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The July Effect and its Impact on External Ventricular Drain Placement by Neurosurgical Trainees—Analysis of the National Inpatient Sample

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■ OBJECTIVE: **External ventricular drain (EVD) placement is a life-saving procedure performed frequently by neurosurgical residents. The July effect is a theoretic decline in quality of health care sometimes perceived in teaching hospitals at the start of an academic year. We sought to quantify the learning curve of ventriculostomy drain placement in teaching hospitals and determine its impact on patient outcomes, health care utilization, and cost.**

■ METHODS: **The National Inpatient Sample was queried for patients admitted nonelectively between 2012 and 2015 requiring EVD placement at a teaching hospital determined by using *International Classification of Diseases, Ninth Revision* codes. Rates of multiple EVD placements per admission, infection and hemorrhage, mortality, length and cost of hospital stay, and discharge disposition were compared between admissions in the first quarter (Q1) of an academic year (July—September) versus those in Q4 (April—June).**

■ RESULTS: **A total of 7783 admissions met inclusion criteria (3901 in Q1 and 3882 in Q4). The odds ratios (OR) for all combined complications, mortality, and long-term care disposition were similar between Q1 and Q4 groups. There was a significant reduction in the OR of wound and infectious complications in Q1 versus Q4 (1.60% vs. 2.31%; OR, 0.66; $P = 0.01$). The impact of Q1 EVD placement on total hospital charge and number of EVD codes was not statistically significant. However, there was a statistically significant reduction in length of stay in Q1 compared with Q4 ($\beta = -0.04$ days; $P < 0.0001$).**

■ CONCLUSIONS: **There was no evidence of a July effect on EVD complication rates in outcomes for patients admitted in the beginning of an academic year versus the end.**

INTRODUCTION

The July effect describes the impact on patient care of new residents and fellows beginning a new academic year.[1] Multiple studies examining this phenomenon suggest that the month of July is associated with an increased rate of medical errors and worse patient care[2,3] However, this remains a controversial topic, and its existence is hotly debated.[4] A few studies have addressed the topic within neurosurgery, with no significant differences reported in patient outcomes in July compared with other months.[5-8]

External ventricular drain (EVD) placement is one of the most frequently performed procedures in neurosurgery.[9] It is a life-saving core competency of any junior neurosurgical resident on call[10] and is performed by residents more frequently than by attendings.[11] For many new trainees, it is the first neurosurgical procedure that they learn and perform independently.[12] As with any invasive procedure, it is not without risks or complications. This factor is particularly true given the typically emergent nature of EVD placement, suboptimal procedure locations such as the emergency department (as opposed to a neuro—intensive care unit or equivalent), need for intervention in the middle of the night, and the fact that many patients with hemorrhage requiring EVD are on antiplatelet and/or anticoagulant medications. Complications include infection, hemorrhage, pseudoaneurysm or arteriovenous fistula formation, misplacement requiring repeat procedure, and damage to surrounding structures possibly causing long-term or irreversible deficits.[11,13-15]

Given the number of EVDs placed by new interns and residents in July, we sought to look for any evidence of a July effect in

Key words
- EVD
- July effect
- Teaching hospital
- Ventriculostomy

Abbreviations and Acronyms
EVD: External ventricular drain
ICD-9: *International Classification of Diseases, Ninth Revision*
NIS: National Inpatient Sample
Q1: Quarter 1

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patients undergoing EVD placement by analyzing a large national database. Trainees are expected to be the most competent in their respective year during the months of April, May, and June, as the year of training comes to an end, making that quarter the appropriate comparison group. Key outcomes that have yet to be formally investigated for this procedure include associated morbidity, mortality, and hospital stay. Our goal was to either reassure teaching hospitals and residency programs that this is a safe procedure for new trainees with appropriate supervision or to bring attention to this subject should a significant July effect for EVD placement be found.

METHODS

Data Source

Data were obtained from the 2012–2015 Healthcare Cost and Utilization Project National Inpatient Sample (NIS). It is the largest all-payer database of its kind, and consists of a stratified random sample of 20% of all U.S. nonfederal, nonrehabilitation hospital discharges amounting to >7 million records per year.[16] Each discharge record contains data on patient demographics, hospital characteristics, diagnosis and procedure codes, comorbidities, length of stay, cost of stay, primary payer, and discharge disposition. The end point of 2015 was chosen because the database switched from *International Classification of Diseases, Ninth Revision* (*ICD-9*) coding to *ICD-10* in 2016, and using a single coding scheme allowed for simpler and more accurate analysis.

