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Task-Sharing for Emergency Neurosurgery: A Retrospective Cohort Study in the Philippines

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■ OBJECTIVE: **The safety and effectiveness of task-sharing (TS) in neurosurgery, delegating clinical roles to non-neurosurgeons, is not well understood. This study evaluated an ongoing TS model in the Philippines, where neurosurgical workforce deficits are compounded with a large neurotrauma burden.**

■ METHODS: **Medical records from emergency neurosurgical admissions to 2 hospitals were reviewed (January 2015–June 2018): Bicol Medical Center (BMC), a government hospital in which emergency neurosurgery is chiefly performed by general surgery residents (TS providers), and Mother Seton Hospital, an adjacent private hospital where neurosurgery consultants are the primary surgeons. Univariable and multivariable linear and logistic regression compared provider-associated outcomes.**

■ RESULTS: **Of 214 emergency neurosurgery operations, TS providers performed 95 and neurosurgeons, 119. TS patients were more often male (88.4% vs. 73.1%; $P = 0.007$), younger (mean age, 27.6 vs. 50.5 years; $P < 0.001$), and had experienced road traffic accidents (69.1% vs. 31.4%; $P < 0.001$). There were no significant differences between Glasgow Coma Scale (GCS) scores on admission. Provider type was not associated with mortality (neurosurgeons, 20.2%; TS, 17.9%; $P = 0.68$), reoperation, or pneumonia. No significant differences were observed for GCS improvement between admission and discharge or in-hospital GCS improvement, including or excluding inpatient deaths. TS patients had shorter lengths of stay (17.3 days vs. 24.4 days; coefficient, −6.67; 95% confidence interval, −13.01 to −0.34; $P < 0.05$) and were more likely to undergo tracheostomy (odds ratio, 3.1; 95% confidence interval, 1.30–7.40; $P = 0.01$).**

■ CONCLUSIONS: **This study, one of the first to examine outcomes of neurosurgical TS, shows that a strategic TS model for emergency neurosurgery produces comparable outcomes to the local neurosurgeons.**

Key words
- Global health
- Global neurosurgery
- LMIC
- Neurotrauma
- Task-sharing
- Task-shifting
- Workforce

Abbreviations and Acronyms
BMC: Bicol Medical Center
CI: Confidence interval
CT: Computed tomography
GCS: Glasgow Coma Scale
HIC: High-income country
ICU: Intensive care unit
LMIC: Low- and middle-income country
MS: Mother Seton Hospital
OR: Odds ratio
TBI: Traumatic brain injury
TS: Task-sharing
TS/S: Task-shifting and task-sharing

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INTRODUCTION

Each year, approximately 5 million essential neurosurgical cases go untreated, and >23,000 more neurosurgeons are needed in low- and middle-income countries (LMICs) to address this treatment gap.[1] Most of these conditions arise from traumatic brain injury (TBI), stroke, hydrocephalus, tumors, epilepsy, and infection.[1-5] The ability to perform emergency surgical procedures for TBI is especially important, because 69 million individuals experience all-cause TBI annually, particularly in Southeast Asia and the Western Pacific Region.[1] The most recent Disease Control Priorities report[6] indicated that district hospitals should be able to perform burr holes for hematomas and increased intracranial pressure and shunts for hydrocephalus, whereas tertiary-care centers should have the capacity to perform craniotomies and craniectomies, predominantly for neurotrauma. However, current resource limitations and neurosurgical workforce deficits continue to be significant barriers to care provision.[2]

In many Southeast Asian and Sub-Saharan African countries, the neurosurgical capacity is only 0.01—0.1 neurosurgeons per 100,000 population, when the expected ratio is at least 1/100,000.[7,8] To this end, there is an imminent need to increase the neurosurgical workforce, particularly in countries with the greatest burden of disease. Although there have been efforts to increase the number of residency training programs, short-term missions, training camps, and twinning,[9-11] the workforce deficit remains substantial, and there is an increasing interest in the employment of neurosurgical task-shifting and task-sharing (TS/S): delegating certain neurosurgical tasks to nonspecialists, such as general surgeons, general practitioners, or nonphysician clinicians.[11,12] Task-shifting is the rational redistribution of tasks and clinical autonomy from highly qualified health care workers to those with shorter training and fewer qualifications.[13] In contrast, task-sharing (TS) is when duties are transferred to less qualified cadres, but both a specialist and less qualified provider share clinical responsibility.[14] The latter method incorporates workplace strategies that build on the collective input of the health team so there is shared responsibility over patient care to achieve a high-quality outcome. Therefore, TS is not intended to replace specialists but to create collaborative teams that enable specialists to expand their reach via training and continued consultation. Both task-shifting and TS in neurosurgery are highly controversial because of safety, ethical, financial, legal, and professional implications.[15] On one hand, having a necessary operation via TS/S may be superior to no care at all, and TS/S may offer acute stabilization of emergency patients to enable safer transfer to tertiary-care facilities. Conversely, TS/S raises concerns for lower-quality care and disrupting professional roles if less-skilled workers displace higher-skilled staff.

