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Epilepsy & Behavior 111 (2020) 107194

Contents lists available at ScienceDirect

Epilepsy & Behavior

journal homepage: www.elsevier.com/locate/yebeh

Using ICD-10 codes to identify elective epilepsy monitoring unit admissions from administrative billing data: A validation study

Brad K. Kamitaki [a,*], Shelly Rishty [a], Ram Mani [a], Stephen Wong [a], Lisa M. Bateman [b], Charlotte Thomas-Hawkins [c], Joel C. Cantor [d], Lawrence C. Kleinman [e]

[a] Department of Neurology, Rutgers-Robert Wood Johnson Medical School, 125 Paterson Street Suite 6200, New Brunswick, NJ 08901, United States
[b] Department of Neurology, Columbia University Medical Center, 710 West 168th Street 7th Floor, New York, NY 10032, United States
[c] Division of Nursing Science, School of Nursing, Rutgers University, 180 University Ave ACK 330, Newark, NJ 07102, United States
[d] Center for State Health Policy, Rutgers University, 112 Paterson Street 5th Floor, New Brunswick, NJ 08901, United States
[e] Department of Pediatrics, Rutgers-Robert Wood Johnson Medical School, 125 Paterson Street 7th Floor, New Brunswick, NJ 08901, United States

ARTICLE INFO

Article history:
Received 3 May 2020
Accepted 24 May 2020
Available online 10 June 2020

Keywords:
EMU
Health services research
Secondary analysis
International classification of diseases
Epidemiology
Code sets

ABSTRACT

Video-electroencephalogram (EEG) monitoring in the epilepsy monitoring unit (EMU) is essential for managing epilepsy and seizure mimics. Evaluation of care in the EMU would benefit from a validated code set capable of identifying EMU admissions from administrative databases comprised of large, diverse cohorts. We assessed the ability of code-based queries to parse EMU admissions from administrative billing records in a large academic medical center over a four-year period, 2016–2019. We applied prespecified queries for admissions coded as follows: 1) elective, 2) receiving video-EEG monitoring, and 3) including diagnoses typically required by major US healthcare payers for EMU admission. Sensitivity (Sn), specificity (Sp), and predictive value positive/negative (PVP, PVN) were determined. Two approaches were highly effective. Incorporating epilepsy, seizure, or seizure mimic codes as the admitting diagnosis (assigned at admission; Sn 96.3%, Sp 100.0%, PVP 98.3%, and PVN 100.0%) or the principal diagnosis (assigned after discharge; Sn 94.9%, Sp 100.0%, PVP 98.8%, and PVN 100.0%) identified elective adult EMU admissions with comparable reliability ($p = 0.096$). The addition of surgical procedure codes further separated EMU admissions for intracranial EEG monitoring. When applied to larger, more comprehensive datasets, these code-based queries should enhance our understanding of EMU utilization and access to care on a scalable basis.

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1. Introduction

Recording seizures with concomitant video-electroencephalogram (EEG) monitoring in the epilepsy monitoring unit (EMU) remains critical for evaluating and managing patients with epilepsy, particularly the one-third of patients with medically refractory epilepsy who may be surgical candidates [1]. Prior studies indicate that EMU admissions are consequential and frequently influence future care [2,3]. Furthermore, admissions to accredited inpatient EMUs in the United States are increasing, from 65,000 in 2011 to more than 90,000 in 2017 [4]. These trends suggest that studying the clinical epidemiology of EMU utilization may aid our understanding of the management of epilepsy, along with associated costs, quality measures, and outcomes.

Secondary analysis of existing databases is efficient and can provide important insights into healthcare quality and equity by aggregating large numbers of diverse patients across many centers [5,6]. Such databases are derived from individual billing records inputted by professional medical coders based on the clinical record. They typically include patient demographics, associated diagnoses, and procedures coded by the International Classification of Disease (ICD) and Current Procedural Terminology (CPT) systems. However, without a specific code indicating "EMU admission," there is currently no validated way of studying databases that incorporate EMU admissions. We, thus, sought to develop a code set to identify EMU admissions from an inpatient hospital billing database.

2. Materials and methods

2.1. Study population and eligibility criteria

This study was approved by the Rutgers University Institutional Review Board. We retrospectively identified a cohort of adult patients ≥18 years of age consecutively admitted to Robert Wood Johnson University Hospital-New Brunswick (RWJUH) for EMU admission between January 1, 2016 and December 31, 2019 from an internal EEG reporting database. This cohort represented the reference standard for adult EMU

* Corresponding author at: 125 Paterson Street, Suite 6200, New Brunswick, NJ 08901, United States.
E-mail address: brad.kamitaki@rutgers.edu (B.K. Kamitaki).

https://doi.org/10.1016/j.yebeh.2020.107194
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admissions at RWJUH. We specifically chose to examine adult admissions only, as the character of pediatric EMU admissions differs substantially from adult admissions.

