

Original Article

Patient Safety in Canadian Epilepsy Monitoring Units: A Survey of Current Practices

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ABSTRACT: Background: Guidelines on epilepsy monitoring unit (EMU) standards have been recently published. We aimed to survey Canadian EMUs to describe the landscape of safety practices and compare these to the recommendations from the new guidelines. **Methods:** A 34-item survey was created by compiling questions on EMU structure, patient monitoring, equipment, personnel, standardized protocol use, and use of injury prevention tools. The questionnaire was distributed online to 24 Canadian hospital centers performing video-EEG monitoring (VEM) in EMUs. Responses were tabulated and descriptively summarized. **Results:** In total, 26 EMUs responded (100% response rate), 50% of which were adult EMUs. EMUs were on average active for 23.4 years and had on average 3.6 beds. About 81% of respondents reported having a dedicated area for VEM, and 65% reported having designated EMU beds. Although a video monitoring station was available in 96% of EMUs, only 48% of EMUs provided continuous observation of patients (video and/or physical). A total of 65% of EMUs employed continuous heart monitoring. The technologist-to-patient ratio was 1:1–2 in 52% of EMUs during the day. No technologist supervision was most often reported in the evening and at night. Nurse-to-EMU-patient ratio was mostly 1:1–4 independent of the time of day. Consent forms were required before admission in 27% of EMUs. **Conclusion:** Canadian EMUs performed decently in terms of there being dedicated space for VEM, continuous heart monitoring, and adequate nurse-to-patient ratios. Other practices were quite variable, and adjustments should be made on a case-by-case basis to adhere to the latest guidelines.

RÉSUMÉ : La sécurité des patients dans les unités de surveillance de l'épilepsie au Canada : résultats d'une enquête sur les pratiques courantes. **Contexte :** Les lignes directrices sur les normes relatives aux unités de surveillance de l'épilepsie (USE) ont été publiées dernièrement. L'enquête ici présentée visait d'abord à brosser le tableau des pratiques en matière de sécurité dans les USE, au Canada, puis à les comparer avec les recommandations contenues dans les nouvelles lignes directrices. **Méthode :** Un questionnaire d'enquête, comptant 34 éléments d'évaluation et portant sur la structure des USE, la surveillance des patients, l'équipement, le personnel, l'application de protocoles normalisés et l'utilisation d'outils de prévention des blessures, a été distribué en ligne aux 24 centres hospitaliers dans lesquels les USE appliquaient la surveillance de l'EEG par vidéo (SEV). Les réponses recueillies ont été présentées sous forme de tableau et de résumé descriptif. **Résultats :** Au total, 26 USE ont participé à l'enquête (taux de réponse : 100 %), dont 50 % étaient réservées aux adultes. En moyenne, celles-ci comptaient 23,4 ans d'existence et avaient 3,6 lits. Environ 81 % des répondants ont fait état de l'existence d'une aire réservée à la SEV et 65 %, de lits spécialement réservés à des USE. Si 96 % des USE disposaient d'un poste de surveillance par vidéo, 48 % seulement assuraient une observation continue des patients (par vidéo et/ou présence physique) et 65 % de toutes les unités, une surveillance cardiaque continue. Le ratio technologue/patients était de 1/12 dans 52 % des USE le jour, mais la plupart du temps il n'y avait pas de technologue pour assurer la supervision le soir et la nuit. Quant au ratio infirmière-infirmier/patients dans les USE, il s'établissait en général à 1/14, quel que soit le moment de la journée. Des formulaires de consentement devaient être remplis avant l'admission dans 27 % des USE. **Conclusion :** Tout compte fait, les USE au Canada se comparent relativement bien aux autres services en ce qui concerne les aires réservées à la SEV, la surveillance cardiaque continue et le rapport infirmière-infirmier/patients. Par contre, d'autres pratiques se sont soldées par des écarts importants, et les améliorations à apporter afin de respecter les toutes dernières lignes directrices devraient se faire au cas par cas.

Keywords: Epilepsy monitoring unit; EMU; Safety; Survey; Canada; Seizure detection; Long-term monitoring

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Introduction

Long-term video-EEG (electroencephalography) monitoring (LTVEM) plays an essential role in the evaluation of people with epilepsy (PWE).¹ Undertaken in epilepsy monitoring units (EMUs), LTVEM is used to record seizures for differential diagnosis, classification, and seizure quantification purposes.^{2,3} More specific examples of LTVEM's usage include differentiation between epileptic and non-epileptic events, the classification of patients by seizure type or epilepsy syndrome, and the evaluation of drug-resistant PWE for resective brain surgery.^{2,4}

