



## Drowning in epilepsy: A population-based case series

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### ABSTRACT

**Objectives:** The risk of drowning is reported to be 15–19 times greater in people with epilepsy compared to the general population. Despite this disproportionate burden, there is limited data about the circumstances surrounding drowning deaths in people with epilepsy. This population-based case series characterizes drowning deaths in people with epilepsy.

**Methods:** Postmortem data from coroner-ordered autopsies conducted in Ontario between 2014 and 2016 were screened for cases of drowning in people with a history of seizures. Demographic information, epilepsy characteristics, and circumstances surrounding death were extracted from post mortem reports. The incidence of drowning in people with epilepsy was calculated using government estimates of the Ontario population and the number of people with epilepsy.

**Results:** Twenty-five people with epilepsy drowned during the three-year study period, giving an estimated incidence of 1.5 per 10,000 epilepsy person-years (95% CI: 0.98, 2.23). Decedents were mostly young (mean age 36 years) and without physical or developmental disability. Approximately one-third had psychiatric comorbidities. Epilepsy severity ranged from well-controlled to drug refractory. Only 3 people had alcohol or illicit drugs detected on toxicological analysis. Forty-four percent of deaths were the result of an unwitnessed drowning in a bathtub.

**Conclusions:** This population-based case series confirms people with epilepsy drown at a rate nearly ten times greater than the general population (1.5 per 10,000 epilepsy person-years compared to the estimated provincial average of 0.13 per 10,000). Drowning deaths in people with epilepsy most often occur in the bathtub. These deaths are only rarely associated with intoxication. People with epilepsy should receive counseling on the increased risk of drowning, including information regarding the significant risk associated with bathtub use, the potential protective roles of anti-epileptic drug (AED) adherence and supervision when in or around water, and the fact that all people with epilepsy remain at an increased risk of drowning regardless of their apparent seizure control.

### 1. Introduction

People with epilepsy are at a 2–3 times greater risk of premature mortality than the general population (Thurman et al., 2017). Drowning is one cause of premature mortality in people with epilepsy and is a potentially preventable cause of death. Based on a 2008 meta-analysis, people with epilepsy have a 15–19 times greater risk of drowning than the general population (Bell et al., 2008), which is evidenced in population-based drowning cohort studies (Peden et al., 2018; Mahony et al., 2017).

While the excess burden of drowning in those with epilepsy is relatively well-documented, information about the circumstances

surrounding death and characteristics of those who died is limited. The only population-based study of drownings in people with epilepsy was conducted between 1981 and 1990 in Alberta, Canada and identified 25 deaths (Ryan and Dowling, 1993). Other studies have been conducted exclusively in children (Diekema et al., 1993; Franklin et al., 2017; Kemp and Sibert, 1993; Orłowski et al., 1982; Pearn, 1977). It is unknown whether these findings describe the general and current epilepsy populations.

To better inform prevention recommendations, a population-based case series was conducted to describe characteristics of epilepsy-related drownings and obtain a current estimate of the incidence of drowning in people with epilepsy.

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## 2. Methods

Case summaries of all autopsies conducted by the Ontario Forensic Pathology Service in Ontario, Canada between January 1st, 2014 and December 31st, 2016 were retrospectively searched for the terms “Seiz-”, “Epilep-”, and “Sz” to identify decedents with a history of epilepsy or seizures. Cases were then reviewed for evidence of drowning or potential drowning, either through the listed cause of death or a history suggesting the death occurred around water. Full post mortem reports of these cases were reviewed. Cases were excluded if the history of seizure did not meet the inclusion criteria for epilepsy, that is if there was no history of recurrent unprovoked seizures, or if there was no evidence of drowning detailed in the post mortem report.

Data was abstracted from the post mortem reports, including basic demographic information, medical history, epilepsy/seizure history, the pathologist’s judgment of the causal and contributing factors to death, circumstances surrounding death, and post-mortem toxicology results. Natural water drownings were further described by water depth, as shallow when the water was less than 12 in. deep and deep when the water depth was 12 in and greater.

The incidence of drowning in people with epilepsy was calculated by dividing the number of observed cases by the estimated number of epilepsy person-years during the study period. Epilepsy person-years was calculated by applying an estimate of the prevalence of epilepsy across all ages from 2010 to 2012 obtained from government survey data (Gilmour et al., 2016) to government census data of the population living in Ontario during 2014–2016 (Statistics Canada, 2016). Confidence intervals (95%) were determined using MedCalc Statistical Software version 17.9.7 (MedCalc Software bvba, Ostend, Belgium; <http://www.medcalc.org>; 2017), assuming the Poisson distribution.

This study was approved by the Hospital for Sick Children Research Ethics Board (REB# 1000034304).