Although many countries use TS/S for obstetrics, anesthesia, and general surgery,[9,10,16] the efficacy of this practice in neurosurgery is not well understood, particularly for TS, which is believed to be the more favorable and safer approach of the two.[14] Regarding task-shifting in neurosurgery, the few studies reported were neither sufficiently structured nor powered to assess clinical implications. In a recent Malawi study, 10% of 1186 total operations were neurosurgical, most of which were performed by a nonphysician clinical officer.[17] An assessment of 1036 surgeries in Liberia showed that all 31 neurosurgical cases were performed by general surgeons.[18] Clinical practitioners seem to be more supportive of TS/S involving general surgeons rather than clinical officers,[8,11] but there remains concern that these providers may not obtain sufficient exposure to trauma surgery or neurosurgery during their training and may therefore be ill equipped to appropriately manage patients.[19] To our knowledge, only 1 TS model in neurosurgery with clinical outcomes has been reported: a retrospective review in the rural Royal Darwin Hospital (Darwin, Northern Territories; 2650 km from Perth, Western Australia), where general surgeons regularly performed emergency neurosurgery.[20] Luck et al.[20] concluded that surgical outcomes were comparable to Congress of Neurological Surgeons guidelines and mortality in other high-income countries (HICs) such as Canada and Sweden. Importantly, that model was set in an HIC with relatively robust infrastructure and resources and is not directly comparable to an LMIC setting. Furthermore, neurosurgeon specialists have since been recruited to the site, and the TS model is no longer active.[21] Overall, more data are needed to better understand ongoing and prospective models of TS/S in neurosurgery.

The goal of this research was to conduct a retrospective cohort study of a TS model in neurosurgery in the Philippines to compare neurosurgical patient outcomes between a hospital with fully trained neurosurgeons delivering care versus a government hospital using a TS model in which general surgery trainees conduct emergency neurosurgery under the intermittent supervision of a neurosurgeon. A thorough understanding of current practices will help inform future discussions on policy and training programs and elucidate whether TS is a permissible temporary solution to the workforce deficit or if efforts should focus only on full training programs.

METHODS

Study Setting

The Philippines exemplifies a region experiencing a multidimensional neurosurgical burden. It is an archipelago of >7000 islands, which are home to >100 million people, half of whom are younger than 23 years.[22] The complex geography poses significant limitations for access to timely emergency surgical care. Concomitantly, the current neurosurgical workforce is 0.108 neurosurgeons/100,000 population, only 10% of the proposed capacity, and most are concentrated in the metropolitan capital, Manila.[23] These limitations are of major concern given that road traffic injuries are a leading cause of death in individuals younger than 24 years, and TBI is frequently the primary clinical cause of road traffic accident mortality.[24,25] Moreover, recent urbanization has correlated with a 45% increase in road traffic deaths in <10 years.[24] Hence, the Philippines is faced with both workforce and geographic challenges to delivering timely neurosurgical care in the setting of an increasing burden of severe TBI.

The Bicol Region is one of 17 Philippines regions and is home to nearly 6 million people.[26] There is only 1 full-time board-certified neurosurgeon who is recognized as a fellow of the Academy of Filipino Neurosurgeons. She is primarily based at the 500-bed national referral hospital for the region, Bicol Medical Center (BMC), where nearly all patients in need of emergency neurosurgery are either initially taken or transferred once a provincial hospital anticipates a need for neurosurgical intervention. In addition to the primary neurosurgeon at BMC, there is a visiting neurosurgeon in the Bicol region, whose availability and location fluctuate; both neurosurgeons are listed as staff at 5–10 hospitals. Consequently, TS has been increasingly practiced at BMC during the past 5 years in an attempt to increase the provision of emergency neurosurgical care when neurosurgeons are unavailable.

TS Model

In this TS model, the 2 consultant neurosurgeons train general surgery residents to perform emergency procedures. The focus of the training primarily involves craniotomies or craniectomies for evacuation of posttraumatic hematomas, including epidural and subdural hemorrhages, as well as decompressive craniectomies for uncontrolled cerebral swelling (**Figure 1** shows a Filipino craniotomy kit and **Figure 2** shows an emergency epidural hematoma evacuation). The patients legally remain under the care of a consultant neurosurgeon throughout. The resident training program is based at BMC, the government hospital at which emergency neurosurgery is chiefly performed by general surgery residents (TS providers). Residents also rotate at Mother Seton Hospital (MS), an adjacent private hospital 800 meters from BMC, where neurosurgery consultants must be the attending on record during any neurosurgical case. There are infrastructural differences between the 2 hospitals, including computed tomography (CT) and mechanical ventilation availability. General surgery residents complete a 3-month rotation at both BMC and MS during their second year of the 5-year residency under the 2 consultant neurosurgeons. The neurosurgical rotator is responsible for mastering a set curriculum in emergency neurosurgery, seeing all neurosurgical admissions, medically managing these patients on the floor or in the intensive care unit (ICU), and attending neurosurgical operations. All medical and surgical plans are discussed with the consultant neurosurgeons via telephone call and/or text message in a neurosurgery-specific message thread that includes the rotator, consultants, and all residents who previously completed the rotation. The initial medical management for TBI is empirically started and includes hyperosmolar therapy (mannitol), antibiotics (cephazolin), a proton pump inhibitor (omeprazole), pain medication (paracetamol), and an antiepileptic (valproic acid). If surgery is required, the consultants and residents collectively decide among transferring care to MS, having the consultant come to operate at BMC, or having a general surgery resident who has completed the neurosurgery rotation operate themselves at BMC. Consultant surgeons also conduct rounds every few days with the rotator to discuss plans in person. Furthermore, patient care is discussed with the entire BMC surgery department during 3 weekly conferences: ICU discussion, morbidity and mortality conference, and weekly census. A more comprehensive outline of the training program can be found in **Appendix 1**.