In the EMU, a combination of strategies is typically used to precipitate seizures so that they may be captured by video-EEG; these strategies include but are not limited to anti-seizure medication tapering, sleep deprivation, and photic stimulation.¹ As seizures of higher frequency and intensity are recorded, the risk of adverse events increases. Though LTVEM is generally regarded as a safe process,¹ the act of precipitating seizures does carry risks for patients' safety. A meta-analysis investigating the safety in adult EMUs and using data from 1968 to 2016 reported an overall pooled adverse event proportion of 7%, with significant inter-study heterogeneity. Seizure clusters were the most common adverse event (18.4%), followed by medication-related events (5.5%), postictal psychosis (1.8%), status epilepticus (1.5%), falls (1.3%), other seizure-related injuries (0.5%), and cardiorespiratory complications (0.04%).⁵ The 2013 MORTEMUS study showed that across 147 EMUs around the world, 16 SUDEP occurred during epilepsy monitoring.⁶ The incidence of SUDEP and near-SUDEP in EMUs was estimated to be 3.7 and 6.0 per 1,000 patient-years, respectively. These studies were primordial in describing the non-negligible safety risks in EMUs, pushing administrators and researchers to investigate measures to improve patient safety. It is now well accepted that EMUs should imperatively follow clear, standardized guidelines to maximize patient safety.⁵

The Working Group of the International League Against Epilepsy (ILAE) and the International Federation of Clinical Neurophysiology (IFCN) have jointly issued guidelines on general EMU practices in December 2021.² These guidelines highlighted various safety recommendations regarding EMU structure, staffing, surveillance, vital sign monitoring, activation procedures, etc.² The last Canadian EMU safety survey was published in 2016 with results suggesting significant inter-EMU heterogeneity in terms of safety practices. This study used an 18-item survey distributed to lead nurses, physicians, and administrators of Canadian EMUs located in urban teaching centers to better understand EMU characteristics and nursing resources. The authors highlighted the variability in nurse-to-patient ratios, nursing skill levels, specialty nursing support, EEG technician availability, and EMU localization and structure across Canadian centers. This survey underlined the need to develop standardized practices, with focus on nursing education and adherence to best practice recommendations.⁷ Previous studies performed in Europe, Israel, the USA, and Canada published before December 2021 have also highlighted critical aspects of patient safety in EMUs and have emphasized the need for safety standards.^{1,3,8-11} As such, the 2021 ILAE/IFCN guidelines are a welcome step towards optimizing and standardizing EMU safety.

In this study, we conducted a survey of Canadian EMUs, collecting data on safety practices and comparing them to the minimum safety standards recommended in the 2021 ILAE/IFCN guidelines.² In comparison with the previous study on Canadian

EMU practices in 2016,⁷ our survey placed added emphasis on the usage of detection systems (supplemented by alarm systems), technologist-to-patient ratios, nurse-to-patient ratios, and the continuous observation of EMU patients, in accordance with the updated 2021 ILAE/IFCN recommendations.²

Methods

The survey was a 34-item instrument built to collect data on current EMU practices in Canada (Table S1). Questions were categorized into six sections. The first section assessed basic characteristics of the EMU, such as hospital name, EMU type (adult vs pediatric), how long the EMU had been active, and the occurrence of deaths in the EMU. The second section evaluated the structure of the EMU, which included questions on the number of beds, the location of the EMU in the hospital, and whether the EMU had designated beds. In the third section, we evaluated whether EMU patients were continuously monitored at all times, either by video or by the presence of a staff member near the bedside of the patient. The fourth section focused on personnel and aimed to identify the technologist-to-patient and nurse-to-patient ratios at different parts of the day as well as if the EMU recommended for its patients the presence of caregivers and family. The fifth section assessed whether EMUs functioned in accordance with specific standardized protocols for adverse events and whether they required patients to sign a consent form. The final section investigated whether EMUs used specific safety measures against injuries. Survey questions were mostly built to reflect the recommendations that were either directly or indirectly stated in 2021 ILAE/IFCN guidelines, although some questions (e.g., basic EMU characteristics) did not purposefully reflect these guidelines and were of more general interest.

The link to the Google Forms-based survey was sent via e-mail to all 24 Canadian hospital centers with EMUs. The EMUs were requested to only have one person (i.e., the EMU medical director) respond as to avoid duplicate data. If a given hospital center had two EMUs (one adult and one pediatric), one survey response was asked for each EMU. The survey was launched on August 18, 2022, when a pilot questionnaire was first sent to EMUs in Quebec. EMU directors across Quebec as well as nursing staff from our hospital provided comments on the structure and content of the survey. The structure and wording of certain questions were changed, although no new items were added to the survey. The questionnaire was then sent to the rest of Canada, and data collection was terminated on December 15, 2022, when all centers had responded. Ethics approval was waived by the University of Montreal Hospital Center institutional research ethics committee due to this project being an audit. Descriptive statistical analyses were performed using R version 4.2.2.¹² Categorical data are presented as count (proportion), and continuous data are presented as mean (standard deviation). Missing data were treated with pairwise deletion.

Results

In total, 26 EMUs from 24 Canadian hospital centers responded to our survey (participation rate of 100%). Table 1 presents the basic characteristics of these EMUs. Briefly, 50% were adult EMUs, and 12% reported a death occurring during LTVEM. On average, EMUs were active for 23.4 years (range of 1 to 65 years) and had 3.6 beds (range of 1 to 11 beds). EMUs were most commonly (42%) integrated in the neurology ward. Most EMUs had a dedicated area in the hospital for LTVEM (81%) and had designated beds (65%).