2.2. Billing database query to identify EMU admissions

We next analyzed the RWJUH billing database (McKesson Performance Analytics; McKesson Corporation) from January 1, 2016 to December 31, 2019. We devised search queries intended to identify EMU patient admissions following discussion with experienced medical coders and database administrators. Because all RWJUH EMU admissions are elective by institutional policy, we hypothesized that EMU admissions could be readily extracted by searching for 1) elective adult (age ≥18 years) patient admissions, 2) receipt of video-EEG monitoring, and 3) presence of one of a selected group of ICD-10 diagnosis codes, which we determined after a review of diagnoses published by health payers as approved indications for video-EEG monitoring (Table 1 [7–11]). After prespecifying these diagnoses, we then applied the following queries to the RWJUH billing database:

- Query #1: Presence of ICD-10 procedure code 4A10X4Z, or CPT procedure code 95951 (both indicating video-EEG monitoring services); and Admission Type = Elective.
- Query #2: Search 1) as above, and an *Admitting Diagnosis* ICD-10 code listed in Table 1. The "Admitting Diagnosis" refers to the diagnosis assigned at the time of hospitalization [12].
- Query #3: Search 1) as above, and a *Principal Diagnosis* ICD-10 code listed in Table 1. The "Principal Diagnosis" refers to the diagnosis that prompted the admission after review of the diagnostic examinations performed in hospital [12].

2.3. Statistical analysis

We provided descriptive statistics of the EMU admission study cohort identified from the internal EEG reporting database and linked this cohort to the RWJUH billing database. We then determined the number of true positives (TP), false negatives (FN), false positives (FP), and true negatives (TN) for queries #1–3 using EMU admissions from the internal EEG reporting database as the reference standard. We calculated the sensitivity (Sn), specificity (Sp), predictive value positive (PVP), and predictive value negative (PVN) with exact 95% confidence intervals (95% CI) for each query. McNemar's test was used to assess whether the underlying discrimination of these methods was similar. We followed the Standards for Reporting of Diagnostic Accuracy (STARD) guidelines [13]. Analyses were performed using MedCalc Statistical Software version 19.2.0.

Table 1
Proposed ICD-10 diagnosis-based query for elective epilepsy monitoring unit admission from a review of selected health payer policies.

ICD-10 Code	Diagnosis
G40.XXX	**Epilepsy**
• **G40.0XX, G40.1XX, G40.2XX** • **G40.3XX, G40.4XX** • **G40.5XX** • **G40.AXX, G40.BXX** • **G40.8XX, G40.9XX**	• **Focal epilepsy** • **Generalized epilepsy** • **Epilepsy related to external causes** • **Absence and juvenile myoclonic epilepsy** • **Other epilepsy, unspecified**
R56.01	Post-traumatic seizures
R56.9	**Unspecified convulsions / seizure-like activity**
F44.5	Conversion disorder with psychogenic non-epileptic seizures
F44.9	Dissociative and conversion disorder, unspecified
R25.0-R25.9	Abnormal involuntary movements
R40.4	Transient alteration of awareness
R41.0	Disorientation, unspecified
R41.82	Altered mental status, unspecified
R55	Syncope and collapse
R94.01	Abnormal EEG

The above ICD-10 codes were devised based on requirements from selected health payers for approval of inpatient video-EEG monitoring.[7-11] Bolded ICD-10 diagnosis codes were included in all of the policies reviewed.

3. Results

3.1. Description of the EMU admission cohort

Three hundred and fifty-one adult patient admissions to the RWJUH EMU were identified over the four-year study period from the internal EEG reporting database (Fig. 1). This comprised 298 unique patients, 43 of whom were admitted multiple times. There were 58.1% (173/298) women patients, with a median age of 36 years at the time of admission (range: 18–85; interquartile range [IQR]: 27). The median length of stay was four days (range: 0–25, IQR: 3).

Fourteen patients underwent evaluation with intracranial electrode implantation. This group had a median age of 33 years (range: 19–62 years, IQR: 24.75), and 28.6% (4/14) were women. The median length of stay for intracranial EEG evaluation was nine days (range: 5–25, IQR: 3).

