A Novel Neuroscience Intermediate-Level Care Unit Model: Retrospective Analysis of Impact on Patient Flow and Safety

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Abstract

Background and Purpose: Neurointensive care units have been shown to improve patient outcomes across a variety of neurological and neurosurgical conditions. However, the efficacy of less resource-intensive intermediate-level care units to deliver similar care has not been well studied. The purpose of this study is to evaluate the impact of neurocritical specialist comanagement on patient flow and safety in a neuroscience intermediate-level care unit. **Methods:** Our intervention consisted of the addition of a physician with critical care experience as well as training in neurology, anesthesiology, or intensive care to a neuroscience intermediate-level care unit to comanage patients alongside neurology and neurosurgery staff during weekday daytime hours. A retrospective analysis was performed on prospectively collected data pertaining to all patients admitted to the unit over a 3-year period, 1 year before our intervention and 2 years after. Patient statistics including wait times to admission, length of stay (LOS), and mortality were reviewed. **Results:** Following the intervention, there were significant reductions in wait times to unit admission from both the emergency department and postanesthetic care unit, as well as reductions in the average LOS. No significant safety concerns were identified. **Conclusion:** This study has demonstrated that the optimization of a neuroscience intermediate-level care unit involving comanagement of patients by a neurocritical specialist can reduce wait times to admission and lengths of stay, with preserved safety outcomes.

Keywords

neurocritical care, neurointensive care, intermediate-level, step-down, neurocritical specialist

Introduction

Neurointensive care is increasingly recognized to improve outcomes for critically ill neurological and neurosurgical patients. Patients with intracerebral hemorrhage (ICH) have been shown to have lower mortality rates when admitted to dedicated neurointensive care units rather than to general medical or surgical intensive care units (ICUs).^{1,2} Neurointensive care units have also been shown to improve functional outcomes and reduce hospital length of stay (LOS) for patients with ICH and traumatic brain injury (TBI).³⁻⁸ As well, the use of neurointensivist or neurohospitalist physicians specially trained to manage acutely ill neurological and neurosurgical patients has been shown to improve outcomes for patients admitted to hospital with ICH and with subarachnoid hemorrhage, independent of the effects of neurointensive care units.⁹⁻¹³ A recent study by Rodricks et al demonstrated that the addition of a neurointensivist to an existing neurocritical care unit was also able to improve patient flow metrics.¹⁴

In line with this growing body of evidence, the importance of neurointensive care services is reflected in modern standards of practice. Recent guidelines for the care of patients with ICH recommend observation in an ICU or dedicated stroke unit.¹⁵ However, it is not immediately clear what element of neurointensive care (physician expertise, monitoring, nursing support, or other factors) is most responsible for the observed improvement in outcomes.¹⁶ Moreover, neurointensive care is not

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universally available, is expensive to offer, and places an increased burden on already busy intensive care services.

In contrast, intermediate-level care (also called step-down or step-up) units have been shown to be safe, feasible, and cost-effective for the management of many neurology and neurosurgery patients, including those with ICH.^{17,18} We sought to examine whether the optimization of an intermediate-level care unit by the addition of physician specialist resources could provide high-quality care to a variety of neurological and neurosurgical patients. Specifically, we examined the impact of the addition of a parallel physician with critical care experience and background in neurology, anesthesiology, or critical care (neurocritical specialist) to an existing neurosciences intermediate-level care unit. This intervention was assessed for its ability to decrease resource use and provide safe care to patients with a variety of diagnoses including but not limited to ICH, TBI, acute stroke, and central nervous system (CNS) tumors. We evaluated the impact of this intervention on overall patient flow and safety by examining its effect on (1) wait times to admission, (2) diagnosis-specific LOS, and (3) markers of safety and adverse events including diagnosis-specific mortality and readmission rates to the hospital and to the unit itself.

Methods

Setting and Intervention

Starting on October 1, 2011, an existing 16-bed intermediate-level care unit, the neurosciences acute care unit (NACU) of The Ottawa Hospital, was altered by the addition of a neurocritical specialist. This neurocritical specialist was present in the unit during weekday working hours to co-manage patients alongside attending neurologists and neurosurgeons. As before the intervention, the attending neurology and neurosurgery staff remained the most responsible physicians for their patients admitted to the unit, but following the intervention, the neurocritical specialist was available to more expediently address day-to-day issues arising within the unit. Attending neurology and neurosurgery staff would meet daily with the neurocritical specialist, and patients' overall plans of care were determined by the attending staff, often in consultation with the neurocritical specialist.