Table 1: Basic characteristics of Canadian EMUs

EMU characteristic, N = 26	Value
EMU type	
Adult, n (%)	13 (50)
Children, n (%)	12 (46)
Adult and children, n (%)	1 (3.8)
Years of activity, mean (SD) [range]	23 (16) [1–65]
Previous death in the EMU, n (%)	3 (12)
Number of EMU beds, mean (SD) [range]	3.6 (2.7) [1–11]
Patients relocated between day and night, n (%)	1 (3.8)
Ward	
Neurology, n (%)	11 (42)
Pediatrics, n (%)	6 (23)
“Epilepsy”, n (%)	2 (7.7)
Medical/surgery, n (%)	1 (3.8)
Neurology/neurosurgery, n (%)	1 (3.8)
Neurology/cardiology, n (%)	1 (3.8)
Neurosurgery, n (%)	1 (3.8)
Orthopedics, n (%)	1 (3.8)
Pediatric surgery, n (%)	1 (3.8)
Surgery, n (%)	1 (3.8)
Presence of a dedicated area for VEM, n (%) *	21 (81)
Presence of a designated EMU with designated beds, n (%) *	17 (65)
Room type	
Individual, n (%)	14 (54)
Shared, n (%)	7 (27)
Both, n (%)	5 (19)
EMU with epilepsy fellowship program, n (%) **	15 (58)
EMU providing intracranial EEG, n (%)	14 (53)

*Directly pertaining to recommendations from 2021 ILAE/IFCN guidelines.²
 **Information not gathered from survey, but rather from the Canadian League Against Epilepsy fellowship online postings.²⁹
 All 26 EMUs answered the questions presented in this Table; as such, there were no missing data.
 EMU = epilepsy monitoring unit; n = count; N = sample size; SD = standard deviation; VEM = video-EEG monitoring.

Figure 1 displays the number of beds reported by each EMU. Most frequently, EMUs reported having two beds.

Table 2 presents the monitoring characteristics across the 26 EMUs. Briefly, although a continuous video monitoring station was available in most EMUs (96%), staff was only dedicated to continuously monitor the live video feed in 56% of EMUs during the day (85% for adult EMUs and 18% for pediatric EMUs) and 36% of EMUs during the night (54% for adult EMUs and 18% for pediatric EMUs). Out of the 19 EMUs in which there was no continuous supervision of the video recordings all day and night, 32% required a continuous physical monitoring of patients by staff members (86% for adult EMUs and 0% for pediatric EMUs). As such, a total of 13 (50%) EMUs had neither continuous video supervision nor continuous physical supervision of patients, 11 of which were pediatric EMUs. Most EMUs employed continuous heart monitoring (65%), and a bit more than a half did not employ continuous oximetry monitoring (54%). Some EMUs (23%) employed real-time automated seizure detection systems; all were EEG-based. Nurses were dedicated to only EMU patients in 36% of EMUs. Almost all adult EMUs (92%) recommended caregivers to stay with adults with cognitive/behavioral challenges, and almost all pediatric EMUs (92%) recommended caregivers to stay for

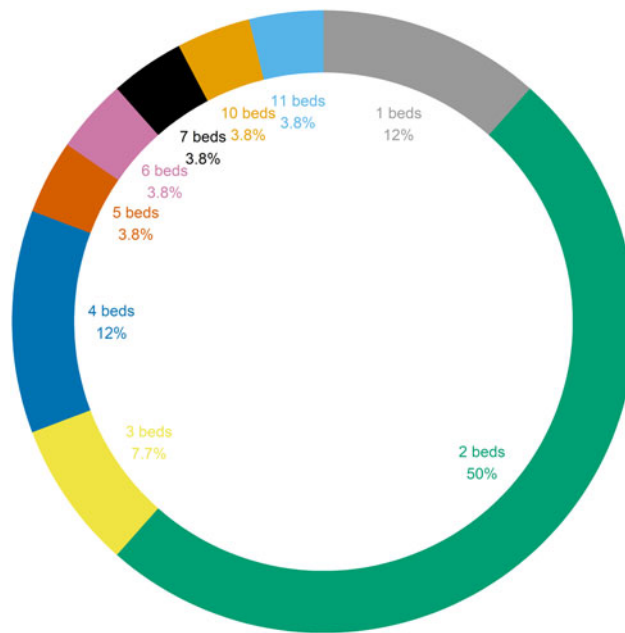


Figure 1: Number of beds per EMU. EMU = epilepsy monitoring unit.