Figure 1. Craniotomy kit at Bicol Medical Center. In many low- and middle-income countries, a hand-crank Hudson-Brace is used with a Gigli saw (*not pictured*) to make burr holes to complete the craniotomy, compared with a power drill in high-income countries.

Study Design

Retrospective patient data on emergency neurosurgical admissions were extracted from medical records at the 2 hospitals, BMC and MS (January 2015–June 2018). 2015 was used as a start date because the operative census was first recorded in a traceable computed form that year. The computer census was used to identify the medical record numbers for patients, and the respective paper charts were pulled from hospital archives. Patients were included if they met specified inclusion criteria: 1) they were admitted to the neurosurgical service at BMC or MS for an emergent cranial condition; and 2) they had a primary diagnosis of TBI, intraparenchymal hemorrhage, contusion, subdural hematoma, epidural hematoma, hydrocephalus, or increased intracranial pressure. Patients were excluded if the hospital admission was for an elective nonemergent surgery; spinal condition; or surgery for other specifications, such as suturing of a head laceration, aspiration of subgaleal hematoma, skin debridement, or tracheostomy.

Variables collected included patient age, sex, time of injury, mechanism of injury, duration from condition onset to admission at a facility with neurosurgical care, hospital transfer information, Glasgow Coma Scale (GCS) score on arrival,[27] date of CT imaging, official results of the scan (original images were not reviewed), perioperative resuscitation including hyperosmolar therapy and intubation, need for surgery, in-hospital time to procedure, type of procedure performed, and person performing procedure. TBI severity was defined as mild (GCS score 13–15), moderate (GCS score 9–12), or severe (GCS score 3–8). The primary outcome was in-hospital mortality. Secondary outcomes included length of stay, GCS score on discharge, improvement in GCS score from admission to discharge, change between lowest in-hospital GCS score to GCS score at discharge, reoperation, receipt of mechanical ventilation if indicated (vs. not available and/or bag-valve mask ventilation), pneumonia, and 30-day readmission. Measures of functional status such as Glasgow Outcome Scale score or

Figure 2. Emergency craniotomy for an emergency epidural hematoma evacuation. A general surgery resident uses a Gigli saw to complete the craniotomy after consulting with the local neurosurgeon, who was concurrently resecting a brain tumor.

modified Rankin Scale score could not be consistently elucidated from the paper medical records.

Ethical approval was obtained from King's College London, Harvard Medical School, and the National Intuitional Review Board of the Philippines via the Bicol Regional Teaching and Training Hospital.

Statistical Analysis

Statistical analyses were performed using STATA 14.0 (StataCorp LLC, College Station, Texas, USA). Univariable analysis was used to compare categorical variables and screen for potential confounders. A Bonferroni correction was used (calculated as α/κ, 0.05/15 = 0.0033) and significant variables were corrected for in the multivariable regression analysis. Multivariable logistic and linear regression models evaluated the association of provider type with the 6 outcomes. Regressions were run to control for the following potential confounders without overfitting the model: mortality: patient age, GCS score on arrival, mechanism of injury, and radiographic diagnosis; GCS score at discharge/GCS score from admission to discharge/GCS score from lowest in-hospital score to discharge: patient age, year, time from injury to hospital, GCS score on arrival, mechanism of injury, and radiographic diagnosis; length of stay: patient age, year, time from injury to hospital, GCS score on arrival, mechanism of injury, and radiographic diagnosis; inpatient pneumonia: patient age, GCS score on arrival, and radiographic diagnosis; reoperation: patient age, GCS score on arrival, and radiographic diagnosis; tracheostomy: patient age, GCS score on arrival, and radiographic diagnosis. Concordance (C) statistics and R^2 adjusted scores assessed the discriminatory capacity of the regression models. Probability values <0.05 were considered significant.

