.

Data analysis

All data were analyzed using the descriptive statistics. The chi-square or the independent *t*-test was used for binary or continuous data as appropriate. Normality of data was assessed using visual inspection of histograms and the Kolmogorov–Smirnov test. If data were determined to be non-parametric, median and range were calculated, and the Mann–Whitney *U* test was used to compare groups. A multivariable logistic regression was constructed to evaluate predictors of mortality. Covariates were first tested using a bivariate analysis and those found to be significant were further tested in the multivariable model. In this analysis, covariates with $p < 0.1$ were considered for inclusion in the final model. Covariates were then entered in the model using a backward stepwise approach and only those with a $p < 0.05$ were retained in the final model apart from pre-closure unit which was retained regardless of significance. To evaluate the mean difference in total and ICU LOS as well as ventilator days while accounting for confounding, generalized linear models with a Gaussian distribution and a logarithmic link function were constructed.[13] The estimated means, adjusted for confounding variables, were calculated for each group (pre-closure vs closed unit) for ventilator days, ICU LOS, and hospital LOS. All analyses were performed using SPSS v 27.0 (IBM Corporation, Armonk, NY, USA).

Results

A total of 549 mechanically ventilated patients were included in our analysis: 285 patients in the pre-closure cohort (of a total of 1197 ICU admissions) and 264 patients in the post-closure cohort (of a total of 1162 ICU admissions). Baseline demographics and clinical characteristics including eSOFA scores and Charlson Comorbidity Index (Table 1) were similar between cohorts. The post-closure group had higher rates of diabetes mellitus and dementia and more frequently had elevated lactic acid levels. The pre-closure cohort had higher rates of myocardial infarction and chronic pulmonary disease. There was no significant difference in mortality between the pre- and post-closure groups, 40.7% versus 38.6%, respectively; odds ratio (OR) unadjusted = 0.91; 95% confidence interval (CI) = 0.65–1.28; $p = 0.577$; OR adjusted for eSOFA, age, and vasopressor use = 0.82; 95% CI = 0.56–1.18; $p = 0.283$. A 60% reduction in ventilator days was identified in the post-closure group from a median of 3.71–1.50 days ($p < 0.01$) with no significant difference in reintubation rates (Table 2). In the closed model, the median ICU LOS was reduced by 53% from 5.8 to 2.7 days ($p < 0.01$). The median hospital LOS was also reduced in the closed model from 10.9 to 7.3 days ($p < 0.01$). In our secondary analysis of the aforementioned outcomes, significance was retained after adjusting for confounding variables (Table 3). Tracheostomy rates were significantly reduced from 8.4% in the pre-closure group to 3.8% in the post-closure group ($p = 0.024$). A trend was identified toward discharge to home in the post-closure model (22.1 vs 15.8%) but was not statistically significant ($p = 0.064$).

Overall complications were reduced from 19% to 3.8% in the closed services model ($p < 0.001$) (Table 4). The decrease

Table 1. Patient demographic and clinical characteristics.

Characteristics	Pre-closure ($n=285$)	Post-closure ($n=264$)	p-value
Age (years, mean ± SD)	71.4 ± 16.4	70.6 ± 15.4	0.556
Female (n, %)	132 (46.3)	137 (51.9)	0.191
Caucasian (n, %)	222 (77.9)	212 (80.3)	0.766
Platelet count	183.5 ± 93.7	185.8 ± 103.1	0.783
Serum creatinine (mg/dL, mean ± SD)	1.95 ± 1.79	1.98 ± 1.76	0.867
Total bilirubin	1.2 ± 2.1	1.2 ± 2.8	0.879
Lactic acid	2.6 ± 3.3	3.6 ± 4.4	0.004
eSOFA score	2.4 ± 1.2	2.5 ± 1.3	0.185
Vasopressor use	46 (16.1)	53 (20.1)	0.231
Myocardial infarction (n, %)	80 (28.1)	43 (16.3)	0.001
Heart failure (n, %)	119 (41.8)	92 (34.8)	0.097
Cerebrovascular disease (n, %)	45 (15.8)	28 (10.6)	0.074
Peripheral vascular disease (n, %)	26 (9.1)	30 (11.4)	0.386
Dementia (n, %)	4 (1.4)	27 (10.2)	<0.001
Chronic pulmonary disease (n, %)	119 (41.8)	83 (31.4)	0.012
Rheumatic disease (n, %)	8 (2.8)	9 (2.4)	0.807
Peptic ulcer disease (n, %)	9 (3.2)	7 (2.7)	0.803
Liver disease (n, %)	21 (7.4)	19 (7.2)	0.938
Any diabetes (n, %)	60 (21.1)	89 (33.7)	0.001
Hemiplegia/paraplegia (n, %)	21 (7.4)	11 (4.2)	0.110
Renal disease (n, %)	56 (19.6)	64 (24.2)	0.193
Any malignancy (n, %)	38 (13.3)	28 (10.6)	0.326
Metastatic solid tumor (n, %)	16 (5.6)	17 (6.4)	0.684
AIDS/HIV (n, %)	3 (1.1)	3 (1.1)	1.000
Charlson Comorbidity Index (mean ± SD)	3.1 ± 2.6	3.1 ± 2.5	0.937

SD: standard deviation; eSOFA: electronic Sequential Organ Failure Assessment.