Table 2: Monitoring characteristics of Canadian EMUs

EMU characteristic	Value
Continuous video monitoring station available . . . N = 26	25 (96)
In the day, n (%)	25 (96)
In the night, n (%)	
Staff dedicated to continuous monitoring of video . . . N = 25	14 (56)
In the day, n (%)	9 (36)
In the night, n (%)	
For EMUs in which there is no continuous monitoring of video at one point of the day or night (N = 19), presence of at least continuous physical monitoring of patients, n (%)	6 (32)
Sound turned on at monitoring station, n (%), N = 26	13 (50)
Continuous heart monitoring, N = 26*	11 (42)
All patients, n (%)	6 (23)
Some patients, n (%)	9 (35)
None, n (%)	
Use of alarms for heart abnormalities, n (%), N = 26	7 (27)
Continuous oximetry monitoring, N = 26*	5 (19)
All patients, n (%)	7 (27)
Some patients, n (%)	14 (54)
None, n (%)	
Use of alarms for heart abnormalities, n (%), N = 26	8 (31)
Use of real-time automated seizure detection systems, N = 26*	5 (19)
All patients, n (%)	1 (3.8)
Some patients, n (%)	20 (77)
None, n (%)	
Nurses dedicated only to EMU patients, n (%), N = 25	9 (36)
Caregivers recommended for . . . N = 24*	12 (50)
Adults with cognitive or behavioral challenges, n (%)	12 (50)
All children, n (%)	
When caregivers are recommended . . . N = 22*	19 (86)
Day, evening, and night, n (%)	1 (4.5)
Day and evening, n (%)	1 (4.5)
Day, n (%)	1 (4.5)
Night, n (%)	

*Directly pertaining to recommendations from 2021 ILAE/IFCN guidelines.²
 When a question had a sample size (N) lower than 26, it meant that that question went unanswered by certain centers, therefore yielding missing data.
 EMU = epilepsy monitoring unit; n = count; N = sample size; SD = standard deviation.

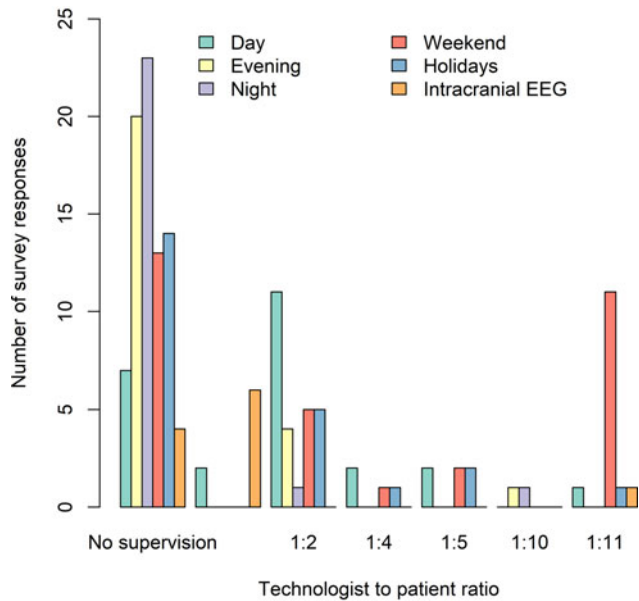


Figure 2: Technologist-to-patient ratio across Canadian EMUs. Out of 26 EMUs, the total number of answers was 25, 25, 25, 22, 23, and 11 for the day, the evening, the night, the weekend, holidays, and intracranial EEG, respectively. EMU = epilepsy monitoring unit.

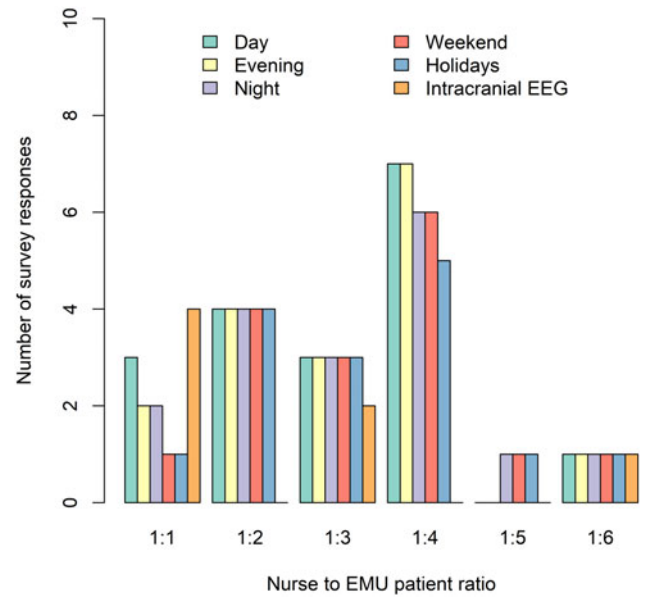


Figure 3: Nurse-to-EMU-patient ratio across Canadian EMUs. Out of 26 EMUs, the total number of answers was 18, 17, 17, 16, 15, and 7 for the day, the evening, the night, the weekend, holidays, and intracranial EEG, respectively. EMU = epilepsy monitoring unit.

children. Caregivers were recommended all day, evening, and night when possible by most EMUs (86%).