Patient Selection

All discharges with *ICD-9, Clinical Modification* (*ICD-9-CM*) procedure code for EVD placement (code 02.21) from 2012 to 2015 were identified. Those younger than 18 years, elective, and nonteaching hospital admissions were excluded. Data included EVDs placed at the bedside (emergency department or neuro–intensive care unit or equivalent) as well as those that were placed in the operating room, because the NIS does not code the clinical setting of the procedure. This sample was then divided into 2 subpopulations: those admitted in April–June and those admitted in July–September.

Study Variables

Independent variables included patient age, sex, race, primary payer, hospital bed size, hospital region, patient household income by quartile, year, and number of comorbidities. Age was converted into a categorical variable based on inflections observed when plotting the data. Comorbidities were identified using the Healthcare Cost and Utilization Project Elixhauser comorbidity tool and were modeled categorically as number of comorbidities = 0, 1, 2, or 3. All independent variables were included in regression analyses to control for their confounding effects.

Outcomes

The first quarter (Q1) and Q4 groups were compared on the basis of number of EVD procedure codes, hemorrhagic complications, iatrogenic wound/infectious complications, discharge disposition, length of stay, cost of stay, and death. The NIS does not allow for quantification of number of passes required for successful placement of a catheter. Instead, this element had to be studied by calculating the number of times that EVD placement was coded on a given discharge record. This technique attempts to identify patients who required additional ventriculostomies because of misplacement or other issues but also includes patients with bilateral ventriculostomy. Wound and infectious complications were modeled together as the presence of any of the *ICD-9-CM* diagnosis codes 998.30, disruption of wound, unspecified; 998.32, disruption of external operation (surgical) wound; and 998.59, postoperative wound infection. Hemorrhagic complications were modeled as the presence of codes 997.02, iatrogenic cerebrovascular infarction or hemorrhage, or 998.12, hematoma complicating a procedure.

Missing Data

Patterns in missing data were analyzed to ensure that there were no underlying correlations between missing variables. Missing data were accounted for by 20 multiple imputations of missing variables using the Monte Carlo Markov Chain technique. Data imputed for missing variables were compared with complete cases to make sure that they had similar distributions.

Statistical Analysis

All statistical analysis accounted for the complex survey design of the NIS by using appropriate domain, cluster, and discharge weights. χ^2 analysis was used for comparison of categorical baseline patient demographics and hospital information between the Q1 and Q4 patient populations. Statistical significance was defined as $\alpha < 0.05$. Survey weighted logistic regression was used to model the effect of Q1 placement of EVD on the risk of mortality, disposition to a long-term care facility, and development of iatrogenic hemorrhagic, infectious, or wound complications. Generalized linear mixed models were used to assess length of stay and number of EVD attempts via Poisson distributions, and total hospitalization charge was modeled using a log linear distribution. All analysis was conducted with SAS Studio version 3.8 (SAS Institute Inc., Cary, North Carolina, USA).

Assumptions/Limitations

The quality of the NIS database depends on the quality of coding for each discharge, and complications could be left out if not coded correctly. It is assumed that hemorrhagic or infectious diagnosis codes represent complications of EVD placement, not other aspects of the patient's admission (a known oversimplification). Data collected included EVD procedures performed at teaching hospitals in any setting (operating room or bedside). Differences in EVD catheter products between institutions could not be accounted for. The number of passes or attempts (or total operative/procedural time) required for successful placement of the catheter could not be accounted for because the database is reliant on *ICD-9* procedural codes.

RESULTS

Patient Demographics and Hospital Characteristics

A total of 7783 admissions meeting inclusion criteria underwent EVD placement in Q1 and Q4 of the academic year (3882 and 3901, respectively) at U.S. urban teaching hospitals. Baseline patient

Table 1. Baseline Study Demographics for First Quarter (July—September) Versus Fourth Quarter (April—June) Groups