RESULTS

A total of 3241 cases were examined during the study period: 2233 at BMC and 1008 at MS. The overall mortality for all emergency neurologic admissions was 20.9% (n = 466) at BMC and 18.7% at MS (n = 167 of 893 with available mortality data). Surgery was performed for 214 patients (6.6% of admissions, 4.3% at BMC, and 11.3% at MS). TS providers performed 95 emergency neurosurgical operations, whereas neurosurgeons performed 119 (Table 1). Nearly all emergency surgeries performed by TS providers were at BMC (96.8%, n = 92); the 3 TS cases at MS were performed by a general surgery resident who transferred into a neurosurgery program and treated a patient at MS during rare emergencies. Neurosurgeons performed 9.2% (n = 11) of the emergency neurosurgeries at BMC. TS patients were more often male (88.4% vs. 73.1%; P = 0.007), younger (mean age 27.6 vs. 50.5 years; P < 0.001), and had had road traffic accidents (69.1% vs. 31.4%; P < 0.001). Most road traffic accident admissions to TS providers were from motorcycle crashes (70.3% of road traffic accidents for TS and 15.4% for neurosurgeons; odds ratio [OR], 13.0; 95% confidence interval [CI], 4.90–34.5; P < 0.001). Patients under the care of neurosurgeons were more likely to have a CT on admission, and other material supply differences were apparent (e.g., 10 TS patients requiring ventilator support were ventilated via a bag-valve mask ventilator rather than a mechanical ventilator). Additional variables are shown in Table 1.

In multivariable regression for mortality (Table 2) (after correcting for patient age, GCS score on arrival, mechanism of injury, and radiographic diagnosis in the statistical model), there was no significant difference in surgical mortality between groups (overall, 19.1%; neurosurgeons, 20.2%; TS, 17.9%; OR, 0.84; 95% CI, 0.36–1.96; P = 0.68). There were also no significant differences between reoperation and pneumonia. For all or surviving-only patients, no significant differences were observed for GCS score at discharge, change in GCS score from admission to discharge, or in-hospital GCS score improvement. TS patients had shorter lengths of stay (17.3 days vs. 24.4 days; coefficient, −6.67; 95% CI, −13.01 to −0.34; P < 0.05) and were more likely to undergo tracheostomy (OR, 3.1; 95% CI, 1.30–7.40; P = 0.01).

DISCUSSION

This retrospective cohort study is one of the first to thoroughly examine the quality of TS care provision in neurosurgery, and this model shows potential to increase access to neurotrauma care and to maintain acceptable clinical outcomes. The regional demand

Table 1. Univariable Analysis of Patient and Hospital Characteristics

Variable	Total Population (N = 214), n (%)	Neurosurgeon (N = 119), n (%)	TS/S (N = 95), n (%)	Odds Ratio	95% Confidence Interval	*P* Value
Patient characteristics						
Age (years), mean (SD)	44.7 (19.7)	50.5 (19.8)	27.6 (17.3)	−12.7	−17.8 to −7.65	<0.001
Sex (female)	43 (20.1)	32 (26.9)	11 (11.6)	0.35	0.17–0.75	0.007
Hospital characteristics						
Government/public (Bicol Medical Center)	103 (48.1)	11 (9.2)	92 (96.8)	Ref	Ref	
Private (Mother Seton)	**111 (51.9)**	**108 (90.8)**	**3 (3.2)**	**0.003**	**0.00–0.01**	**<0.001**
Time from injury to hospital (hours), median (interquartile range)	0.82 (0.22–3.06)	0.47 (0.15–3.03)	0.89 (0.22–3.15)	Coef. 0.0005	−0.00 to 0.001	0.23
Mechanism of injury						
Road traffic accident	102 (47.9)	37 (31.4)	65 (69.1)	Ref	Ref	
Motorcycle	66 (64.7)	11 (29.7)	55 (84.6)	Ref	Ref	
Other (3–4+ wheeled)	**36 (35.5)**	**26 (70.3)**	**10 (15.4)**	**13.0**	**4.90–34.54**	**<0.001**
Fall	39 (18.4)	22 (18.5)	17 (18.1)	0.44	0.21–0.93	0.032
Assault/violence	10 (4.7)	3 (2.5)	7 (7.5)	1.33	0.32–5.45	0.69
Spontaneous hemorrhage	**49 (23.1)**	**45 (38.1)**	**4 (4.26)**	**0.05**	**0.02–0.15**	**<0.001**
Other (tumor, infection)	9 (4.3)	9 (7.76)	0 (0.0)	1	Collinear	Collinear
Radiographic findings						
Acute subdural hematoma	70 (32.7)	37 (31.1)	33 (37.4)	Ref	Ref	
Epidural hematoma	65 (30.4)	27 (22.7)	38 (40.0)	3.56	1.12–11.29	0.03
Chronic subdural hematoma	32 (15.0)	17 (14.2)	15 (15.8)	1.73	0.54–5.60	0.34
Hydrocephalus	28 (13.1)	26 (21.8)	2 (2.1)	0.08	0.01–0.77	0.02
Subarachnoid hemorrhage	22 (10.3)	10 (8.4)	12 (12.6)	0.93	0.18–4.90	0.93
Contusion	53 (24.8)	20 (16.8)	33 (34.7)	4.39	1.38–13.9	0.01
Skull fracture	25 (11.7)	11 (9.2)	14 (14.7)	2.41	0.70–8.3	0.16
Herniation	16 (7.5)	11 (9.2)	5 (5.3)	0.84	0.21–3.43	0.81
Severity indices						
GCS score on admission, mean (SD)	11.2 (3.6)	11.1 (3.8)	11.3 (3.4)	0.17	−0.82 to 1.16	0.74
GCS score on admission						
Mild TBI	94 (43.9)	55 (46.2)	39 (41.1)	Ref	Ref	
Moderate TBI	62 (29.0)	28 (23.5)	34 (35.8)	1.71	0.90–3.27	0.10
Severe TBI	58 (27.1)	36 (30.3)	22 (23.2)	0.86	0.44–1.69	0.66
Treatment variables						
Intubated before admission if GCS score <8 (n = 57)	9 (15.8)	3 (8.6)	6 (27.3)	4.0	0.88–18.1	0.07
Computed tomography day of admission	**185 (92.5)**	**114 (97.4)**	**71 (85.5)**	**0.16**	**0.04–0.57**	**0.005**
Hyperosmolar therapy	167 (80.7)	11 (12.5)	77 (87.5)	2.26	1.06–4.81	0.04