Neurocritical specialists assigned to the unit were drawn from a pool comprised of neurovascular-trained neurologists (3), anesthesiologists (2), and general intensivists (3) already employed by the hospital. A total number of 8 physicians rotated through the service, each managing the unit for periods of 1 week at a time, for a total of 6 to 8 weeks each per year. During weeknights and weekends, when no neurocritical specialist was present in the unit, attending physicians were responsible for the total management of their patients admitted to the unit.

Throughout the period under study, there was no significant change in patient sources of admission, nursing staff, or

allied health-care provision. Both before and after the intervention, the patient to nurse ratio in the unit was 2:1, and patient assessment by nursing staff was continuous. As an intermediate-level care unit, patients eligible for admission to the unit were nonventilated patients requiring frequent clinical monitoring including vitals for every 2 hours or more frequently. The unit had the ability to use arterial lines and could provide most intravenous medications including those for vasopressor support and pressure control, as well as the capability to monitor intraventricular drains.

Patient Data Acquisition

We reviewed data pertaining to all patients who were discharged from the NACU between October 2010 and September 2013. This period represented the 12-month period prior to and the 24-month period following the intervention. A total of 2947 patients were discharged from the NACU over the 36-month study period. Fourteen encounters were excluded on the basis of overlapping the intervention period, and 2 were excluded due to incomplete records. Of the total of 2931 encounters that were studied, patients were classified into the following groups: preintervention (October 2010 to September 2011, $n = 822$), postintervention year 1 (October 2011 to September 2012, $n = 1035$), and postintervention year 2 (October 2012 to September 2013, $n = 1074$). By partitioning the postintervention period into 2 groups, we were able to assess whether any changes noted immediately following the intervention were sustained.

Data Sources

All data were drawn from The Ottawa Hospital Data Warehouse. The Ottawa Hospital Data Warehouse is a single data repository that contains routinely generated information relevant to all patient visits at The Ottawa Hospital. All patient registration, admission, discharge and transfer information, and health record data using standardized coding of diagnoses (*International Classification of Diseases, Tenth Revision*) and procedures (Canadian Classification of Interventions) are captured and can be retrieved for retrospective analysis.

Outcome Assessment

The purpose of our intervention was to increase the efficiency in terms of patient flow through the unit without compromising patients' safety or quality of care. Measured patient flow outcomes were LOS in pre-NACU locations (eg, wait time in the emergency department [ED] prior to admission to the unit) and LOS in the unit itself (NACU-specific LOS). The primary patient safety outcomes were in-hospital mortality and 30-day unplanned readmission rates. Secondary outcomes including 24-hour readmission rates to NACU and overall hospital LOS were also assessed.

Statistical Analysis

A descriptive analysis was first performed to assess for any differences between patients pre- and postintervention. We measured sex, age, Escobar risk-adjusted mortality,¹⁹ Charlson comorbidity score,²⁰ and resource intensity weighting²¹ at baseline to determine the underlying health status of NACU patients upon hospital admission.

For the primary analysis, the Kruskal-Wallis 1-way analysis of variance test was used to detect significant differences in the LOS outcomes between the pre- and postintervention groups. For all other outcomes, the χ^2 test for proportions was used. All tests of significance were 2 tailed, with a significance level of .05, and all analyses were conducted in SAS version 9.3 (SAS Institute Inc).

Subgroup analyses were also conducted to assess whether the results differed between admitting service and discharge diagnosis. Since there were over 300 different discharge diagnoses, they were grouped into 34 medically relevant categories (Table 1).

IRB Approval

Our study was approved by our local Research Ethics Board (REB). A waiver of informed consent was granted.

Results

Demographic data of the 2931 patients who were cared for in NACU over the 36-month study period are summarized in Table 2. Patients did not differ significantly pre- versus postintervention in terms of age, sex, Charlson score, or risk-adjusted mortality. There was no significant change pre- versus postintervention in the relative proportions of the 14 most admitted diagnoses to the unit, nor proportions of patients admitted from neurology compared to neurosurgery. Both before and after the intervention, the 3 most common preadmission locations were ED, postanesthesia care unit (PACU), and ICU.

Wait times to admission are depicted in Figure 1. Following the intervention period, there was a significant reduction in times spent in both the ED and PACU prior to NACU admission, with the mean ($\pm$ standard deviation, SD) number of hours spent in ED decreasing from 23 (19.5) to 12 (11.4) and in PACU from 21 (17.7) to 14 (11.2). Both of these reductions were sustained throughout the second year postintervention. There was no significant change in the number of days spent in ICU prior to NACU admission.