## 3. Results

Thirty-two people with a history of seizures and a death suspicious of drowning were identified based on case history summaries and cause of death. After review of the post mortem reports, 25 cases were considered drowning in an individual with epilepsy as per the pathologist’s interpretation. Of the seven excluded cases, four had no evidence of drowning as per the pathologist’s report and three did not meet epilepsy inclusion criteria (one had provoked seizures and two had seizure histories limited to a single seizure at the time of death). There was no indication in the data reviewed that any of the cases represented intentional drowning.

The estimated incidence of drowning in the general epilepsy population of Ontario is 1.5 per 10,000 people with epilepsy (95% CI: 0.98, 2.23). This was calculated using government survey data that reported a prevalence of active epilepsy of 4.0 per 1000 people (Gilmour et al., 2016), and the summed population in Ontario for each year during the study period of 2014–2016 (total 41,465,200) (Statistics Canada, 2016).

Characteristics of the drowning cohort are described in Table 1. Fourteen (56%) were male. The mean age was 36 years (median age 32, range 12–68). In the 23 cases with information about body habitus three were obese and eight were overweight. About a third (n = 8) had documented psychiatric comorbidities, including schizophrenia, depression, borderline personality disorder, bipolar disorder, and anxiety disorder. Few had documented developmental delays (n = 4; 3 with global delays, 1 with a learning disability) or motor disability (n = 3). Information available from the post mortem reports on seizure frequency and severity was limited. When present, time from last known seizure ranged from 10 days to 2.5 years and seizure severity was described as “relatively well-controlled” to “intractable”. The majority of people were known to be prescribed antiepileptic drugs (AED) (n = 18) and, of these, most (n = 10) were on monotherapy. Twenty-one percent

**Table 1**  
Population Characteristics.

Variable	Category	N = 25	%
Sex	Male	14	56%
	Female	11	44%
Age	< 15	1	4%
	15–24	7	28%
	25–34	6	24%
	35–44	2	8%
	45–54	6	24%
	≥ 55	3	12%
BMI Category <sup>a</sup>	Underweight (< 18.5 kg/m <sup>2</sup> )	1	4%
	Normal (18.5–24.9 kg/m <sup>2</sup> )	11	44%
	Overweight (25–29.9 kg/m <sup>2</sup> )	8	32%
	Obese (> 30 kg/m <sup>2</sup> )	3	12%
	Unknown	2	8%
Co-morbidities	Developmental Delay	4	16%
	Psychiatric Condition	8	32%
	Motor Disability	3	12%
Last Known Seizure	< 1 month	3	12%
	> 1 month to < 2 years	3	12%
	≥ 2 years	2	8%
	Unknown	17	68%
Seizure Severity as Indicated By Pathologist	“Relatively Well-Controlled”	1	4%
	“Intractable”/“Brittle”	2	8%
	No Statement Made	22	88%
Seizure Frequency	≥ 1 per month	2	8%
	Increasing in frequency	1	4%
	“Often”	1	4%
	Unknown	21	84%
Evidence of Craniotomy <sup>b</sup>	Yes	5	21%
AED Therapy	Monotherapy	10	40%
	Polytherapy	5	20%
	On medication, unclear of number	3	12%
	No AEDs	1	4%
	Unknown	6	24%
Reported History of AED Adherence <sup>c</sup>	Adherent	1	4%
	Non-adherent	5	21%
	Not reported	18	75%

<sup>a</sup> One individual was a child and as such growth curves were used instead of BMI calculations. When BMI could not be calculated (n = 2), clear indications of body habitus from autopsy were used as an estimate of BMI.

<sup>b</sup> The one individual who did not receive a full autopsy was not included in this calculation.

<sup>c</sup> The one individual who was not on any AEDs was not included in this calculation.

(n = 5) had evidence of a prior craniotomy. Five people had a reported history of AED nonadherence.

Details of the circumstances surrounding death are presented in Table 2. Eleven (44%) died in the bathtub, and 10 (40%) died in natural water settings. Most deaths were unwitnessed (n = 20, 80%). Six people had evidence supporting a seizure prior to drowning, such as a tongue bite at autopsy or a documented seizure (e.g. video footage from a security camera, witness account). In 12 cases (48%), seizures were described in the post-mortem report as the only contributor to drowning. In 5 cases (20%), seizure, along with another competing potential contributor to the drowning was described by the pathologist, including possible arrhythmia in the setting of heart disease (n = 4), and acute ethanol intoxication (n = 1). In 8 cases (32%), the post-mortem report did not include an acknowledgement that a seizure could have contributed to the drowning. In 4 of these cases, no additional contributing factors to drowning were listed. In the other 4, the report listed factors that may have contributed to death, but were not

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