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Estimating the cost of admissions related to convulsive status epilepticus in the United States of America

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ABSTRACT

Purpose: To estimate the cost of admissions related to status epilepticus (SE) in the USA and to evaluate SE mortality.
Method: Descriptive retrospective study using national estimates from the KID's Inpatient Database (KID) for children and from the National Inpatient Sample (NIS) for adults for the years 2007–2012, the largest collection of all-payer, encounter-level hospital care data in the United States. The individual observation in this study is hospital admission.
Results: From a population of 186,013,640 admissions, a total of 184,500 admissions were related to SE. The median (p_{25}-p_{75}) cost of admissions related to SE was $7690 ($3893–$17,247) in the KID 2010–2012, $6529 ($3,370–$14,854) in the KID 2007–2009, $13,874 ($6699–$29,176) in the NIS 2012, $13,313 ($6,483–$28,598) in the NIS 2011, $12,999 ($6,366–$27,505) in the NIS 2010, $11,833 ($5721–$24,657) in the NIS 2009, $11,479 ($5,611–$24,326) in the NIS 2008, and $10,759 ($5493–$22,928) in the NIS 2007. Costs were more than two times higher for super-refractory SE admissions than for refractory SE admissions. Costs stratified by age followed an "U"-shaped distribution with higher costs in admissions of young children and older adults. Mortality ranged from 2.5% to 3% in children and from 12.7% to 14.9% in adults.
Conclusions: This study estimates the cost of admissions related to SE in the USA to be approximately $7000 in children and $13,000 in adults, and quantifies how costs markedly increase once SE becomes super-refractory.

1. Introduction

Status epilepticus (SE) is one of the most common neurologic emergencies [1–4] with a mortality that ranges from 0 to 3% in children to 20–30% in older adults [1,4–8]. SE requires timely treatment and close monitoring and support of cardiorespiratory function [9], which translates into a resource-intensive management in the hospital.

The cost of managing SE is substantial. In a German study the mean (± standard deviation (SD)) admission costs related to SE were markedly higher (€ 8347 ± €10,773 per patient per admission) than those related to patients with newly-diagnosed epilepsy (€1998 to ± €1089 per patient per admission), or with established epilepsy (€3475 to ± €4413 per patient per admission) [10]. Within SE admissions, super-refractory SE is much more costly than non-refractory and even than refractory SE [11]. In a German study, the median cost for admissions was 7–8 times higher for super-refractory SE (€32,706) than for non-refractory SE (€4063) and for refractory SE (€4581) [11]. There is very limited literature on cost of SE in the USA. A series of 192 SE admissions in the USA from 1993 to 1994 showed a median inpatient reimbursement of $8417 [12]. The median cost of super-refractory SE in the USA in 2012 was estimated at $33,294 [13]. Detailed data on the cost of SE based on large populations are urgently needed, especially in the USA.

This study aims to address this gap in knowledge by estimating the cost of SE admissions using the largest all-payer provider databases in the USA.

2. Patients and methods

2.1. Standard protocol approvals, registrations, and patient consents

This study was performed with the datasets from the Health Care Cost and Utilization Project (HCUP) maintained by the Agency for Healthcare Research and Quality (AHRQ). The Institutional Review

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Board at Boston Children's Hospital considered this study non-human subjects research as the data comes from a de-identified publicly available database.

2.2. Study design

This is a retrospective descriptive study on the National Inpatient Sample (NIS) and the Kids' Inpatient Database (KID) for the years 2007–2012. The NIS releases data annually with information for one year while the KID releases data every three years with information for three years. Therefore, even if we analyzed 6 NIS databases and 2 KID databases, the period studied is the same for both NIS and KID: 2007–2012.

2.3. Data

HCUP is the largest all-payer encounter-level hospital care data in the USA. The HCUP family of databases include several databases with different datasets focusing on different aspects of healthcare: emergency department, inpatient setting, readmissions, data for individual States within the US, and ambulatory surgery. Among these databases, those with information on hospital admission costs are NIS (for adults) and KID (for pediatric patients). These databases are generated through a stratified sampling strategy that extracts approximately 20% of raw data from the State databases including all relevant strata. Sampling weights are calculated to permit a national estimate which represents approximately 97% of all inpatient hospital discharges [14]. The NIS contains a stratified sample from more than 7 million hospital stays each year representing a population of more than 30,000,000 admissions each year [14]. The KID is the largest publicly available, all-payer pediatric database in the USA [14]. It contains a sample of 2–3 million pediatric hospital discharges per release (releases for the KID database occur every 3 years) representing a population of more than 6,000,000 admissions per release [14].