We further assessed flow through each of these preadmission locations during the period of time overlapping our intervention. Analysis of ED quality metrics showed that during the first year following our intervention, there was also a significant increase in the percentage of patients admitted to a critical care bed within 90 minutes of their time of presentation to ED. This benchmark was met by 23% of the patients in the year prior to our intervention, rising to 26% in the first year following our intervention, and 27% in the second year. This

Table 1. Diagnostic Grouping Categories.

Diagnostic Category	Number (n)
CNS tumor	583
Ischemic stroke	570
Aneurysmal subarachnoid hemorrhage	232
Other cerebrovascular diseases	186
Epi- or subdural hemorrhage	173
Intracerebral hemorrhage	157
Pituitary/pineal disorder	138
Seizure	93
Spinal cord injury	86
Complication of neurological/neurosurgical procedure	78
Other neurological disorder/dysfunction	72
Traumatic brain injury	67
Primary general medical condition	64
Other neoplasm	57
Nonaneurysmal subarachnoid hemorrhage	52
CNS infection/inflammation	46
Palliation	40
Guillain-Barré syndrome	34
CSF leak	29
Headache/migraine	23
Myasthenia gravis	22
Transient ischemic attack	21
Other neuropathy/polyneuropathy/neuromuscular disorder	19
Focal neurological sign/symptom	17
Rehabilitation	13
Hydrocephalus	12
Other surgical complication	12
Primary psychiatric condition	9
Cerebral venous thrombosis/infarct	6
Radiculopathy/plexopathy	5
Demyelinating disorder	3
Other neurosurgical primary	2
Neuropsychiatric	2
Dementia	2

Abbreviations: CSF, cerebrospinal fluid; CNS, central nervous system.

finding suggests that overall ED performance enhancements likely contributed, at least in part, to our finding of reduced wait times for admission to NACU following our intervention. Analysis of PACU quality metrics revealed no gross overall changes in flow through the unit over the time course of our intervention.

Length of stay data are summarized in Figure 2. Following our intervention, there was a significant drop in both overall LOS in hospital (from 11 days preintervention to 8 days in postintervention year 1) and LOS in NACU (from 4 days preintervention to 3 days in postintervention year 1). Both of these decreases in LOS were sustained throughout the second year postintervention (8 and 3 days, respectively). There were no significant differences noted in diagnosis-specific LOS with the exception of CNS tumors, which did show a significant reduction in NACU LOS (Table 3). Overall, LOS in ICU during the period overlapping our intervention did not change significantly, indicating that the decreased LOS