	Quarter 1 (July—September) Study Group (N = 3882)		Quarter 4 (April—June) Study Group (N = 3901)		
Variable	**Frequency**	**EVD (%)**	**EVD Frequency**	**EVD (%)**	***P* Value**
Year					
2012	932	53.44	812	46.56	0.0010
2013	967	50.16	961	49.84	0.76
2014	1061	49.56	1079	50.42	0.74
2015	922	46.78	1049	53.22	0.0009
Age					
18—40 years	894	51.09	856	48.91	0.25
41—60 years	1527	48.90	1596	51.10	0.14
>60 years	1461	50.21	1449	49.79	0.64
Gender					
Female	1797	50.59	1755	49.41	0.25
Male	2084	49.27	2146	50.73	0.25
Race					
Asian	152	48.10	164	51.90	0.50
Black	713	49.48	728	50.52	0.62
Hispanic	432	49.04	449	50.96	0.50
White	2105	50.81	2038	49.19	0.14
Native	28	49.12	29	50.88	0.87
Other	176	48.22	189	51.78	0.49
Income percentile					
First (bottom)	1125	49.78	1135	50.22	0.75
Second	948	49.27	976	50.73	0.41
Third	907	50.25	898	49.75	0.85
Fourth (top)	800	51.25	761	48.75	0.28
Primary expected payer					
Medicaid	772	48.89	807	51.11	0.38
Medicare	1250	51.59	1173	48.41	0.05
Private	1335	49.21	1378	50.79	0.41
Self-pay	335	50.15	333	49.85	0.88
Other	164	48.24	176	51.76	0.55
No charge	18	38.30	29	61.70	0.13
Number of comorbidities					
0	277	50.92	267	49.08	0.60
1	578	50.13	575	49.87	0.85
2	820	50.49	804	49.51	0.57
≥3	2207	49.46	2255	50.54	0.37

Complete case analysis before imputation of missing data.
EVD, external ventricular drain.

Continues

Table 1. Continued

Variable	Quarter 1 (July–September) Study Group (N = 3882)		Quarter 4 (April–June) Study Group (N = 3901)		
	Frequency	EVD (%)	EVD Frequency	EVD (%)	*P* Value
Hospital bed size					
Low	197	52.67	177	47.33	0.20
Medium	613	49.68	621	50.32	0.87
Large	3072	49.75	3103	50.25	0.64
Disposition					
Routine	664	48.90	694	51.10	0.41
Short-term	184	47.79	201	52.21	0.39
Long-term	1781	50.06	1777	49.94	0.78
Home health	249	49.50	254	50.50	0.86
Against medical advice	4	26.67	11	73.33	0.07
Death	990	50.90	955	49.10	0.30
Alive unknown	9	60.00	6	40.00	0.39

Complete case analysis before imputation of missing data.
EVD, external ventricular drain.

demographics and hospitalization characteristics including age, gender, race, income percentile, primary payer, comorbidities, hospital bed size and disposition were not significantly different between the Q1 and Q4 populations ($P > 0.05$; Table 1) with the exceptions of 2012 and 2015 EVD frequency between Q1 versus Q4. There was no significant difference in number of EVD placement codes between groups in any other year. The most frequently occurring diagnosis codes for hospitalization requiring EVD placement are provided in Table 2.

Mortality and Complications

All-cause mortality for the Q1 and Q4 patient populations did not differ significantly (25.51% vs. 24.50%; adjusted odds ratio 1.06 comparing Q1 vs. Q4; 95% confidence interval [CI], 0.96–1.18; $P = 0.26$). Similarly, number of coded procedures for EVD placement was not significantly different (1.10 ± 0.35 in Q1 vs. 1.11 ± 0.43 in Q4; $P = 0.26$). On univariate analysis via t test, length of stay did not differ significantly (18.75 ± 18.59 days in Q1, 19.44 ± 18.81 in Q4; $P = 0.09$). However, on multivariate Poisson regression controlling for patient demographics, hospital characteristics, and comorbidities, discharges in Q1 were associated with a small but statistically significant decrease in length of stay ($\beta = -0.04$ days; 95% CI −0.05 to −0.02 days; $P < 0.0001$). Total charge of hospitalization did not differ significantly with t test ($288036 ± 270809 in Q1, vs. $299108 ± 273001 in Q4; $P = 0.05$; Table 3) or multivariate generalized mixed linear model controlling for potential confounders ($\beta = -2\%$; 95% CI −5% to +1%; $P = 0.24$; Table 4).

When performing logistic regression of dichotomous outcomes, there was no significant difference between overall complication rates, mortality, or long-term care disposition. However, when complications were further categorized, there was a statistically significant reduction in the odds ratio of wound and infectious complications in the Q1 group versus the Q4 group. July–September discharges had a statistically significant reduction in infectious/wound complication diagnosis codes (1.60% vs. 2.31%; odds ratio, 0.66; $P = 0.01$; Table 5).