Table 2. Summary of clinical and financial endpoints.

	Pre-closure ($n=285$)	Post-closure ($n=264$)	p-value
Median hospital length of stay (days, IQR)	10.9 (5.3–18.6)	7.3 (3.6–12.8)	<0.001
Median ICU length of stay (days, IQR)	5.8 (2.6–10.4)	2.7 (1.5–5.6)	<0.001
Median ventilator days (days, IQR)	3.71 (1.4–6.7)	1.5 (0.7–3.2)	<0.001
Median costs (US$, IQR)	16,197 (7943–28,460)	12,731 (7646–23,889)	0.009
Reintubation (n, %)	13 (4.6)	13 (4.9)	0.844
Venous thromboembolism (n, %)	41 (14.4)	4 (1.5)	<0.001
Discharge home (n, %)	45 (15.8)	58 (22.0)	0.064
Hospice (n, %)	5 (1.8)	3 (1.1)	0.726
Mortality (n, %)	116 (40.7)	102 (38.6)	0.621

IQR: interquartile range; ICU: intensive care unit.

Table 3. Estimated mean difference for length of stay and ventilator days between groups.

	Pre-closure	95% CI	Post-closure	95% CI	Mean difference	p-value
Total hospital length of stay, days	12.03	10.06–14.39	8.87	7.35–10.7	3.16	0.036
ICU length of stay, days	7.30	6.17–8.64	4.02	3.39–4.77	3.28	<0.001
Ventilator days	5.02	4.18–6.04	2.52	2.10–3.03	2.50	<0.001

95% CI: 95% confidence interval; ICU: intensive care unit.
*All models adjusted for eSOFA >3 and CCI >5 in a generalized linear model with a Gaussian distribution and a logarithmic link function.

in complications was driven primarily by a reduction in VTE and *Clostridium difficile* colitis both of which were found to be significantly reduced in the post-closure group. Utilizing univariate and multivariable analysis, factors associated with mortality were found to include age >65 years, severity of illness (eSOFA), Charlson Comorbidity Index, and vasopressor requirement (Table 5). Direct hospital costs were reduced from a median of US $16,197 per patient in the pre-closure cohort to US $12,731 in the closed services model ($p=0.009$).

Discussion

Safar and Grenvik[14] first suggested benefits from an intensivist-led ICU service in 1977. Since then, various staffing models with diverse patient populations have shown similar beneficial results.[15] In 1998, Multz et al.[16] confirmed these benefits in a medical ICU by reducing MV time and ICU LOS with no change in mortality rates. In 2001, the Society of Critical Care Medicine (SCCM) designed a task force to determine the best practice model for critical care delivery.[6] This group reviewed survey results, practice models, the literature, as well as the impact of multidisciplinary care. The task force ultimately recommended an HIS model with an emphasis on multidisciplinary team-based care.

Table 4. Composite endpoint for morbidity.

	Pre-closure ($n=285$)	Post-closure ($n=264$)	p-value
Overall morbidity	54 (19.0)	10 (3.8)	<0.001
VTE	41 (14.4)	4 (1.5)	<0.001
VAP	2 (0.007)	2 (0.008)	0.943
CLABSI	0 (0)	1 (0.004)	0.962
CAUTI	4 (1.4)	3 (1.1)	0.999
Clostridium difficile	7 (2.5)	0 (0)	0.020

VTE: venous thromboembolism; VAP: ventilator-associated pneumonia; CLABSI: central line-associated blood stream infection; CAUTI: catheter-associated urinary tract infection.

In 2006, a large-scale survey found that over half of the ICUs in the United States are small, general medical–surgical ICUs located in non-teaching, community hospitals.[17] Less than half of these ICUs have any intensivists or dedicated physician coverage, and less than 20% would be considered HIS models.

An HIS model, defined as either a mandatory intensivist consultation for all admitted ICU patients or a closed services model in which all care is managed by the intensivist, has been shown to reduce mortality, and improve resource utilization.[3,8,18–20] There are very few studies that compare a mandatory consultation model with a closed-ICU model for delivery of patient care in the ICU. Given the ongoing COVID-19 pandemic, resource utilization has been at the forefront of healthcare discussions. In particular, the availability of ICU beds, ventilators, drug shortages, and qualified healthcare personnel including nurses, physicians, and respiratory therapists has been strained.