Table 2. Cohort Demographics.^a

Total No. of Encounters	Preintervention (October 2010 to September 2011; N = 822)	Postintervention Year 1 (October 2011 to September 2012; N = 1035)	Postintervention Year 2 (October 2012 to September 2013) N = 1074)	Total (N = 2931)	P (Pre vs Post-1)	P (Post-1 vs Post-2)
Gender						
F	403 (49.0%)	480 (46.4%)	499 (46.5%)	1382 (47.2%)	.256	.969
M	419 (51.0%)	555 (53.6%)	575 (53.5%)	1549 (52.8%)		
Age group at Admission						
39 and under	132 (16.1%)	155 (15.0%)	150 (14.0%)	437 (14.9%)	.24	.369
40-49	118 (14.4%)	113 (10.9%)	129 (12.0%)	360 (12.3%)		
50-59	162 (19.7%)	215 (20.8%)	218 (20.3%)	595 (20.3%)		
60-69	166 (20.2%)	236 (22.8%)	218 (20.3%)	620 (21.2%)		
70-79	130 (15.8%)	156 (15.1%)	198 (18.4%)	484 (16.5%)		
80-89	102 (12.4%)	138 (13.3%)	135 (12.6%)	375 (12.8%)		
90 and over	12 (1.5%)	22 (2.1%)	26 (2.4%)	60 (2.0%)		
Age, mean $\pm$ SD	58.24 $\pm$ 18.45	59.68 $\pm$ 18.12	60.20 $\pm$ 17.75	59.47 $\pm$ 18.09	.091	.506
Charlson score						
Mean $\pm$ SD	1.68 $\pm$ 1.99	1.76 $\pm$ 2.08	1.79 $\pm$ 2.19	1.75 $\pm$ 2.10	.365	.755
Median (IQR)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)	.458	.816
Risk-adjusted mortality (Escobar)						
Mean $\pm$ SD	0.10 $\pm$ 0.11	0.09 $\pm$ 0.11	0.10 $\pm$ 0.12	0.09 $\pm$ 0.12	.596	.396
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	.491	.407
Pre-NACU location						
ICU	84 (10.2%)	93 (9.0%)	91 (8.5%)	268 (9.1%)	.369	.677
PACU	279 (33.9%)	274 (26.5%)	345 (32.1%)	898 (30.6%)	<.001	.004
Ward	51 (6.2%)	81 (7.8%)	64 (6.0%)	196 (6.7%)	.177	.09
ED	378 (46.0%)	518 (50.0%)	517 (48.1%)	1,413 (48.2%)	.082	.38
SDA	9 (1.1%)	48 (4.6%)	39 (3.6%)	96 (3.3%)	<.001	.245
TCU	9 (1.1%)	2 (0.2%)	0 (0.0%)	11 (0.4%)	.012	.15
Stepdown unit	0 (0.0%)	5 (0.5%)	0 (0.0%)	5 (0.2%)	.046	.023
Birthing unit	0 (0.0%)	0 (0.0%)	1 (0.1%)	1 (0.0%)		.326
Direct admission (no pre-NACU location)	12 (1.5%)	14 (1.4%)	17 (1.6%)	43 (1.5%)		
Primary service						
Neurosurgery	569 (69.2%)	667 (64.4%)	695 (64.7%)	1,931 (65.9%)	.095	.936
Neurology	251 (30.5%)	365 (35.3%)	375 (34.9%)	991 (33.8%)		
All other	2 (0.2%)	3 (0.3%)	4 (0.4%)	9 (0.3%)		
Admission diagnosis (MRDX)						
CNS tumor	151 (18.4%)	204 (19.7%)	228 (21.2%)	583 (19.9%)	.466	.388
Ischemic stroke	156 (19.0%)	220 (21.3%)	194 (18.1%)	570 (19.4%)	.225	.065
Aneurysmal SAH	86 (10.5%)	78 (7.5%)	68 (6.3%)	232 (7.9%)	.027	.276
Other cerebrovascular diseases	56 (6.8%)	50 (4.8%)	80 (7.4%)	186 (6.3%)	.067	.012
Epi- or subdural hemorrhage	45 (5.5%)	64 (6.2%)	64 (6.0%)	173 (5.9%)	.518	.829
Intracerebral hemorrhage	53 (6.4%)	48 (4.6%)	56 (5.2%)	157 (5.4%)	.088	.541
Pituitary/pineal disorder	45 (5.5%)	50 (4.8%)	43 (4.0%)	138 (4.7%)	.532	.355
Seizure	16 (1.9%)	37 (3.6%)	40 (3.7%)	93 (3.2%)	.036	.855
Spinal cord injury	22 (2.7%)	32 (3.1%)	32 (3.0%)	86 (2.9%)	.597	.881
Complication of neurological/neurosurgical procedure	21 (2.6%)	26 (2.5%)	31 (2.9%)	78 (2.7%)	.954	.596
Traumatic brain injury	21 (2.6%)	18 (1.7%)	28 (2.6%)	67 (2.3%)	.223	.173
Guillain-Barré syndrome	9 (1.1%)	16 (1.5%)	9 (0.8%)	34 (1.2%)	.402	.133
Myasthenia gravis	8 (1.0%)	7 (0.7%)	7 (0.7%)	22 (0.8%)	.478	.945
TIA	10 (1.2%)	6 (0.6%)	5 (0.5%)	21 (0.7%)	.14	.716
All other	123 (15.0%)	179 (17.3%)	189 (17.6%)	491 (16.8%)	.176	.855

Abbreviations: CNS, central nervous system; ED, emergency department; F, female; ICU, intensive care unit; IQR, interquartile range; M, male; MRDX, most responsible diagnosis; NACU, neurosciences acute care unit; PACU, postanesthesia care unit; SAH, subarachnoid hemorrhage; SD, standard deviation; SDA, same day admission; TCU, transitional care unit; TIA, transient ischemic attack.

^aPercentages are column percentages.

Figure 1. Wait times to admission.

Figure 2. Length of stay.

observed in the NACU was not at the expense of critically ill patients being discharged to ICU.