3.2. Accuracy of billing database search queries in identifying EMU admissions

Each proposed search query was applied to the RWJUH billing database, which encompassed 126,727 total inpatient admission records over the four-year study period. Performance measures of each query, including Sn, Sp, PVP, and PVN, are shown in Table 2.

Query #1, which identified all elective admissions with an associated ICD-10 or CPT code for video-EEG monitoring without constraints on diagnosis, resulted in a high number of FP admission detections. Of the 109 FP admissions, 34.9% (38) were admitted for neurosurgical reasons, including elective interventions for intracranial aneurysm, arteriovenous malformation, or meningioma, 22.9% (25) for cardiac etiologies, including valve replacement and coronary angiography, and 19.3% (21) for cancer treatment. The remaining 22.9% of FP admission indications included various infections, other organ system dysfunction, other

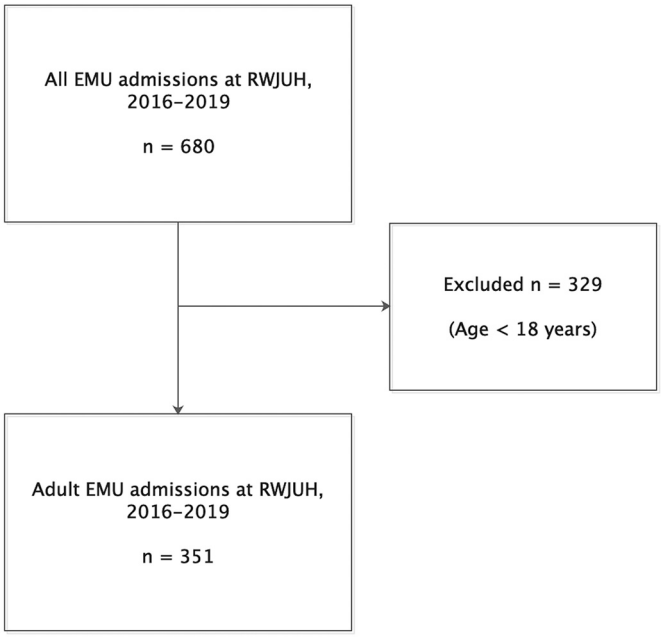

Fig. 1. Patient selection from the RWJUH internal EEG reporting database.

Table 2
Accuracy of ICD-10-based queries of the RWJUH billing database to identify EMU admissions, 2016–2019.

	True positives	False negatives	False positives	True negatives	Sensitivity (95% CI)	Specificity (95% CI)	Predictive value positive (95% CI)	Predictive value negative (95% CI)
Query #1: • Elective admission • Presence of code for video-EEG monitoring	350	1	109	126,267	99.7% (98.5–100.0)	99.9% (99.9–99.9)	76.8% (73.2–79.9)	100.0% (100.0–100.0)
Query #2: • Query #1 and • *Admitting* ICD-10 diagnosis code listed in Table 1	338	13	6	126,370	96.3% (93.8–98.0)	100.0% (100.0–100.0)	98.3% (96.2–99.2)	100.0% (100.0–100.0%)
Query #3: • Query #1 and • *Principal* ICD-10 diagnosis code listed in Table 1	333	18	4	126,372	94.9% (92.0–96.9)	100.0% (100.0–100.0)	98.8% (96.9–99.6)	100.0% (100.0–100.0)

surgical or orthopedic procedures, and obstetrical reasons. Thus, while query #1 displays nearly perfect Sn and Sp, the PVP was notably low at 76.8% due to a high FP rate.

Queries #2 and #3, which differed by querying the admitting diagnosis (#2) and the principal diagnosis (#3), showed better results than query #1, with Sn, Sp, PVP, and PVN all exceeding 94% (Table 2). The performance of queries #2 and #3 was not statistically different by McNemar's test ($p = 0.096$). The number of FP admissions markedly decreased with the use of queries #2/3 and numbered six and four, respectively. Four of these FP admissions, common to both queries #2 and 3, were for epilepsy or seizures: two were transfers from other institutions for video-EEG monitoring not done in the EMU, one was admitted directly from prison with seizures, and one was an epilepsy surgery patient admitted for laser ablation of an epileptic focus, with admission complicated by concern for breakthrough seizures.

There was, however, an increase in the number of FN cases with queries #2/3. Review of these revealed potential seizure mimics not included in Table 1 (9/12 FN cases for query #2; 16/18 for query #3): alcohol withdrawal, weakness, orthostatic hypotension, stupor, movement disorder, dizziness and giddiness, migraine with aura, and myoclonus. A minority (3/12 FN cases for query #2; 2/18 for query #3) were seemingly unrelated to the physician-documented reason for EMU admission and included diagnoses like gastroparesis, lymphadenopathy, or scoliosis. Although these may represent frank coding errors, epilepsy or seizure diagnoses were represented for most of these admissions (80%, 4/5) in associated (nonprimary or nonadmitting) diagnosis code positions.

