



## Original Article

## Pediatric Epilepsy Readmissions: The Who, When, and Why

Marissa Vawter-Lee, MD <sup>a, b, \*</sup>, Alexandria Lutley, MD <sup>a, c</sup>, Sharon W. Lake, PhD, RN <sup>d</sup>,  
Shirley Fledderjohn, RN <sup>a</sup>, Anna King, RN <sup>a, †</sup>, Paul S. Horn, PhD <sup>a, b</sup>,  
Kristen R. Wesselkamper, MD <sup>a, b</sup>

<sup>a</sup> Division of Child Neurology, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio

<sup>b</sup> Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati, Ohio

<sup>c</sup> Department of Neurology, Medical College of Wisconsin, Milwaukee, Wisconsin

<sup>d</sup> Cincinnati Children's Hospital Medical Center, Neuroscience Trauma Unit, Cincinnati, Ohio

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## ABSTRACT

**Background:** Prior studies have demonstrated a pediatric epilepsy readmission rate of 6% to 10% but have not described details of the readmitted patients. We report the characteristics of pediatric patients admitted for epilepsy who were readmitted to the hospital within 30 days of discharge.

**Methods:** An interdisciplinary team was established to individually review and characterize the 30-day readmissions of patients admitted for epilepsy from May 2014 to October 2016. The team contained both inpatient and outpatient neuroscience nurses, care managers, a quality outcomes manager, and child neurology physicians.

**Results:** Over a 30-month period we had an all-cause 30-day readmission rate of 8.0%, which was 219 pediatric epilepsy readmissions from 169 patients. We found that 21.5% of readmissions were scheduled, 37% were for progression of chronic epilepsy, 9.6% were for recently diagnosed epilepsy, and 14.6% were for unrelated diagnoses. We classified 21.5% of readmissions as preventable and 64.9% as not preventable. Thirty-five percent of readmissions occurred within seven days of the initial discharge, including 29 of 47 (61.7%) preventable readmissions. The most common reasons for preventable readmissions were problems with the discharge care plan or medication management.

**Conclusions:** We demonstrate that 21.5% of pediatric epilepsy readmissions were scheduled and 21.5% were judged to be preventable. The majority of preventable readmissions occurred within seven days of index discharge. Characterizing epilepsy readmissions is the first step in being able to reduce readmissions.

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## Introduction

The medical community is interested in reviewing hospital readmissions to improve health care. Readmission rates have been reported for various specialties, and there has been reporting on

the degree of preventability of readmissions. There are readmission data for adult neurology and pediatrics as a whole, whereas there is limited information on pediatric neurology patients. The only data reported thus far have been for pediatric patients with epilepsy, for which 30-day readmission rates of 6.9% (unplanned) to 9.4% (all

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\* Communications should be addressed to: Vawter-Lee; Cincinnati Children's Department of Neurology; 3333 Burnet Avenue, MLC 2015; Cincinnati, OH, 45229.

E-mail address: [Marissa.Vawter@cchmc.org](mailto:Marissa.Vawter@cchmc.org) (M. Vawter-Lee).

† Deceased 8 February 2017.

cause) have been reported.<sup>1,2</sup> Guterman et al. found that adults with epilepsy have an unplanned 30-day readmission rate of 9.9%.<sup>3</sup>

When discussing readmissions, the ideal methods for data collection and review are a subject of debate. To determine preventability, some groups have used computer models, whereas others have favored manual review of charts.<sup>2,4</sup> Jackson et al. found that in adult patients (excluding those with pregnancy, human immunodeficiency virus, or metastatic cancer) automatic evaluation showed that 78% of readmissions were preventable, whereas manual review determined that only 47% were preventable.<sup>4</sup> Jackson et al.'s conclusion was that manual chart review was a more accurate way to determine preventability.