Results are stratified by provider training level (neurosurgeon vs. TS/S). A Bonferroni correction was used (calculated as α/κ, 0.05/15 = 0.0033). Statistically significant differences with univariable linear and logistic regression are in bold.

TS/S, task-shifting and task-sharing; SD, standard deviation; Coef., coefficient; Ref, reference; GCS, Glasgow Coma Scale; TBI, traumatic brain injury.

Continues

Table 1. Continued

Variable	Total Population (N = 214), n (%)	Neurosurgeon (N = 119), n (%)	TS/S (N = 95), n (%)	Odds Ratio	95% Confidence Interval	*P* Value
In-hospital intubation preoperatively	77 (36.0)	38 (31.9)	39 (41.1)	1.48	0.84—2.60	0.17
Mechanical ventilation received	97 (45.3)	63 (52.9)	34 (35.8)	0.59	0.33—1.04	0.07
Bag-valve mask ventilator	10 (4.7)	0 (0.0)	10 (10.5)	1	Collinear	Collinear
Intensive care unit admission	148 (69.2)	91 (76.5)	57 (60.0)	0.46	0.25—0.83	0.01

Results are stratified by provider training level (neurosurgeon vs. TS/S). A Bonferroni correction was used (calculated as α/κ, 0.05/15 = 0.0033). Statistically significant differences with univariable linear and logistic regression are in bold.
TS/S, task-shifting and task-sharing; SD, standard deviation; Coef., coefficient; Ref, reference; GCS, Glasgow Coma Scale; TBI, traumatic brain injury.

for neurosurgical care was evident, with an average of 650 emergency neurosurgical admissions per year to the regional government referral center. Demographically, the patients mirrored the epidemiologic neurosurgical burden in other LMICs, with most cases arising from road traffic accidents involving young men and motorcycles,[1,28,29] in contrast to the epidemiology in HICs, where chronic subdural hematomas from falls in the elderly are a larger problem.[30] Furthermore, given that the operative rate was only 6.6% of admissions (4.3% at BMC and 11.3% at MS), and operation rates for TBI in developed nations range between 5% and 10%,[30] the intervention rate suggests that clinical decision making on patient selection for surgical intervention was appropriate.

Outcomes data showed that the use of TS between general surgery residents and neurosurgeons enabled residents to achieve similar outcomes compared with their neurosurgical mentors. After correcting for patient age, GCS score on arrival, mechanism of injury, and radiographic diagnosis in the statistical model, the overall mortality was 19.2%, with no statistically significant difference in surgical mortality between provider groups. The study was powered to detect a 16% difference in mortality between groups (3.07% overall mortality difference) but the observed difference was 2.3% (20.2 for neurosurgeons and 17.9 for TS). Thus, the care provided by the TS group seems to be noninferior to the neurosurgical cohort, acknowledging that TS providers solely provided basic emergency neurosurgical care. However, each health system likely has unique perspectives on what is an acceptable clinically significant difference between operators. The mortality in this Philippines study is expected to be higher than in an HIC because mortality of patients with TBI in LMICs concurrently reflects inequity in staff, stuff, space, and systems.[25,30-33] For instance, in a 46-country study that enrolled nearly 9000 patients, those with severe TBI in LMICs had >2 times the odds of mortality compared with patients in HICs (51% mortality vs. 30%; OR, 2.23; 95% CI, 1.15—3.30).[28] In addition to mortality, this Philippines model showed no significant difference in complication rates, change in GCS score, or reoperation rates. Despite its importance in neurosurgical outcomes,[27] a measure of quality of life beyond a GCS score could not be ascertained. Length of stay was significantly shorter for the TS providers; however, these data are difficult to interpret because many patients in fee-for-service private hospitals, such as MS, tend to have longer lengths of stay because they are paid for services rendered.[34-36] The significantly higher rates of tracheostomy by TS providers compared with the neurosurgeon group likely reflects the TS providers' more protocolized approach to care and the known disparities in care between the 2 hospitals. In this setting, the TS providers were instructed by the neurosurgeons to place a tracheostomy if the patient had a GCS score <9 to facilitate early weaning from a ventilator or bag-valve mask ventilation. In addition, placing a tracheostomy was believed to ease pulmonary care given the dearth of personnel to monitor and suction the endotracheal tubes in both the ICU and on the wards. TS providers practiced in a lower resource hospital with limited access to ventilator support, CT scans, and ICU level care, yet they were still able to achieve comparable clinical outcomes.