Lastly, while queries #2/3 accurately identified elective EMU admissions to RWJUH, they did not distinguish between admissions for noninvasive scalp EEG versus invasive intracranial EEG monitoring. When we applied an additional query parameter of an ICD-10 procedure code in any position beginning with 00H (00HXXXX), indicating insertion of a central nervous system monitoring device, all 14 admissions for intracranial EEG monitoring were subsequently identified.

4. Discussion

Our findings indicate that search queries utilizing ICD-10/CPT code sets reliably parse elective EMU admissions from a single-center inpatient hospitalization billing database over a four-year period. Assessing for neurosurgery procedural codes further differentiates usual EMU patient admissions from those receiving intracranial EEG monitoring.

Researchers have previously validated ICD-9/10-based search queries designed to pinpoint individual epilepsy cases from administrative data in Canada and the US [14–16]. Jetté and colleagues noted that coders demonstrated excellent accuracy for epilepsy cases when using ICD-10 codes G40 and G41 for epilepsy and status epilepticus. However, broadening the query to include R56.9 (seizure-like activity) increased Sn but decreased Sp/PVP, as expected [15–16]. They also found that coders were less facile in distinguishing epilepsy subtypes, such as focal versus generalized-onset syndromes [15]. Coders may encounter further difficulties classifying intractable (G40.X1X) versus nonintractable epilepsy cases (G40.X0X) depending on the thoroughness of the medical record, though accurate descriptions of epilepsy syndromes in administrative data would be useful for both clinical and research purposes.

In the EMU, however, not all patients have epilepsy, and many are ultimately diagnosed with epilepsy mimics like psychogenic nonepileptic seizures or syncope. We found that capitalizing on the need to meet specified payer criteria for EMU admission greatly improved the accuracy of our search queries. Epileptologists are often advised that even if a patient is unlikely to have epilepsy or seizures, providing an admitting diagnosis code to "rule out" seizures or epilepsy will frequently result in payer approval. This approval is mandatory prior to proceeding with elective hospitalization and, consequently, appears to facilitate the identification of EMU admissions in US billing data. It would be valuable to evaluate the performance of our proposed queries in other countries where approval prerequisites for EMU admission may differ substantially.

Our single-center study design limits generalizability to more comprehensive databases. These findings should ideally be confirmed in multiple hospitals that provide EMU services, or via the creation of larger prospective EMU registries. Importantly, some epilepsy centers utilize the EMU for emergent management of breakthrough seizures or status epilepticus not requiring intensive care unit-level care. Our queries identify elective EMU admissions only, as there is no other clear way to differentiate patients admitted from the emergency department to the EMU versus the general hospital ward. However, queries #2/3 should still capture the vast majority of EMU patients, who are typically admitted from the outpatient setting. Query #2 may be preferred when assessing all-comers to the EMU. In contrast, query #3 could be utilized when assessing specific populations, for example, those with a clinician-determined diagnosis of epilepsy based on clinical and video-EEG data acquired during hospitalization.

The diagnosis-based queries used in our study thus demonstrate excellent accuracy when applied to a large academic center's billing database spanning four years and >350 unique EMU admissions. Future research capitalizing on large administrative sources such as the Agency for Health Research and Quality (AHRQ) Healthcare Cost and Utilization Project (HCUP) databases should greatly improve our understanding of EMU outcomes via analyses of morbidity, mortality, and hospital readmissions. Moreover, ongoing surveillance ensuring widespread access to specialty epilepsy care remains critical. Schiltz et al. previously found that inherent socioeconomic factors such as lack of access to a nearby epilepsy center, uninsured or public insurance status, and minority race contributed to a decreased likelihood of receiving video-EEG monitoring services in California [17]. Continued close scrutiny is needed to ensure that external influences, for example, recent sizable reductions in video-EEG monitoring reimbursements, do not jeopardize patient access to quality epilepsy

care. These issues remain relevant, particularly as persistent inequities in the American healthcare system are laid bare by the current COVID-19 pandemic crisis [18].

Declaration of competing interest

None of the authors has any conflict of interest to disclose. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. We confirm that we have read the journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

Acknowledgments

We would like to thank Virginia Antonelli and Charles Braido for their technical expertise and contributions to this study.

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