The rate of preventability in pediatric readmission studies has ranged from 6% to 29.5% depending on the methods used. Using chart review and fault tree analysis, a preventability rate of 6% for 15-day readmissions was found for general pediatric patients.<sup>5</sup> Using chart review and group discussion, a preventability rate of 20% for 15-day readmissions was found for all pediatric patients (general and subspecialty).<sup>6</sup> Using chart review and family interviews a 29.5% preventability rate was found for all pediatric patient 30-day readmissions (excluding scheduled and psychiatric readmissions).<sup>7</sup>

In 2013 an article was published about the concept of measuring a pediatric neurology program's quality by its readmission rate.<sup>8</sup> The authors make the assumption that the most likely pediatric neurology patients to be readmitted are those undergoing epilepsy surgery evaluation and that the rate of preventability in pediatric neurology is likely low.<sup>8</sup>

Seizures are the most common pediatric neurology disorder for admission to a hospital and later readmission.<sup>1,2</sup> Knowing that patients with epilepsy are a high-risk group for readmission, our team decided to focus on pediatric patients with epilepsy and identify the key characteristics of those who are readmitted within 30 days, including the reason, timing, and preventability of readmission. Our goal was to gather and report descriptive data on these patients as none have previously been reported. We felt that without this background data being known, future quality improvement projects would be difficult.

## Methods

### *Study design and participants*

Our hospital is a tertiary care, free-standing children's hospital in an urban setting. In 2014 a collaborative was formed to examine 30-day readmissions. The readmission collaborative is multidisciplinary and initially included members from cardiology, general pediatrics, neonatology, neurology, and psychiatry; it now includes members from every subspecialty that admits patients. Neurology was selected to be part of the collaborative as past research showed that pediatric patients with seizure have among the highest rates for readmission.<sup>1</sup> The goal of the collaborative was for key members of each division to share data on readmissions and discuss possible interventions to lower readmission rates.

The neurology division formed a team to focus on patients admitted for epilepsy who had a readmission within 30 days. This team included child neurology physicians, inpatient and outpatient nurses, an inpatient nurse care manager, a quality outcomes manager, and parents of a child with epilepsy. The group met every two weeks to discuss data and review the project. A subgroup (which included outpatient nurses, a quality outcomes manager, and child neurology physicians) met weekly to review readmissions. International Classification of Diseases (ICD)-9 or ICD-10 codes were not

used to predetermine scheduled readmissions and exclude them from review as the team believed that without examining scheduled readmissions, it was impossible to say they were not preventable.

This project was part of a hospital-wide collaborative tasked with understanding and preventing all-cause 30-day hospital readmissions and therefore Institutional Review Board approval was not required.

### *Data collection*

Data were collected from May 1, 2014, to October 30, 2016, as readmissions occurred. The decision was made that regardless of the index admission team, if a patient was initially hospitalized for epilepsy the readmission would be reviewed by the neurology team. This captured patients with epilepsy admitted to the neuroscience floor who were on neurology, general pediatrics, neurosurgery, and the epilepsy monitoring unit. Team members involved in the index admission were given the option to excuse themselves from that review if a conflict of interest was self-determined to exist. Index and readmitting attendings along with discharge nurses were contacted by e-mail and asked to provide additional input on the readmission.

Members of the subgroup separately evaluated and characterized each readmission before a weekly meeting. At the weekly meeting each readmission was individually analyzed, with each subgroup member discussing how they had characterized the readmission. If conflict existed between how individuals had categorized a readmission, that particular aspect was discussed until consensus was reached. Information for the review was entered into a hospital database.

### *Outcomes*

All readmissions were assigned one of 10 categories to describe the reason for readmission (Table 1). These categories were chosen by our hospital's readmission collaborative and applied across all subspecialties participating in the collaborative.

All readmissions were assigned a preventability score. The hospital's readmission collaborative used a previously studied Likert scale model with preventability scores ranging from 1 to 5.<sup>6</sup> This model was shown to have good interrater reliability. A readmission was scored a 1 if it was judged to be not preventable. A score 2 was given for readmissions more likely not preventable. A score 3 was given when group members were uncertain on preventability. Readmissions given a score 4 were judged to be more likely preventable. A score 5 was given for readmissions judged to be definitely preventable. We defined a "preventable" readmission as one given a score of 4 or 5. Each review was approached with the mind-set that every readmission was potentially preventable. Examples of items we looked for in chart review to determine preventability included if standard of care was followed, if discharge care plans were appropriate, if there were clear emergency action plans, and if prescriptions were correct.