Figure 2 shows the various technologist-to-patient ratios across different times of the day and during special scenarios (e.g., intracranial EEG). Only during the day and with patients with intracranial EEG was supervision by technologists more frequent than no supervision. During the evening, the night, the weekends, and on holidays, there was most often no technologist supervision. Figure 3 shows the nurse-to-EMU-patient ratios in a similar fashion. The most frequent nurse-to-EMU-patient ratio was one nurse for four EMU patients, and this held true for all moments of the day, during the weekend, and during holidays. The nurse-to-EMU-patient ratio for intracranial EEG patients was most frequently one to one. Nurse supervision was lower at night, on weekends, and during holidays. Few EMUs had nurses supervise more than four EMU patients at a time. Figure S1 shows the nurse-to-total-patient ratios for 16 EMUs that did not have nurses who were entirely dedicated to EMU patients. Missing data were frequent for survey questions on nurse-to-patient ratios (see Figure 3 and Figure S1 for exact number of missing data).

Figure 4 presents the survey answers to questions on the use of consent form, standardized protocols, and various specific safety measures used by EMUs to mitigate physical harm.

Discussion

Most studies on EMU patient safety practices across the world have shown that these practices were often heterogeneous between centers.^{1,3,7-11} Differences in EMU structure, patient monitoring, staffing, use of standardized protocols, and general safety measures against injuries all contribute to this heterogeneity. Safety is paramount in the EMU, especially given that patients are often weaned off their medication to precipitate seizures. With adverse events occurring in approximately 7% of EMU admissions,⁵ it has become increasingly evident that clear and implementable safety

standards could help homogenize EMU practices and improve overall patient safety. Consequently, the publication of the 2021 ILAE/IFCN clinical practice recommendations, although not only focused on patient safety, was both warranted and important.² In this cross-sectional study, we surveyed Canadian EMUs to (a) collect information on EMU safety practices in a post-COVID era and (b) compare Canadian practices to those in the 2021 ILAE/IFCN guidelines. In doing so, we highlight the heterogeneous nature of safety practices in Canadian EMUs and reinforce the need to improve patient safety by implementing the latest recommendations.

The 2021 ILAE/IFCN guidelines were written in such a way so that certain recommendations could be directly extracted, whereas others could be inferred from the text and the tables.² These recommendations were as follows: (a) the maximal LTVEM technologist-to-patient ratio is one to two, (b) the maximal LTVEM nurse-to-patient ratio is one to four, (c) patient companions during the night are recommended for children and adults with cognitive or behavioral challenges, (d) a dedicated hospital area should be used for LTVEM, (e) there should be a designated EMU, (f) ECG monitoring is recommended, whereas oximetry, extraoculography, and polygraphy are optional, (g) automated algorithms for seizure detection may be used, (h) informed consent should be obtained before LTVEM, and (i) a written, standardized protocol may be used to manage and test patients during seizures.

Concerning staffing, our study emphasized much variability in personnel ratios across Canadian EMUs. These personnel ratios varied according to the time of day, during weekends, during holidays, and for intracranial EEG patients. The ILAE/IFCN recommended a maximum technologist-to-patient ratio of one to two. Although most EMUs respected this ratio during the day, there was most often no technologist supervision in the evening, in the night, during weekends, and during holidays. However, it remains unclear both in the general literature as well as in the 2021

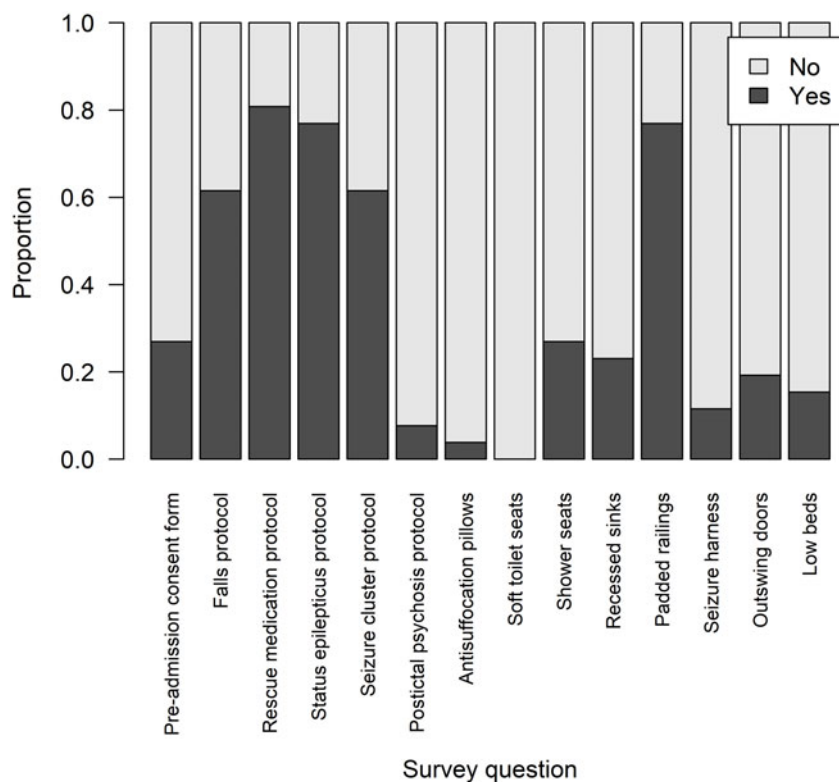


Figure 4: Survey responses to protocol and safety equipment questions across Canadian EMUs. There were no missing data. EMU = epilepsy monitoring unit.