Mortality and patient safety outcomes are summarized in Table 4. Following our intervention, there was no change in

rates of readmission, both within 24 hours of discharge from the unit to general medical–surgical wards or within 30 days of discharge from hospital. There was also no overall change in in-hospital mortality (both within NACU and following transfer from NACU to other hospital locations) for the top 14 most admitted diagnoses to the unit. Patients with CNS tumors, who accounted for the largest percentage of patients on the unit (Table 2), displayed a significant decrease in in-hospital mortality in the first year following our intervention (6.6% preintervention, 0% postintervention year 1, $P < .001$). In the second year, the mortality for this group rose nonsignificantly (1.8%) though remained significantly lower than pre-intervention baseline.

A preliminary cost analysis was performed based on the reduced LOS observed as a result of the intervention. Using an estimated cost per patient of CAD\$2000 per day in NACU and the reduced NACU LOS of 1 day per patient per year following our intervention ($P < .001$), this would produce an annual savings of CAD\$2 108 000 per year.

Discussion

Acutely ill neurological and neurosurgical patients benefit from neurointensive care. However, specialty units are resource and cost intensive and are not universally available. Intermediate-level care units incorporating neurocritical specialist comanagement may offer a relatively cost-effective alternative model for many of these nonventilated patients. This model makes use of existing resources, including a preexisting unit and physicians already employed by the hospital, thus incurring minimal costs and demonstrating feasibility within a tertiary care center. It highlights that physician engagement is a key element in providing critical care-level services.

Our findings are in keeping with other programs that have used intermediate-level care units for patients traditionally admitted to critical care units. In a variety of neurological and neurosurgical populations, intermediate-level care units have been shown to be cost-effective while maintaining quality of care in comparison with comprehensive ICUs.^{17,18} Intermediate-level care units have similarly been shown to be effective among general medical, respiratory, and cardiac patient populations.²²⁻²⁶

The use of neurocritical specialists has elsewhere been shown to improve outcomes for a variety of neurological and neurosurgical patients admitted to hospital, independent of the effects of specialized units.⁹⁻¹³ To our knowledge, no previous study has evaluated the outcome of the addition of a neurocritical specialist physician to an intermediate-level care unit. The particular value of a neurocritical specialist dedicated to this type of unit may involve the ability to more closely follow patients, respond acutely to changes in patient condition, facilitate enhanced multidisciplinary collaboration, and aid in patient management and discharge planning.

Table 3. LOS Overall and Diagnosis-Specific LOS.

LOS, Median (IQR)	Preintervention (October 2010 to September 2011)	Postintervention Year 1 (October 2011 to September 2012)	Postintervention Year 2 (October 2012 to September 2013)	P (Pre vs Post-1)	P (Post-1 vs Post-2)
Overall in-hospital, days	11 (5-21)	8 (4-19)	8 (4-17)	<.001	.113
Overall NACU, days	4 (2-7)	3 (2-6)	3 (1-5)	<.001	.024
Diagnosis-specific NACU LOS, median (IQR), days					
CNS tumor	3 (2-5)	2 (1-4)	2 (1-4)	.002	.329
Ischemic stroke	4 (2-7)	3 (2-6)	3 (2-5)	.120	.384
Aneurysmal SAH	7 (2-10)	5 (2-9)	7 (3-13)	.187	.011
Other cerebrovascular diseases	3 (2-6)	3 (2-5)	2 (1-4)	.450	.020
Epi- or subdural hemorrhage	4 (2-7)	4 (2-7)	3 (1-4)	.577	.050
Intracerebral hemorrhage	7 (3-9)	4 (2-7)	4 (2-8)	.012	.514
Pituitary/pineal disorder	4 (3-5)	4 (3-6)	4 (3-6)	.757	.648
Seizure	4 (2-5)	3 (1-4)	2 (1-3)	.399	.176
Spinal cord injury	4 (1-5)	3 (2-4)	2 (1-5)	.908	.203
Complication of neurological/neurosurgical procedure	5 (3-13)	7 (2-8)	2 (1-8)	.584	.200
Traumatic brain injury	3 (2-5)	4 (2-6)	3 (2-5)	.639	.632
Guillain-Barré syndrome	3 (2-6)	7 (2-10)	5 (2-6)	.731	.931
Myasthenia gravis	5 (3-8)	4 (2-6)	3 (0-5)	.442	.364
TIA	3 (1-4)	4 (2-5)	1 (1-2)	.742	.094

Abbreviations: CNS, central nervous system; IQR, interquartile range; LOS, length of stay; NACU, neurosciences acute care unit; SAH, subarachnoid hemorrhage; TIA, transient ischemic attack.