Evaluation of the TS Training Model

While examining these outcomes, it is paramount to critically examine the TS training and sustaining model to ensure patient safety and mitigate negative consequences. As mentioned in the Lancet Commission on Global Surgery and shown in Figure 3, TS models should have systematic training and competency-based evaluation before TS providers are allowed to practice.[14] First, systematic training programs should occur locally and involve a structured training curriculum, adequate oversight during medical and operative management, and competency-based evaluation at the end of the dedicated training cycle. Subsequently, local supervision should happen periodically to ensure maintenance of skills and competencies, and proper referral networks should be established for complex cases and complications to allow for teleconsultation and physical transfer of patients when necessary. Furthermore, it is critical for task-sharers to be officially recognized and supported by their institutions with a clear definition of their scope of practice, adequate financial remuneration, and clear career progression avenues to prevent attrition of practitioners and prevent task-creep: practicing beyond the scope of their training.[14]

The Philippines model (Figure 4) corresponds well to the theoretic model (Figure 3). The structured 3-month rotation allows for a dedicated time for the resident to study and practice neurosurgery in both medical management and procedural intervention. However, the model could move toward standardization by implementing targets for numbers and types of surgeries needed before advancing to operating independently. A competency-based written examination on medical management

Table 2. Multivariable Analyses

Surgical Outcomes	Total (n = 214)	Neurosurgeon (n = 119)	Task-Shifting (n = 95)	Odds Ratio /Coefficient	95% Confidence Interval	*P* Value	Concordance Statistic/Adjusted R^2
In-hospital mortality (%)	19.2	20.2	17.9	0.84	0.36—1.96	0.68	0.77
GCS score							
At discharge (all patients)	11.6 (4.8)	11.4 (5.0)	11.8 (4.6)	0.61	−0.74 to 1.95	0.37	0.26
At discharge (alive patients)	13.8 (2.3)	13.9 (2.2)	13.7 (2.3)	−0.03	−0.80 to 0.73	0.92	0.22
Δ admission: DC (all patients)	+0.42 (4.4)	+0.31 (4.4)	+0.55 (4.4)	0.61	0.95—1.08	0.37	0.07
Δ admission: DC (alive patients)	+1.8 (3.4)	+1.6 (3.5)	+2.0 (3.1)	0.30	−0.60 to 1.2	0.51	0.49
Δ lowest: DC (all patients)	+2.9 (3.2)	+2.9 (3.3)	+2.8 (3.1)	0.27	−0.75 to 1.29	0.61	0.04
Δ lowest: DC (alive patients)	+3.6 (3.4)	+3.7 (3.4)	+3.4 (3.4)	−0.04	−1.16 to 1.09	0.95	0.23
Length of stay (days), mean (standard deviation)	**21.3 (21.7)**	**24.4 (26.9)**	**17.3 (11.3)**	**−6.67**	**−13.01 to −0.34**	**0.039**	**0.06**
Inpatient pneumonia (%)	19.6	16.8	23.2	2.2	0.94—5.13	0.07	0.75
Reoperation (%)	3.3	3.4	3.2	2.2	0.33—14.6	0.41	0.66
Tracheostomy (%)	**15**	**9.2**	**22.1**	**3.1**	**1.30—7.40**	**0.011**	**0.78**

The association of the provider type with outcomes after emergency neurosurgery. Statistically significant differences with multivariable linear and logistic regression are shown in bold type.

and practical examination on technical skills could also improve the quality of the training program because it would motivate individuals to master the curriculum and provide instructors with information on where remediation may be required. For the practice interval, TS providers staff all cases with the consultant neurosurgeon, so if any referrals or expertise are needed, there is regular interaction between the TS and the neurosurgeon. The scope of practice is limited to trauma and emergencies to prevent task-creep. The greatest opportunity for improvement in the Philippines model is maintenance of providers, which typically involves higher-level systems managers and a political agenda. The practice of TS is acknowledged at the local and regional level but is not officially recognized by the Philippine College of Surgeons or Academy of Filipino Neurosurgeons. Maintenance is also inherently absent in this model, because general surgery residents are instructed not to continue practicing neurosurgery once they leave this training program, unless it is an absolute emergency (for which they are invited to call the neurosurgeon) or they transfer to a neurosurgical residency. Instead, the intention is that once the general surgeons go into practice, their neurosurgical experience improves nonsurgical neuromanagement at outside hospitals as well as timely recognition of when patients need to be transferred to a hospital with the ability to deliver neurosurgical care. It is conceivable that if there were avenues to maintain certification in emergency neurosurgery management after general surgery residency, and continued communication with specialist neurosurgeons, then graduates from the TS model could continue to provide emergency neurosurgery care as general surgery consultants, analogous to the Australian model at Darwin Hospital.[20] However, the extent of communication and sharing of clinical autonomy would likely be less, and this approach would instead emulate a task-shifting model. This strategy would expand the pool of individuals able to provide neurosurgical care but may risk the clinical safety of the process. In addition, there is no direct financial compensation for TS residents; the neurosurgical work is part of their curriculum and consultant and resident remuneration is under the umbrella government salary allotted per annum. In addition, patient payment is either made to the government hospital by PhilHealth, the government insurance plan, or performed as a charity case. Therefore, to respect and retain task-sharers, the governing organizations may consider officially recognizing TS models and practitioners and providing them with a certification for professional development and/or financial remuneration.[37-40]