Data were collected for the day of index discharge, day of readmission, index and readmission length of stay, number of days between initial discharge and readmission, initial admission team, and readmission team. Day of the week information was collected as there is adult literature that patients discharged on weekends are more likely to be readmitted, although this finding has not held up in pediatric studies.<sup>9-11</sup>

**TABLE 1.**  
Definitions of Categories for Readmission

Category	Description	Example
1	Financial/payer issues: readmission caused by financial issues	Insurance refuses to approve a medication prior authorization for a medication patient was already on, leading to patient running out of seizure medication and having seizures requiring readmission
2	Patient activation: responsibility for readmission lies with patient or family	Family is nonadherent to recommended medical treatment, and child has more seizures
3	Discharge care plan: responsibility for readmission lies with hospital care providers	Family discharged but did not understand expected seizure frequency or how to administer a new medication
4	Medication management: readmission caused by medication issue(s)	Medication side effects or toxicity
5.1	Medical plan of care—treatment or complication: readmission caused by complication related to care provided at index encounter	During admission a lumbar puncture is done for evaluation of epilepsy etiology; patient later readmitted with a low-pressure headache
5.2	Medical plan of care—progression of acute disease: readmission caused by evolution of disease present at index encounter or complication of acute disease	A patient with recently diagnosed epilepsy is readmitted with more seizures
6	Uncontrolled advancement of chronic disease: readmission caused by uncontrolled advancement/exacerbation of chronic disease	Patient with known epilepsy goes into status epilepticus
7	Outpatient physician related: readmission due to patient's inability to receive care from physician in the outpatient setting	Patient calls in multiple times with questions or concerns, and provider does not call back, leading to patient coming to the emergency room and being readmitted
8	Scheduled readmission: a readmission that was scheduled or expected at time of the previous discharge	Patient admitted for phase 1 epilepsy surgery evaluation; before discharge known to have an epilepsy surgery date in 3 weeks
9	Unrelated readmission: a readmission that was not scheduled or expected at the time of the previous discharge and is unrelated to the previous encounter	Patient with epilepsy readmitted for cellulitis

### Data analysis

For continuous type variables, such as days until readmission, means and standard deviations were derived. The Wilcoxon rank sum test was used to test group differences for readmission days and boxplots were used to graphically display group-wise distributions. To compare frequencies for readmission days, the chi-square test assuming equal proportions was used. To compare frequencies between paired groups, such as initial neurology team admission versus neurology team readmission, McNemar's test for paired proportions was used. Last, Wilson score confidence intervals were used for individual proportions. No adjustments were made for multiple testing. All analyses were conducted using SAS statistical software, version 9.3 (SAS Institute, Inc., Cary, NC, USA).

### Results

Data were collected from May 1, 2014, to October 30, 2016. During that time there were 2734 admissions for epilepsy, with 219 readmissions from 169 unique patients (38 patients had multiple readmissions), which is an all-cause 30-day readmission rate of 8.0%. Of note, we had an all cause seven-day readmission rate of 3.1% during the same time period.

The most common reason patients were readmitted was progression of chronic epilepsy (readmission category 6), which was 37.0% of readmissions (Table 2). Scheduled readmissions (readmission category 8) were the second highest reason at 21.5%.

Problems with the discharge care plan (readmission category 3) led to 6.4% of readmissions. Examples included not providing clear medication plans, not providing medication refills when discharging over the weekend, discharging before parents being comfortable going home, retrospective feeling from the reviewing team that the patient was discharged too quickly, and not recognizing feeding intolerance. Another example is that multiple patients were discharged before the electroencephalogram (EEG) being read from the epilepsy monitoring unit after undergoing 24-hour monitoring to evaluate for electrical status epilepticus during sleep (ESES). After the EEG was interpreted as showing ESES, each of these patients was readmitted to start treatment.

Problems with medications (readmission category 4) led to 4.1% of readmissions. Examples include several patients with known

nonadherence to recommended medical treatment (including some with open medical neglect cases due to seizure medication nonadherence) and a specialty pharmacy shipping an inadequate dosage of a medication, resulting in readmission until the pharmacy shipped the remaining dosages.