2.4. Age range

The KID database provides more granularity in admissions of patients 0–20 years old than the NIS database. We included all admissions of patients in the KID database. To prevent overlap, we excluded patients 20 years or younger from the NIS database.

2.5. Population

We included all admissions related to SE. We excluded admissions with no basic demographic information: age and gender, and admissions with no information on the main outcomes for this analysis: length of stay, death, and cost.

2.6. ICD-9 codes

Admissions considered as having SE were identified using the 9th revision of the International Statistical Classification of Diseases (ICD-9) codes. Status epilepticus was identified using the code 345.3 [Grand mal status] [15]. Mechanical ventilation was identified using the codes 96.7 [Other continuous invasive mechanical ventilation], 96.70 [Continuous invasive mechanical ventilation of unspecified duration], 96.71 [Continuous invasive mechanical ventilation for less than 96 consecutive hours], and 96.72 [Continuous invasive mechanical ventilation for 96 consecutive hours or more].

2.7. Classification of admissions related to SE

Following a modified version of an available classification [11], we divided admissions related to SE into: 1) non-refractory SE if the patient was not mechanically ventilated, 2) refractory SE epilepticus if the patient was mechanically ventilated for less than 96 h, 3) super-refractory SE if the patient was mechanically ventilated for at least 96 h. The clinical definition of refractory and super-refractory SE relies on information on the treatments administered and the response to them. This information is not available in the KID and NIS databases and, therefore, we used a surrogate classification based on prior data [11]. The main difference to this classification scheme is the time to define super-refractory SE. While prior analyses [11] use mechanical ventilation for at least 48 h, this information is not available with ICD 9 codes, so we considered super-refractory SE considering the only time point available: mechanical ventilation for at least 96 h. The use of mechanical ventilation as a surrogate marker for identifying patients in the ICU was previously used in this dataset [16].

2.8. Variables

The main descriptive outcome was cost of admission. Cost of admission is calculated in the KID and NIS databases using cost-to-charge estimates [17]. The KID and NIS databases contain data on total charges for each hospital discharge [18]. This charge information represents the amount that hospitals billed for services, but does not reflect how much hospital services actually cost or the specific amounts that hospitals received in payment [18]. To evaluate how hospital charges translate into actual costs, the cost-to-charge ratio files enable this conversion [18]. Each file contains hospital-specific cost-to-charge ratios based on all-payer inpatient cost for nearly every hospital in the corresponding KID and NIS databases [18]. The cost-to-charge files are unique by year and database [18]. The secondary outcomes were in-hospital mortality and length of hospital stay. We also described other demographic variables of interest including the type of hospital, the demographic characteristics of the admitted patients, and the primary expected payer. Disease severity is estimated based on the risk for complications, the number and severity of comorbidities, and the risk of death (https://www.hcup-us.ahrq.gov/db/nation/nis/OverviewofSeveritySystems.pdf). The structure of the variables in the KID and NIS databases and the definition of all categories in each variable is beyond the scope of this article and can be found at https://www.hcup-us.ahrq.gov/db/nation/kid/kiddde.jsp (KID) and at https://www.hcup-us.ahrq.gov/db/nation/nis/nisdde.jsp (NIS).

2.9. Weighting

Discharge weights allow estimation of national estimates in the KID and the NIS databases. Hospitals are post-stratified based on six characteristics contained in the AHA hospital files –ownership/control, bed size, teaching status, rural/urban location, and USA region, with the addition of one status for freestanding children's hospitals. Additional details on the creation and use of weights can be found at https://www.hcup-us.ahrq.gov/databases.jsp.

2.10. Adjustment for inflation

Costs are calculated in 6 different years. To help the reader compare the different costs and to evaluate how these costs would apply at present, we have provided the inflation-adjusted costs in 2018 US dollars using the inflation statistics from the United States Department of Labor, Bureau of Labor Statistics [19].

2.11. Statistical analysis

All analyses were performed using complex survey weights and procedures for appropriate national projections. Demographic and clinical characteristics were summarized with descriptive statistics. The individual observation in this dataset is the hospital admission and not the individual patient. Therefore different admissions may belong to the same patient and the assumption of independence does not hold.