ILAE/IFCN guidelines if 24/7 technologist monitoring is even desirable. Hence, the one to two technologist-to-patient ratio recommended by the ILAE/IFCN may not have necessarily been constructed to be applied to all hours of the day.² The American Society of Electroneurodiagnostic Technologists underlined the role of EEG technologists in patient observation, maintaining of recording integrity (and following of protocols), identification of EEG patterns and activity, and emergency interventions, which reduce risks of undesirable outcomes.^{13,14} Another study, prior to the 2021 ILAE/IFCN guidelines, recommended a technologist-to-patient ratio of one to four.¹⁴ A 2014 revision of practices in EMUs speculated that the lack of continuous and appropriate supervision by both nurses and technicians led to an increase in adverse events.¹⁵ Findings from our survey add to the body of available data on variability in technologist-to-patient ratios, focusing on differences based on the time of day or year. Nevertheless, it is important to note that prior surveys often did not describe technologist availability in terms of technologist-to-patient ratios. The 2016 survey in Canada, for instance, did not include ratios, but instead noted that 67% of adult EMUs provided 24/7 on-call technician support (56% for pediatric) and that 8% had weekend daytime on-call support (33% for pediatric).⁷ This method of presenting data on technologist availability may be more realistic than presenting technologist-to-patient ratios based on the time of day or year, since continuous monitoring by technologists 24/7 would be difficult to implement and is probably rare.

Our survey showed that most Canadian EMUs seemed to follow the ILAE/IFCN recommendations for the optimal maximum nurse-to-patient ratio of one to four. Almost all EMUs had nurses who supervised only up to four EMU patients, whether it be in the day, in the evening, in the night, on the weekend, or on holidays. Nurses supervising intracranial EEG patients mostly only supervised one patient. Nevertheless, a substantial amount of missing data was present in the nurse-to-patient ratio section, with

many EMU administrators responding that they did not have this information. Although missing data affect the validity of our findings on nurse-to-patient ratios, the fact that many EMU medical directors did not know the nurse-to-patient ratio in itself represents an interesting yet worrisome finding. In addition, as many EMUs have nurses who were not dedicated to EMU patients, the nurse-to-patient ratios reported by some centers may not reflect the true number of patients supervised by one nurse, since one nurse could also supervise non-EMU patients. The importance of the nurse-to-patient ratio of one to four has been evaluated in prior studies, in which it is supported that the number of supervising nurses has an impact on both patient supervision and safe patient care in the EMU.¹⁶⁻¹⁸ In fact, it was found that nurses who had to supervise a higher number of patients were less able to quickly attend to seizures and perform dedicated supervision.⁷ As for intracranial EEGs, higher risks of complications and hemorrhage brought the need for a lower nurse-to-patient ratio.^{2,19} Our survey mirrors previous findings on staff-to-patient ratios in the 2016 Canadian survey: most EMUs employed a nurse-to-patient ratio of one to four or less and modified the ratio for invasive monitoring. No changes in this ratio were reported for daytime, nighttime, days of the week, and pediatric versus adult units in the 2016 survey.⁷ The question of optimal nurse-to-patient ratio and technologist-to-patient ratio is extremely relevant in Canada today, given the difficulty many centers face in recruiting new EMU staff members. It is therefore encouraging to see that nurse-to-patient ratio remained more or less unchanged when compared with the 2016 survey.

In our survey, most adult EMUs recommended caregivers for adults with cognitive or behavioral challenges, and most pediatric EMUs recommended caregivers for all children. The 2021 ILAE/IFCN publication recommended caregivers for the aforementioned scenarios,² although one may instinctively support the presence of caregivers for all patients, since caregivers can lessen

reaction time and precipitate the examination of patients by staff members by pushing call buttons at seizure onset.²⁰

Our study showed variability in unit structure across Canadian EMUs. Indeed, most centers reported having a dedicated hospital area for LTVEM, and most (albeit a lesser proportion) of the participating EMUs practiced monitoring from a designated unit with dedicated epilepsy beds. The importance of dedicated hospital areas and designated EMUs was highlighted in the ILAE/IFCN recommendations.² A study done in the UK to characterize the ideal EMU briefly mentioned the role of unit dedication in patient comfort et monitoring effectiveness. In fact, it determined that proximity and availability of oxygen and suction equipment contributed to environment safety by reducing staff response time. The proximity of other surrounding rooms necessary to epilepsy monitoring (e.g., central monitoring or nursing stations) increased both comfort and security as well.²¹ Another study on patient care in pediatric EMUs suggested that installing effective alarm systems and measures against patient injuries (e.g., rails, shower seats, recessed sinks) as EMUs were established would provide better adaptation and a more secure environment.²² The installation of all these pieces of equipment practically requires that the EMU be standalone, with its own reserved beds. Our findings support the notion that unfortunately not all EMUs operate within dedicated areas with dedicated beds, as was also shown in the 2016 Canadian survey.⁷