We determined that 21.5% ( $n = 47$ ) of all-cause 30-day readmissions were preventable (scores of 4 or 5) (95% confidence interval 16.5% to 27.4%, Wilson's score exact procedure) (Table 2). The majority, 64.8% ( $n = 142$ ), of readmissions were not preventable (scores of 1 or 2). Of the 18 readmissions deemed definitely preventable (score 5), 11 were readmissions occurring because of the discharge care plan. The second most common reason for definitely preventable readmissions was medication management ( $n = 3$ ).

Of the 29 more likely preventable readmissions (score 4), 19 were due to acute or chronic disease progression. The acute disease progression patients were newly diagnosed with epilepsy, and the readmissions were judged to be preventable due to concern that at the time of index discharge the medications were not yet clearly controlling the seizures or the parents were not yet prepared to manage seizures at home.

Patients who were readmitted were initially discharged across all days of the week (Supplementary Table 1). There was no statistical significance between the day of initial discharge and preventability of future readmissions ( $P = 0.78$ , chi-square with six degrees of freedom). Patients were readmitted on all days of the week (Supplementary Table 1). In terms of preventability, there was no statistical significance between the day of readmission and preventability of the readmission ( $P = 0.38$ , chi-square with six degrees of freedom).

Index admission length of stay ranged from less than 24 hours to 28 days (Supplementary Figure 1). The mean index length of stay was 3.1 days, while the mode was one day ( $n = 74$ ). Readmission length of stay ranged from one day to 53 days (Supplementary Figure 2). The mean readmission length of stay was 4.1 days, while the mode was 1 day ( $n = 68$ ).

Thirty-five percent of readmissions occurred within seven days (Table 3). Of the 21.5% ( $n = 47$ ) of readmissions that were preventable (scores 4 or 5), 61.7% ( $n = 29$ ) were readmitted in zero to seven days. Further analysis showed that time to readmission was shorter for patients with a preventability score of 4 or 5 (mean = 8.5 days, S.D. = 8.2 days), versus patients with a

**TABLE 2.**  
Readmission Category and Preventability Scores

Readmission Category	Total n (Percentage, 95% Confidence Interval)	Score 1 Not Preventable	Score 2 Not Likely Preventable	Score 3 Uncertain	Score 4 More Likely Preventable	Score 5 Definitely Preventable
1 (Financial)	1 (0.5%, too small to calculate)	0	0	0	0	1
2 (Patient)	5 (2.3%, 1.0–5.2)	0	0	1	3	1
3 (Discharge plan)	14 (6.4%, 3.9–10.4)	0	0	1	2	11
4 (Medications)	9 (4.1%, 2.2–7.6)	1	3	1	1	3
5.1 (Index complication)	7 (3.2%, 1.6–6.5)	1	1	2	2	1
5.2 (Acute progression)	21 (9.6%, 6.4–14.2)	2	4	5	10	0
6 (Chronic disease progression)	81 (37.0%, 30.9–43.6)	30	24	18	9	0
7 (Outpatient physician)	2 (0.9%, 0.3–3.3)	0	1	0	0	1
8 (Scheduled)	47 (21.5%, 16.5–27.4)	46	1	0	0	0
9 (Unrelated)	32 (14.6%, 10.5–19.9)	22	6	2	2	0
Total n (percentage, 95% confidence interval)		102 (46.6%, 40.1–53.2)	40 (18.3%, 13.7–23.9)	30 (13.7%, 9.8–18.9)	29 (13.2%, 9.4–18.4)	18 (8.2%, 5.3–12.6)

preventability score of 3 (mean = 11.3 days, S.D. = 7.6 days) or patients whose readmissions we judged were not preventable (score of 1 or 2) (mean = 15.7 days, S.D. = 8.8 days) (Fig). Based on the preventability scores, these three groups were all significantly different from each other with Wilcoxon rank sum *P* values = 0.02 (scores 1 or 2 versus score 3), *P* < 0.001 (scores 1 or 2 versus scores 4 or 5), and *P* = 0.04 (score 3 versus scores 4 or 5).