DISCUSSION

As patient safety and quality of outcomes become increasingly scrutinized in the era of modern medicine, the impact of resident training on these topics has followed suit.[17,18] The balance between adequate hands-on training and safe patient care is a serious issue and has been studied extensively. Many subspecialties have looked for a July effect for various procedures but failed to find one, including colonoscopies[19] spine surgery,[20] appendectomies,[21] urologic surgery,[22] shoulder arthroplasty,[23] plastic surgery,[24] cardiac surgery,[25] liver transplant surgery,[26] and several others. The research presented here supports that literature. The Q1 and Q4 EVD patients had similar discharge dispositions, mortality, and rates of total complications.

Length of stay was slightly lower in Q1 (−0.04 days). This effect, although statistically significant, is negligible and does not have an immediately obvious explanation. It is possible that increased oversight and supervision could lead to quicker discharges and more efficient care, but with such a small effect size, it is difficult to make definitive conclusions. Still, it could reflect a variety of factors. Younger trainees are classically tasked with routine discharges and day-to-day orders associated with health care. These trainees are the least experienced in July, and this could perhaps

Table 2. Top 10 *International Classification of Diseases, Ninth Revision* Diagnosis Codes for Nonelective Admissions Requiring External Ventricular Drain in First and Fourth Quarters

Quarter 1 (July - September) Study Group				Quarter 4 (April - June) Study Group			
ICD-9-CM Diagnosis Code		n	% ± SE	*ICD-9-CM* Diagnosis Code		n	% ± SE
430	Subarachnoid hemorrhage	1045	26.92 ± 0.77	430	Subarachnoid hemorrhage	1121	28.74 ± 0.77
431	Intracerebral hemorrhage	778	20.04 ± 0.65	431	Intracerebral hemorrhage	751	19.25 ± 0.63
99663	Infection and inflammatory reaction due to nervous system device, implant, and graft	107	2.76 ± 0.25	1983	Secondary malignant neoplasm of brain and spinal cord	98	2.51 ± 0.25
43491	Cerebral artery occlusion, unspecified with cerebral infarction	90	2.76 ± 0.25	99663	Infection and inflammatory reaction caused by nervous system device, implant, and graft	98	2.51 ± 0.26
3314	Obstructive hydrocephalus	83	2.14 ± 0.22	3314	Obstructive hydrocephalus	95	2.44 ± 0.25
1983	Secondary malignant neoplasm of brain and spinal cord	81	2.09 ± 0.23	43491	Cerebral artery occlusion, unspecified with cerebral infarction	95	2.44 ± 0.24
9962	Mechanical complication of nervous system device, implant, and graft	80	2.06 ± 0.23	4321	Subdural hemorrhage	82	2.10 ± 0.23
80126	Closed fracture of base of skull with subarachnoid, subdural, and extradural hemorrhage, with loss of consciousness of unspecified duration	70	1.80 ± 0.21	9962	Mechanical complication of nervous system device, implant, and graft	75	1.92 ± 0.22
4321	Subdural hemorrhage	63	1.62 ± 0.21	80126	Closed fracture of base of skull with subarachnoid, subdural, and extradural hemorrhage, with loss of consciousness of unspecified duration	64	1.64 ± 0.21
80125	Closed fracture of base of skull with subarachnoid, subdural, and extradural hemorrhage, with prolonged (>24 hours) loss of consciousness, without return to preexisting conscious level	52	1.34 ± 0.18	85221	Subdural hemorrhage after injury without mention of open intracranial wound, with concussion, unspecified	47	1.20 ± 0.17

ICD-9-CM: International Classification of Diseases, Ninth Revision, Clinical Modification; SE, standard error.

account for minor inefficiencies that affect cost and length of stay but not necessarily patient care, as the data reflect.

The rate of infectious complications was significantly lower in Q1 compared with Q4. Perhaps more stringent supervision in Q1 regarding sterile technique and antibiotic prophylaxis could explain some of this difference, but nonetheless, the result is counterintuitive and should be further explored. In any case, we can conservatively conclude that infectious complications are at least not worse in the Q1 group and for reasons to be further studied may even be decreased.