Limitations and Strengths

The limitations of this study warrant further discussion. Primarily, the data collection was retrospective and thus dependent on the quality of hospital census data and the paper medical records. It is likely that cases may be missing, and it was evident that some paper medical records were incomplete. Prehospital data such as alcohol involvement, patient status, and treatment at an outside hospital were variably recorded and often unfit for analysis. In addition, in Bicol, the paucity of quality prehospital care and time delay in reaching a facility fit to provide adequate intervention may contribute to a smaller population of surgical candidates. Although all cases presenting to the hospitals with a neurosurgical emergency were included, it is likely that a contingent of Filipino patients involved in neurotrauma died before hospital arrival and therefore the epidemiologic assessment of TBI within the area cannot be adequately assessed. In-hospital, the physician and nursing notes were often insufficiently detailed and patient functional status at the time of discharge could not be elucidated. Because there was no record of follow-up for these patients, long-term mortality, neurologic status, and functional independence could not be assessed. There were also limitations in comparing

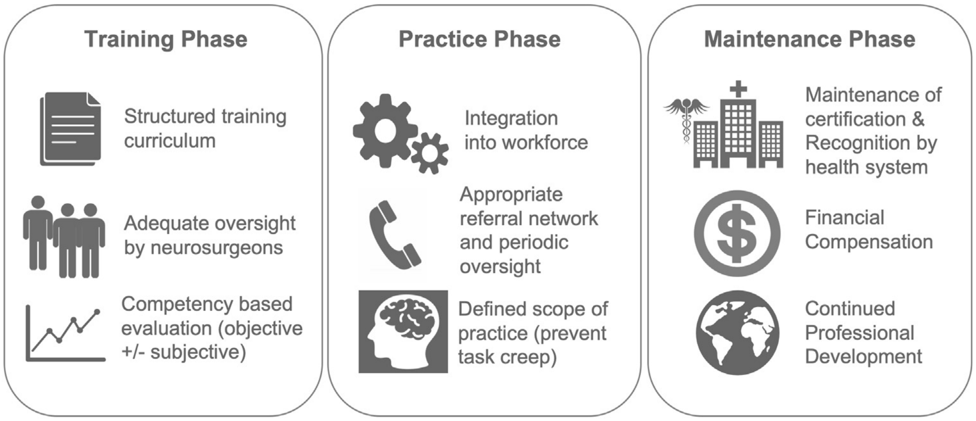

Figure 3. A theoretical task-sharing model. Ideally, task-sharing would involve structure in the 3 phases of training, practice, and maintenance of providers.

the neurosurgeons and TS providers because they operate in 2 separate hospital environments and treat different patient populations. In this study, the TS cohort received more trauma admissions, whereas the neurosurgeons treated more patients with spontaneous hemorrhage. Although we corrected for GCS score on arrival, mechanism of injury, radiographic diagnosis, and patient age in the statistical model, the comparison would have been more robust with more similar patient populations. The private hospital setting is often better resourced and treats patients who can afford higher-quality care. Overall, this factor makes the present analysis a more conservative study because the TS providers are at a hospital quality disadvantage. However, there are likely instances in which critical patients who needed surgery were unable to pay for additional care (e.g., ventilators) at the outside hospital and died before surgery. The generalizability of this study should also be carefully considered. Although these data comprise an original report of clinical outcomes related to TS in neurosurgery in an LMIC, it is a single-region study. Targeted site data collection may miss geographic variation and limit generalizability, not only outside the Philippines but also to different Filipino regions. However, this is a critical starting point for understanding the practice of TS where it is ongoing.

Despite these limitations, our study had several strengths. This retrospective cohort study is one of the first to thoroughly examine the quality of TS care provision in neurosurgery within an LMIC in which there is a large burden of TBI and both workforce and geographic limitations to neurosurgical care. Furthermore, the interventions closely approximate the theoretic model of safe and effective TS put forth by the Lancet Commission on Global Surgery, which incorporates phases of training, practice, and