Seventy percent (n = 153) of epilepsy admissions were initially on the neurology service. Other index services include the epilepsy monitoring unit (26.5%, n = 58), general pediatrics (2.3%, n = 5), and neurosurgery (1.4%, n = 3).

Only 17.2% (10 of 58) of patients in epilepsy monitoring unit were readmitted specifically for epilepsy surgery. Of 219 readmissions 120 (54.8%) were readmitted to the neurology service. Patients initially on the neurology service were more likely to be readmitted to the neurology service (*P* < 0.001, based on McNemar’s test). The next highest services for readmissions were the pediatric intensive care unit with 9.6% (n = 21) and the epilepsy monitoring unit with 9.6% (n = 21). The remaining 57 readmissions were divided among 12 services (endocrine, general pediatrics, gastroenterology, hematology, neurosurgery, orthopedic surgery, otolaryngology, psychiatry, pulmonary, sleep study, surgery, and urology). With the exception of readmissions to the neurosurgery team (which were for postepilepsy surgery problems), the readmissions to these other 11 services were for problems not related to seizures.

**Discussion**

This study found an all-cause pediatric epilepsy 30-day readmission rate of 8.0%. This rate is likely higher than Berry et al.’s rate of 6.9% because our group did not use ICD-9 or ICD-10 codes to exclude scheduled readmissions, which made up 21.5% of this study’s readmissions.<sup>1</sup> We chose to include scheduled readmissions to be internally consistent with the philosophy that all readmissions are potentially preventable.

Berry et al.’s study showed that 71.5% of patients with seizures were readmitted for a neurological problem, and our study found a

similar number, with 72% of patients initially admitted for epilepsy being readmitted to the neurology service, the epilepsy monitoring unit, or to the pediatric intensive care unit for care related to seizures.<sup>1</sup>

By manually reviewing all 219 readmissions over 30 months, the group concluded that 21.5% of all-cause readmissions were preventable. This percentage is similar to the preventability reported by Toomey et al. and Hain et al. in pediatrics.<sup>6,7</sup> Our study demonstrated that the majority of preventable readmissions (61.7%) occurred zero to seven days following index discharge. These are important data to note, as they allow programs to focus on a smaller subset of readmissions.

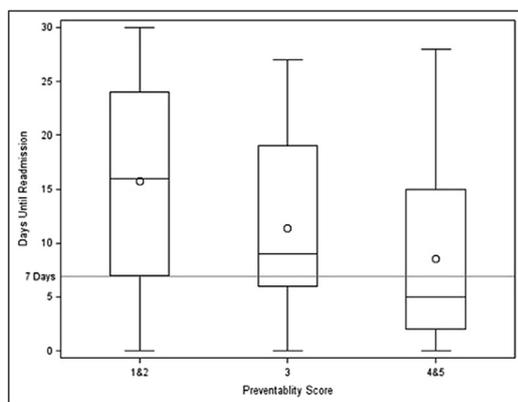
Our results showed that discharge care plan problems led to most of our preventable readmissions. Identifying this, our team worked to improve our discharge process by emphasizing medication reconciliation accuracy, creating discharge instruction templates with clear escalation plans for common pediatric neurology disorders (such as seizures, migraines, infantile spasms, febrile seizures, idiopathic intracranial hypertension, ketogenic diet, and psychogenic nonepileptic spells) and ensuring appropriate health literacy level of discharge instructions.

After recognizing that we had multiple readmissions for ESES, our division changed how EEGs are ordered for suspected ESES. These patients are now scheduled in such a way that if the first night of EEG monitoring shows ESES the treatment is started before discharge home. Since making this change we have had zero patients readmitted for initiation of ESES treatment, which has saved families both money and the burden of a second hospitalization.