Our data on infectious and hemorrhagic complications do not necessarily support results reported in the literature on EVD complications. Tavakoli et al.[27] reported the infectious complication rates of EVD placement as anywhere from 0% to 22% in a meta-analysis. We report infectious or wound complications as 1.60% and 2.31% in Q1 and Q4, respectively. We anticipate that our data underrepresent true rates of these complications to a certain extent, because of the necessity of a relevant ICD-9 code for our inclusion of complications. Regardless of overall rates of these complications, because the same methodology was applied to both groups in our study, the rate of hemorrhagic complications is not significantly different in Q1 versus Q4. The rate of infectious complications was significantly decreased in the Q1 group, as previously discussed.

An interesting comparison group in the literature is patients treated at nonteaching hospitals. One study using the 2011 NIS found evidence of a July effect regarding medical admissions for myocardial infarction.[28] There was a small increase in mortality (odds ratio, 1.217; 95% CI, 1.147–1.290) in 122,280 patients admitted for myocardial infarction in Q1 in teaching hospitals versus nonteaching hospitals. That effect was absent for Q2, Q3, and Q4. The same study noted increased cost and a longer

Table 3. Univariate Analysis Comparison of Length of Stay, Number of External Ventricular Drain Codes, and Total Hospital Charge for Admission Between First and Fourth Quarters

Variable	Quarter 1 (July–September)	Quarter 4 (April–June)	*P* Value
Total charges (U.S. $)	288,036 ± 270,809	299,108 ± 273,001	0.051
Number of external ventricular drain codes	1.10 ± 0.35	1.11 ± 0.43	0.26
Length of stay (days)	18.75 ± 18.59	19.44 ± 18.81	0.09

Results presented as mean ± standard deviation with *P* value calculated using 2-sample *t* test.

hospital stay for those admitted for heart failure. Using the NIS, similar results were found in a study of patients undergoing orthopedic surgery (n = 324,988) having surgery for femoral neck or intertrochanteric fracture from 1998 to 2003, with a 12% greater risk of mortality noted in July/August admissions in teaching versus nonteaching hospitals.[29] Although the necessity of quality teaching hospitals will remain to train the next generation of physicians and surgeons, further research into differences, especially in summer months, is needed to ensure that patients receive the highest quality of care regardless of the type of hospital that they visit. Although our data did not include nonteaching hospitals, an area of future research may seek to identify differences in outcomes for EVD placements performed in that setting.

Several studies have attempted to find a July effect in other aspects of neurosurgery. Lin et al.[7] looked specifically at pediatric neurosurgical procedures to look for a July effect. Using the Kids Inpatient Database (3624 procedures) and National Surgical Quality Improvement Program–Pediatrics (14,855 procedures) for 2012, there was no significant difference in wound infection or dehiscence, venous thromboembolism, cardiac arrest, stroke, coma, or death, among other measures between Q1 and Q4, with no perceivable evidence of a July effect. In adult spinal deformity surgery, De la Garza-Ramos et al.[8] used the NIS over a 9-year period (2002–2011), with 27,794 patients included.

Table 4. Generalized Linear Mixed Model Results Comparing Total Hospitalization Charge, Number of External Ventricular Drain Procedures, and Length of Stay in First Versus Fourth Quarters

Variable	β	95% Confidence Interval	*P* Value
Total Charge of Hospitalization (U.S. $)	−2%	−5% to +1%	0.24
Number of external ventricular drain codes	−0.0083 procedures	−0.05 to +0.03 procedures	0.70
Length of stay (days)	−0.04	−0.05 to −0.02	<0.0001

Patient demographics, hospital characteristics, and complications were controlled for by inclusion in the initial model.

Complications included neurologic deficit, postoperative shock, venous thromboembolism, wound complications, among many others, identified with appropriate *ICD-9* codes. The investigators concluded that total complications, major complications, and inpatient mortality were not significantly different in July versus all other months at U.S. teaching hospitals. The investigators emphasize that corrective surgery for adult spinal deformity is technically demanding and traditionally associated with a high complication rate, making the lack of a July effect particularly convincing evidence. Although newly promoted residents may not be performing these technically advanced procedures alone, their role as a vital assistant keeps these studies relevant to our primary question.