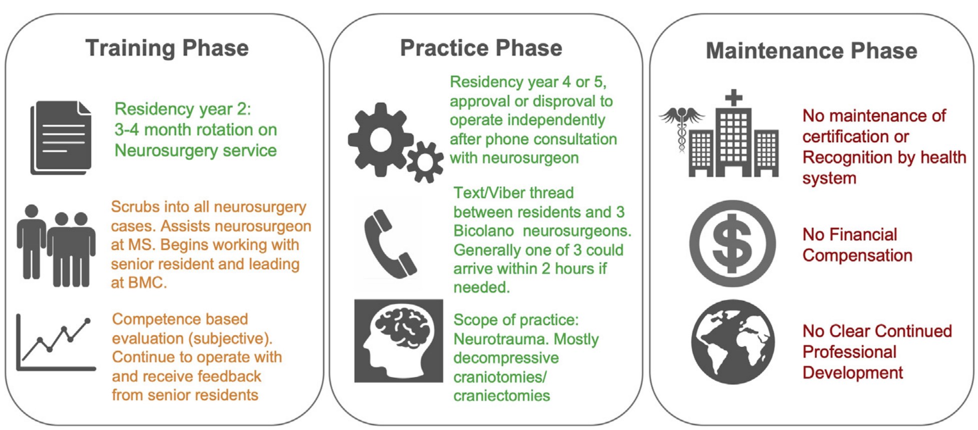

Figure 4. The Bicol Region task-sharing model. The program is depicted in the 3-phase format of training, practice, and maintenance of providers provided in Figure 1. *Green text* indicates consistency with an ideal task-sharing model, whereas *yellow* is partially consistent and *red* is missing or can be improved.

maintenance of providers with regular oversight. This study serves as a starting point for improving our understanding of how TS can be used in neurosurgery and informs the need for additional prospective data collection.

Future Directions

An essential part of delivering safe, timely, and affordable neurosurgical care in LMICs will be successful disease and population management. For neurosurgical populations, there needs to be a multipronged approach to systems improvement of public health prevention, prehospital care, in-hospital care, and rehabilitation. The neurosurgical burden of disease and concomitant workforce deficits in neurosurgery require a concerted effort in workforce expansion in the coming years. This TS model has proved successful because of systematic education and training of surgically skilled providers, local oversight, teleconsultation for coordination of care planning, and a clearly defined scope of practice. Incorporating TS into local, national, and international plans of workforce expansion is not meant to replace specialist providers but rather to strengthen specialist neurosurgical teams by extending the reach of neurosurgeons' expertise in a fashion that complements their traditional job roles. Furthermore, use of TS can decrease both the financial and temporal investment needed to increase the surgical workforce. Through additional prospective data on TS and iterative program evaluation that ensures quality care provision, a TS model has the potential to be expanded to other hospitals within the Philippines and other LMICs to deliver efficient, effective, and safe neurosurgical care.

CONCLUSIONS

Overall, the combination of neurosurgical workforce deficits and the increasing burden of neurologic trauma amplify the demand for scaling up neurosurgical care in low-resource settings. This unmet need often leads to the necessary dependence on visiting surgeons and/or task-shifting to medical officers, but TS is likely a more sustainable and safe option to mitigate the workforce gap. This retrospective cohort study was one of the first to thoroughly examine the quality of TS care provision in neurosurgery within an LMIC. It showed that emergency neurosurgical care could be delivered safely using a carefully designed TS model. Further optimization of the current model is ongoing within the Philippines and we hope that this example serves as a reference for hospitals and ministries of health facing similar challenges as they strive to increase access to safe, timely, and affordable neurosurgical care.

DECLARATION OF COMPETING INTEREST

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APPENDIX 1

Task-sharing protocol

Regarding the acquisition of technical skills, the rotator scrubs (formally participates in the surgery in a sterile fashion) into as many neurosurgery cases at Bicol Medical Center (BMC) and Mother Seton Hospital (MS) as possible during these 3 months. At MS, the rotator assists the consultant neurosurgeon, whereas at BMC, they assist a senior resident (resident year 4 or 5) or the consultant if the consultant is operating. The competency of the rotator in clinical decision making and technical skill is continuously evaluated by the consultants and senior residents; however, there is no clear benchmark for the number of cases the rotator should or will perform with a consultant during the 3 months. Additional autonomy is granted subjectively. After completion of the 3-month neurosurgery rotation, the individual continues to train with senior residents and consultants periodically. Occasionally, the consultant neurosurgeons decide that an individual resident is not competent enough to continue practicing neurosurgery during the latter half of residency; this is communicated to both the individual resident and senior residents.

In the training phase, the postrotation general surgery residents continue consulting with the neurosurgery consultants via a telephone call and/or text message. Their scope of practice is limited to emergency neurosurgery, predominantly for trauma cases. Complex neurosurgical cases such as tumors and aneurysms are not treated by residents. Residents occasionally place ventriculoperitoneal shunts and place lumbar drains to decrease intracranial pressure; external ventricular drains are rarely placed at BMC because of concern for infectious ventriculitis in the perceived limited hygiene quality in the ICU. By their fifth and final year of residency, most trainees are allowed to operate independently and/or advise junior residents who are in years 2–4. These TS individuals are listed as the "Attending on Record" in the medical chart, but the liability and billing lie with the neurosurgery consultants.

There is no clear maintenance phase. General surgery residents do not continue practicing neurosurgery once they leave this training program. However, the intention is that this training improves nonsurgical management at outside hospitals as well as giving timely recognition of when patients need to be transferred to a hospital with the ability to deliver neurosurgical care. There is no additional financial compensation for these residents, because it is part of their curriculum; all proceeds go to the consultant neurosurgeon, although these are minimal given that most are at BMC and are under the umbrella government salary allotted to the consultant neurosurgeon.