ECG and oximetry monitoring were used variably across Canadian EMUs. Most EMUs used continuous heart monitoring but did not employ alarms. On the other hand, most EMUs did not use continuous oximetry monitoring. The ILAE/IFCN guidelines, however, do recommend ECG monitoring based on previous studies and suggestions.^{2,9} Serious cardiac abnormalities, including cardiac arrest, can occur during the peri-ictal time frame (postictal arrhythmia being of higher importance), highlighting the important role of heart rate monitoring in the EMU.²³ A 2016 survey on the EPILEPSY network recorded that 96% of EMUs monitored heart rate, although only 17% of European EMUs in 2015 used alarm systems.²³ Thus, Canadian EMUs seem to employ less ECG monitoring than their European counterparts (65% vs 96%), although percentages for the use of alarms for cardiac anomalies remain somewhat similar (31% vs 17%). Although the use of oximetry monitoring is described as optional in the 2021 ILAE/IFCN guidelines, the fact that most EMUs did not use continuous oximetry monitoring is still concerning, especially since postictal respiratory depression is thought to play a role in SUDEP.²⁴

As for seizure detection systems, the 2021 ILAE/IFCN recommendations stated that automated algorithms could be implemented as complementary aid for expert assessment.² Some authors have shown that automated seizure detection software may improve seizure recognition and hasten intervention from nursing staff, positively contributing to patient safety.^{25,26} A 2015 European survey of monitoring practices found that only 8% of EMUs used automatic detection methods for seizure-related movements and 15% for ictal EEG abnormalities.⁸ Similarly, a study on the E-EPILEPSY network practices showed that 19% of EMUs used automatic seizure and spike detection software.¹ On the other hand, a survey of American EMUs found that a 82% of surveyed EMUs used a seizure detection software.¹¹ In our survey, 23% of EMUs reported using a real-time seizure detection software, all of which were EEG-based. Our findings further highlight the heterogeneity of seizure detection system use across Canadian centers as compared to the USA and Europe.

The 2021 ILAE/IFCN guidelines stipulated that informed consent should be obtained before LTVEM and that written standardized protocols should determine appropriate practices (for managing and testing during seizures). On the matter of consent, patients should be properly informed of the purpose, procedures, and risks of LTVEM, and they should ideally formally consent with their signature.²³ The 2021 ILAE/IFCN article did not go into the details on what should be written on the consent form, however. On the matter of protocols, it has been suggested that standardized protocols for managing patients could be beneficial especially in settings in which staff rotations were frequent, but insufficient evidence exists to back these supposed benefits.^{2,15} Our survey showed that most Canadian EMUs did not require patients to fill out consent forms prior to admission, although most EMUs had protocols for managing falls, rescue medications, status epilepticus, and seizure clusters.

Finally, we investigated whether EMU patients were continuously monitored, either by video or physical presence, throughout their stay. Continuous monitoring in this sense was not explicitly recommended in the 2021 ILAE/IFCN guidelines but seemed important to evaluate given previous recommendations on the subject. A 2017 study of UK EMUs recommended that continuous supervision should be performed by direct observation of the patient, along with video monitoring and nurse alarms. Indeed, continuous patient observation maximizes staff interventions during seizures.⁹ A 2016 study showed that 81% of E-EPILEPSY network EMUs employed continuous observation during regular working hours and 63% outside of working hours.¹ We showed in our survey that although almost every EMU had a video monitoring station available all day and night, most EMUs did not have staff dedicated to watch the live feed continuously throughout the day and night. In these EMUs, most did not provide continuous physical monitoring of patients (e.g., staff member observing patient from outside their room). As such, a substantial proportion of EMUs did not provide continuous monitoring of patients, and this phenomenon seemed to be worse at night. It is important to note, however, that most of these EMUs were pediatric EMUs, which may not have necessitated continuous monitoring of patients by staff members because caretakers were required to be onsite. Our survey was not designed to appropriately assess whether a caretaker was present at all times by bedside. The proportion of EMUs without continuous patient monitoring may therefore be inflated by these pediatric EMUs. Nevertheless, once again, although continuous monitoring of patients was not required in the 2021 ILAE/IFCN guidelines, we believe Canadian EMUs should look into improving this area, as there has been evidence that it may improve patient safety and, at least intuitively, early detection of a patient's seizure may lead to quicker interventions. Our group has shown in a previous publication, for instance, that patients who were being continuously monitored by specialized EMU staff during the day benefited from quicker interventions than patients who were being intermittently monitored by less specialized nursing staff during the night.²⁷ This publication did not show, however, that continuous monitoring by specialized EMU staff resulted in lower rates of adverse events.