This is the first study of its kind to examine the July effect in patients requiring external ventriculostomy. Yuen et al.[13] recently addressed a similar issue by performing a single-center analysis of EVD complication rates by surgeon experience and found no significant difference. Placement of EVDs is one of the first procedures that new neurosurgical trainees learn and is an excellent model procedure to analyze when looking for a potential July effect. There was no significant difference in any of the outcomes or proxy indicators of complications when comparing patients in Q1 and Q4. This finding is consistent with most of the existing literature on the subject, and the results support the notion that junior neurosurgical trainees are taught well and supervised appropriately.

Study Limitations

The benefits of research on administrative databases such as the NIS come at the price of several limitations. Discharge level data such as these capture events occurring only during a given hospitalization and do not allow for follow up on long-term outcomes. The quality of any research conducted on large databases depends on the quality of coding for each discharge, and significant complications could be left out of this analysis if their diagnoses or procedures were not coded correctly. Research on the veracity of coding a hospitalization into *ICD-9* data estimates an accuracy of around 80%.[30,31] The assumption that any additional hemorrhagic or infectious diagnosis codes represent complications of EVD placement is an obvious oversimplification but is necessary when conducting database research. More importantly, it was not possible to distinguish these complications from other relevant neurosurgical procedures that patients might have had. For example, a surgical site infection from a craniotomy incision would have been included as an infectious complication in this data set, regardless if the EVD associated with that patient was performed without complication.

To achieve the largest appropriate sample size, data collected included EVD procedures performed both at the bedside and in the operating room (where senior residents or attending physicians may place EVDs with more frequency). Because most EVD placements nationwide are performed at the bedside and by a junior trainee when applicable, this is likely a minor limitation. It was also impossible to account for changes in EVD manufacturers/materials between institutions (i.e., antibiotic-impregnated vs. nonimpregnated catheters), which may play a role in some complication rates such as infections. Any retrospective analysis is subject to biases such as these. Our large sample size and use of

Table 5. Complication, Mortality and Discharge Disposition Comparisons Between First and Fourth Quarter Study Groups

	Quarter 1 (July–September) Study Group		Quarter 4 (April–June) Study Group				
Outcome	n (N = 3901)	%	n (N = 3882)	%	Adjusted Odds Ratio	95% Confidence Interval	*P* Value
All complications	118	3.04	146	3.77	0.80	0.62–1.02	0.07
Wound and infectious complications	62	1.60	89	2.31	0.66	0.48–0.91	0.01
Mortality	990	25.51	956	24.50	1.06	0.96–1.18	0.26
Long-term care disposition	1781	45.90	1777	45.59	1.02	0.93–1.11	0.71

more straightforward quality metrics less prone to coding errors and assumptions such as length of stay, cost of hospitalization, mortality, and disposition are all strengths that overcome these limitations.

An important consideration regarding the EVD procedure itself is in the number of passes or attempts required for successful placement of the catheter within the ventricular system. This statistic includes total procedural time (which if longer could increase the patient's risk for infection or other complication). A single pass is always ideal and decreases the rate of complications including tract hemorrhages and morbidity associated with additional trauma to the brain.[32] It is not possible to quantify the number of passes required for successful placement using the NIS because the database is reliant on *ICD-9* procedural codes, and only a single EVD placement code is entered regardless of number of passes. Thus, it is not possible in this study to account for a possible July effect regarding the number of times that a catheter is passed for a given EVD procedure code. However, this limitation was partially circumvented by modeling the number of times that EVD insertion is coded on a given medical record. It is possible that EVDs placed in Q1 require more passes than those in other months, but this effect would be missed using our system of data acquisition. However, it is reassuring that because morbidity and mortality are not different between Q1 versus Q4 from our data, the number of passes is unlikely to be clinically significant given the number of similar comparisons between patients admitted in Q1 versus Q4.

CONCLUSIONS

EVD placement is a life-saving procedure that is often one of the first procedures in which a neurosurgical trainee becomes proficient. EVD placement at urban teaching hospitals in Q1 versus Q4 of the academic year is not associated with higher complication rates or other indicators of worse outcome when assessed at the national level, suggesting that there is no associated July effect. This finding is consistent with the literature on this topic in other fields as well as within the neurosurgical literature, providing evidence for the quality of neurosurgical trainee education with appropriate supervision at teaching hospitals around the United States.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Ryan Austerman: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing. **Sibi Rajendran:** Writing - original draft, Writing - review & editing. **Jonathan Lee:** Writing - review & editing. **Gavin Britz:** Conceptualization, Methodology, Supervision, Writing - review & editing.

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