Some preventable readmissions were due to medication management problems. Solutions for the problems we noted included verifying prescriptions were filled and picked up before discharge and having families do teach-back education with nursing staff to demonstrate understanding of how to measure and administer medications. The importance of medication accuracy at discharge has been examined in multiple other studies, both pediatric and adult, that have examined the role of pharmacists in the discharge process and how this affects readmission rates.<sup>12–15</sup>

**TABLE 3.**  
Timeline to Readmission

Timeline of Readmission	Total Patients (n = 219) (%)	Preventable Readmissions (Scores 4/5) (n = 47) (%)
In 0–7 d	77 (35.2)	29 (61.7)
In 8–14 d	45 (20.5)	6 (12.8)
In 15–21 d	39 (17.8)	6 (12.8)
In 22–30 d	58 (26.5)	6 (12.8)



Preventability Score 1 and 2: Not preventable or more likely not preventable  
 Preventability Score 3: Undetermined  
 Preventability Score 4 and 5: More likely preventable or preventable  
 ○ represents mean  
 — represents median

**FIGURE.** Box plot of number of days until readmission based on preventability score.

Patients with acute disease progression, who were newly diagnosed with epilepsy, were noted to have a significant number of more likely preventable readmissions. For some of these readmissions, there was concern that at time of index discharge parents were not yet prepared to manage seizures at home. There have been several pediatric studies examining the child and parent perspectives on readmissions and discharges, including how to determine when a family is ready to be discharged and if parents felt a readmission was preventable.<sup>16–18</sup> An overall theme is open communication with families to make sure instructions are clear and that families understand the treatment plan.

Many times children with chronic epilepsy are readmitted for breakthrough seizures, and providers assume it is an unavoidable readmission. However, we found that 11% of these (nine of 81) chronic epilepsy readmissions (category 6, Table 2) were preventable. These data reflect a not insignificant number of readmissions that should not be dismissed.

Our data contradict the assumptions of Allred et al., showing that patients undergoing epilepsy surgery evaluation were the minority of those with epilepsy readmitted and that 21.5% of pediatric epilepsy readmissions were preventable.<sup>8</sup> In our opinion a preventability rate of 21.5% should not be ignored and is a sign that improvements can be made.

In 2015, Horwitz et al. reported on an algorithm for adult all-cause patients that showed that 7.8% of readmissions were scheduled.<sup>19</sup> Our study's manual chart review indicated that 21.5% of pediatric epilepsy 30-day readmissions were scheduled. Our group believes that using ICD-9 and ICD-10 codes is an imperfect way to determine if a readmission is scheduled versus unexpected. ICD-9 and ICD-10 codes are limited as they clump diagnoses together with no nuance for comorbid conditions or extenuating circumstances. In addition, the ICD code used on admission may be different from the code on discharge. We believe these details are why our scheduled readmission rate was higher than an algorithm would perhaps have predicted.

This study is limited by being a single-center study. Members of the team were aware of patient names and at times had provided care for the patients, which could lead to bias. An additional limitation is that a study like this is time consuming and would be difficult to replicate.

Another limitation is that as time has gone on the group has evolved in how it classifies readmissions, specifically the readmission categories. For example, initially all medication readmissions,

regardless of the reason, were considered a readmission category 4. However, as the group learned from readmissions, it felt that medication readmissions due to insurance or prior authorization issues were better classified as a readmission category 1.

A final limitation is that the existence of this study could have influenced practice patterns, as providers in neurology were aware that readmissions were being reviewed. Supplementary Figure 3 demonstrates that with the exception of June 2013 (which was one year before our study starting), all readmission rates before and during the study time period stayed within the confidence limits. However, we acknowledge that without this study readmission rates could have been worse during the same time period, as providers may have practiced more conservatively knowing readmissions were being reviewed.

## Conclusion

We believe that all readmissions are potentially preventable and that it is worthwhile for child neurologists to review readmissions. Focusing on seven-day readmissions should allow providers to examine the majority of preventable readmissions. After completion of the project our group changed its focus and now reviews all pediatric neurology seven-day readmissions, regardless of the index diagnosis. Although a readmission rate of 8.0% seems low, for us it reflected 169 families having the burden of a repeat hospital stay. It is our hope that these data will provide a base from which quality improvement initiatives can be created to reduce pediatric neurology readmission rates.

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## Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pediatrneurol.2018.12.007>.

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