The most serious adverse event that may occur in the EMU is the death of a patient. Across Canadian centers, three have reported a SUDEP in their EMU. The 2013 MORTEMUS study showed that across 147 EMUs around the world, 16 SUDEP occurred during monitoring, 14 of which were at night.⁶ This study called for enhanced nocturnal supervision to mitigate the risk of

SUDEP. In fact, better general patient supervision, not only at night, may decrease SUDEP risk.²⁸ Nevertheless, the three SUDEP that occurred in Canadian EMUs all occurred in large adult EMUs (none were reported in pediatric EMUs) that have now reported continuously (day and night) monitoring their patients, with nurse-to-patient ratios within the recommended ratio of one to four. A few explanations as to why these SUDEP occurred notwithstanding these levels of supervision may be postulated. Firstly, we do not know exactly when these SUDEP happened; perhaps they occurred when supervision was not as tight, and EMUs strengthened their supervision in reaction to the SUDEP. Secondly, even if an EMU theoretically boasts a 24/7 patient supervision, in practice, staff shift changes and human error may make it so that there are moments in which continuous supervision is broken. If the staff members that ensure this continuous supervision for some reason do not concentrate their attention on the patient (e.g., they are tending to another patient), adverse events such as SUDEP may still occur. EMUs that attempt to ensure continuous supervision should evaluate on a case-by-case basis whether their theoretically continuous supervision holds in practice. In addition, with changes in staff composition, it may be difficult to consistently offer specialized training to all personnel. Finally, with SUDEP being rare, as time goes on, centers may relax their practices; this in turn may predispose to adverse events.

In sum, while this study did not yield data on EEG technologist availability in Canadian EMUs, we suggest that all EMUs review their practices so that technologists may be as available as possible. Furthermore, we would like to stress the importance of abiding by the ILAE/IFCN-recommended nurse-to-patient ratios of one to four (one to one for intracranial EEG patients). Nurses should ideally be “dedicated” to EMU patients; we have shown in our survey that EMU nurses often supervise non-EMU patients, and this practice may have underestimated nurse-to-patient ratios in certain centers. Seeing as several EMU directors were unaware of their unit’s nurse-to-patient ratios, we suggest that EMU directors regularly and actively communicate with their nursing staff for better continuity of care and for audit purposes. We encourage EMUs to recommend caregivers for adults with cognitive or behavioral challenges and for all children, despite 92% EMUs already doing so. Although EMUs should ideally be standalone with dedicated beds, drastically modifying unit structures is not always achievable or warranted. Rather than focus on EMU structure, changes in staffing and equipment seem more feasible and important. EMUs should seriously consider continuous ECG and oximetry monitoring with alarms. Only a minority of Canadian EMUs employ alarms with their ECG or oximetry monitoring. Seizure detection systems may be helpful, although further research should be conducted on these systems to analyze their impact on patient safety and intervention time. EMUs should consider using informed consent forms before patient admission, a seemingly uncommon practice in Canadian EMUs. When possible, standardized protocols for handling certain emergencies can be implemented across EMUs to promote a homogeneous management of adverse events. Finally, we recommend a continuous monitoring of patients, either physically or by video. EMUs should particularly review how monitoring is done at night.

Our study has some limitations. Firstly, some responders were not aware of all their EMU practices (e.g., nurse-to-patient ratio). As such, this study featured some missing data, which were treated with pairwise deletion. Secondly, the 2021 ILAE/IFCN guidelines were not entirely explicit in all their recommendations. A certain level of extrapolation had to be employed to extract the relevant

recommendations, and it is possible that some recommendations may have been missed in the process. Thirdly, we based most of our survey items almost exclusively on the 2021 ILAE/IFCN guidelines. The field of EMU safety is wide-spanning, and a plethora of questions unrelated to these guidelines could have been included in the survey. We chose to use a guidelines-based approach since the adherence of an EMU to these guidelines seemed to be an efficient and easily comparable indicator of the overall safety of EMUs. We believe this approach also helped maximize participation rate, as a lower number of more curated questions made the survey less time-consuming to answer. Nevertheless, in retrospect, many additional topics could have been interesting to explore, the most important being the following: the types and frequency of adverse events, whether EMU directors knew of the new ILAE/IFCN guidelines, the size and exact makeup of the EMU staff, whether nurses and technologists had proper cardiopulmonary resuscitation training, whether nurses were specially trained in epilepsy, the absolute number of technologists screening the recordings, whether the EMU had epilepsy fellows, which person was usually called for emergencies, whether patients were kept over the weekend or holidays, how often the EMU was closed due to hospital overflow, and how patients were tracked during and/or after a seizure. A more in-depth survey not aimed specifically at assessing if centers adhered to ILAE/IFCN guidelines could fill in these knowledge gaps left behind by our current survey.

Conclusion

In conclusion, current practices in Canadian EMUs seem to divert in various areas from the 2021 ILAE/IFCN recommendations. In certain areas, however, Canadian EMUs appear to conform well to these recommendations, for instance in terms of nurse-to-patient ratios, the use of continuous heart monitoring, and the use of caregivers to enhance safety in certain patient populations. We suggest that each EMU evaluate their practices against these guidelines and make necessary adjustments where possible. It must be acknowledged that the ILAE/IFCN guidelines only became accessible in late 2021 and that this review (late 2022) was relatively quick; there is evidently still a lot of time for change.

Supplementary Material. To view supplementary material for this article, please visit <https://doi.org/10.1017/cjn.2023.58>.

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