Table 4. Patient Safety Outcomes: Mortality and Readmissions.

Outcome	Preintervention (October 2010 to September 2011)	Postintervention Year 1 (October 2011 to September 2012)	Postintervention Year 2 (October 2012 to September 2013)	Total	P (Pre vs Post-1)	P (Post-1 vs Post-2)
In-hospital mortality						
Overall	48 (5.8%)	50 (4.8%)	65 (6.1%)	163 (5.6%)	.334	.217
Diagnosis-specific:						
CNS tumor	10 (6.6%)	0 (0.0%)	4 (1.8%)	14 (2.4%)	<.001	.057
Ischemic stroke	14 (9.0%)	17 (7.7%)	19 (9.8%)	50 (8.8%)	.665	.456
Aneurysmal SAH	4 (4.7%)	2 (2.6%)	4 (5.9%)	10 (4.3%)	.477	.314
Other cerebrovascular diseases	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		
Epi- or subdural hemorrhage	1 (2.2%)	6 (9.4%)	6 (9.4%)	13 (7.5%)	.134	1.000
Intracerebral hemorrhage	5 (9.4%)	3 (6.3%)	8 (14.3%)	16 (10.2%)	.554	.184
Pituitary/pineal disorder	0 (0.0%)	0 (0.0%)	1 (2.3%)	1 (0.7%)		.278
Seizure	1 (6.3%)	0 (0.0%)	0 (0.0%)	1 (1.1%)	.125	
Spinal cord injury	2 (9.1%)	1 (3.1%)	2 (6.3%)	5 (5.8%)	.347	.554
Complication of neurological/ neurosurgical procedure	1 (4.8%)	0 (0.0%)	1 (3.2%)	2 (2.6%)	.261	.356
Traumatic brain injury	3 (14.3%)	1 (5.6%)	1 (3.6%)	5 (7.5%)	.370	.747
Guillain-Barré syndrome	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		
Myasthenia gravis	0 (0.0%)	0 (0.0%)	1 (14.3%)	1 (4.5%)		.299
TIA	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		
Readmission to NACU within 24 hours of discharge to ward	2 (0.2%)	7 (0.7%)	3 (0.3%)	12 (0.4%)	.182	.185
Readmission to hospital within 30 days	77 (10.3%)	75 (7.9%)	80 (8.2%)	232 (8.7%)	.232	.917

Abbreviations: CNS, central nervous system; NACU, neurosciences acute care unit; SAH, subarachnoid hemorrhage; TIA, transient ischemic attack.

In our study, this model reduced wait times to admission and lengths of stay, with excellent safety outcomes across a wide variety of neurological and neurosurgical conditions. In

certain patient populations, mortality rates even fell. Although sample limitations prevented the measurement of more specific quality indices, these preliminary data suggest the

promise of an intermediate care unit costaffed with neurocritical specialists.

It is likely that the observed decreases in wait times for admission to the unit and LOS in the unit were due to the ability of the neurocritical specialist to assess patients throughout the day and initiate transfers out of the unit more promptly. Prior to the intervention, this task would fall to attending staff during dedicated rounding times. The observed decrease in overall hospital LOS over the course of our study was likely due to hospital-wide initiatives resulting in improved hospital to home services over the same period of time.

Limitations of our study include the retrospective design, the possibility of confounding variables, for example, performance optimizations in other departments during the study period, and possible lack of generalizability to other hospitals. Requirements for the model tested in our study include a geographically defined unit and an appropriate pool of physicians to provide neurocritical specialist services. The heterogeneous training background of the neurocritical specialist physicians incorporated into our unit further limits the generalizability of our findings. Although the parallel physicians added to our unit all possessed critical care experience, they had variable training backgrounds in neurology, anesthesiology, and critical care. An alternative to our model could be its adaptation to incorporate dedicated neurohospitalists with formal training.

We believe that the model tested in this study demonstrates the efficacy of an intermediate-level care unit in providing safe and effective care to a variety of acutely ill, nonventilated neurological and neurosurgical patients. This study has demonstrated that the optimization of an intermediate-level care unit, with only minimally increased resource use, has the ability to improve patient flow metrics while preserving patient safety. Future directions include demonstrating generalizability of the model to other centers and completing formal cost-benefit analyses. As well, we would hope to test this model in a nonneuroscience setting.

Declaration of Conflicting Interests

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