We hypothesized that transition of physician staffing from a mandatory intensivist consultation to a closed ICU would lead to further improvements in patient care and resource utilization in a medium-sized community hospital. Post-closure of the ICU there was an emphasis placed on a team approach to patient care. Daily multidisciplinary rounds were conducted which included the intensivist, advanced practice provider, bedside nurse, ICU pharmacist, respiratory therapist, registered dietician, and social worker, among others. An emphasis was placed on evidence-based medicine with the incorporation of guideline-driven patient care.[6,21–29]

Our outcomes show the broad range of benefits from ICU closure on patient outcomes and resource utilization. Duration of MV, ICU LOS, hospital LOS, patient complications, and direct hospital costs were all significantly reduced with ICU closure. In the closed model, fewer patients underwent tracheostomy, and there was a positive trend toward discharge to home. Mortality rates, reintubation rates, patient demographics, Charlson Comorbidity Index, and eSOFA scores were similar between the cohorts.

During the comparison dates, there were no organizational changes (i.e. ICU nurse to patient ratio, number of

Table 5. Factors associated with mortality.

Variable	Univariable analysis			Multivariable analysis		
	OR	95% CI	p-value	OR	95% CI	p-value
Pre-closure	0.917	0.651–1.292	0.621	0.853	0.584–1.245	0.410
Age >65 years	1.903	1.338–2.706	<0.001	2.044	1.389–3.008	<0.001
eSOFA >3	3.441	2.225–5.321	<0.001	1.727	1.021–2.290	0.041
Charlson Comorbidity Index >5	2.758	1.681–4.524	<0.001	3.242	1.892–5.554	<0.001
Vasopressor use	4.110	2.856–5.914	<0.001	3.716	2.395–5.767	<0.001
Female sex	1.069	0.759–1.505	0.703			
Reintubation	0.545	0.225–1.319	0.178			
sCr >1.5 mg/dL	0.327	0.029–3.631	0.363			

OR: odds ratio; 95% CI: 95% confidence interval; eSOFA: electronic Sequential Organ Failure Assessment; sCr: serum creatinine.

certified beds, and patient characteristics) which would explain the improved metrics. There were a similar number of ICU admissions in each group. By gathering pertinent baseline characteristics as well as eSOFA scores, we were able to demonstrate similar patient populations in each cohort and then adjusted our endpoints in a regression model. Interestingly, the reductions in ICU LOS (3.1 days) and hospital LOS (3.6 days) were nearly identical which lends credence to the theory that ICU and not hospital level dynamics led to the realized improvements in patient care.

Upon unit closure, intensivist-driven care incorporates multidisciplinary rounds, evidence-based medicine, and consultation of subspecialists to ensure best-case practices.[6] Statistics show that patients receiving ICU care account for a disproportionate amount of acute care costs (greater than 30%), while occupying less than 10% of inpatient beds. In our closed-ICU model, we demonstrated a reduction in direct costs of US $3466 per patient, which equates to US $915,024 in the subset of ICU patients who were intubated. This substantial direct cost savings makes ICU closure a financially viable model. With the current global pandemic, ICU beds, ventilators, and hospital personnel including nurses, respiratory therapists, and clinical pharmacists have been in short supply. Although patient satisfaction was not analyzed, transitioning patients out of the ICU and hospital faster provides them with a better experience, exposure to family as well as the return to normality. In the closed model, we noted a 60% reduction in duration of MV. This amounts to a savings of 583 ventilator days, which in addition to patient benefits serves to lessen the strain on resources including ventilators, sedatives, respiratory therapists, and nurses. Models that optimize utilization of these limited resources should be adopted as quickly as possible.

There are some limitations to our analysis inherent to the study design. No formal sample size calculation was performed which may have resulted in a type II error. Regardless, although a convenience sample was used, an improvement in the overall hospital course was identified. As a retrospective single hospital cohort study, relying on coding and chart review to determine endpoints there is always the possibility of information bias. In addition to electronic extraction of data, we manually extracted information from the health record to mitigate this concern. Regardless, there is potential for residual bias. Our electronic health record (EHR) did not capture Acute Physiology and Chronic Health Evaluation (APACHE) scores; therefore, we relied on the eSOFA score and Charlson Comorbidity Index as validated physiologic methods of risk adjustment. The risk of bias from temporal trends was minimized by only including 1 year of data in each cohort. Despite these limitations, the significant differences in healthcare resource utilization and patient morbidity demonstrated in the post-closure group support a closed-ICU model.

Conclusion

Conversion of a medium-sized community hospital from a mandatory intensivist consultation model to a closed unit resulted in significant improvements in duration of MV, ICU LOS, hospital LOS, and direct hospital costs. While mortality was not impacted, patient complications including VTE and *Clostridium difficile* colitis were reduced, and there was a trend toward discharge to home. Given the current global pandemic with the resultant strain on healthcare resources, hospitals should consider adopting a closed-ICU staffing model.

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Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

Ethical approval for this study was obtained from the Robert Wood Johnson University Hospital Somerset Institutional Review Board on an expedited basis (IRB#17-25).

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Informed consent

Informed consent was not sought for this study because of the retrospective nature of the analysis and blinded observation of standard of care. Waiver of consent was granted on the basis that no prospective intervention or alteration of therapy was performed and use of existing data.

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