



Association of adherence to epilepsy quality standards with seizure control



Lidia M.V.R. Moura^{a,*}, Diego Yacaman Mendez^a, Jonathan De Jesus^a, Rogger A. Andrade^a, Joel S. Weissman^{b,c}, Barbara G. Vickrey^{d,e}, Daniel B. Hoch^a

^a Department of Neurology, Massachusetts General Hospital, Boston, MA 02114, USA

^b Center for Surgery and Public Health, Brigham and Women's Hospital, Harvard Medical School, Boston, MA 02120, USA

^c Department of Health Policy and Management, Harvard T Chan School of Public Health, Boston, MA 02115, USA

^d Department of Neurology, University of California, Los Angeles, CA 90095-1769, USA

^e VA Greater Los Angeles Healthcare System, Los Angeles, CA 90073, USA

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ABSTRACT

Objective: We assessed the relationship between adherence to epilepsy quality measures (EQM) and seizure control over 2–3 years in a retrospective cohort study.

Methods: 6150 patients were identified at two large academic medical centers with a primary or secondary diagnosis of epilepsy, were 18–85 years old and seen in outpatient general neurology or epilepsy units between June 2011 and May 2014. Patients were included if: their initial visit was between June 2011 and June 2012, treatment was with ≥ 1 anti-seizure drug, there was ≥ 1 visit per year during the timeframe, and seizure frequency was documented at initial and final visits, yielding 162 patients/1055 visits from which socio-demographic, clinical and care quality data were abstracted. Quality care was assessed as (1) percent adherence to up to 8 eligible EQM, and (2) defect-free care (DFC: adherence to all eligible EQM). Seizure control (SC) was defined as $\geq 50\%$ reduction in average seizures/month between initial and final visits. Chi-square and *t*-test compared care quality with seizure control. Logistic regression was used to assess the relationships between SC, quality of care and subspecialist involvement.

Results: Care quality, reflected by documentation of seizure frequency, addressing therapeutic interventions, and referral to a comprehensive epilepsy center, all exceeded 80% adherence. Care quality as reflected by documentation of seizure type, etiology or syndrome; assessment of side effects, counseling about epilepsy safety and women's issues, and screening for psychiatric disorders ranged from 40 to 57%. Mean EQM adherence across all applicable measures was associated with greater seizure control ($p=0.0098$). DFC was low ($\approx 8\%$) and did not covary with seizure control ($p=0.55$). The SC and non-SC groups only differed on epilepsy etiology ($p=0.04$). Exploratory analysis showed that mean quality scores are associated with seizure control (OR = 4.9 [1.3–18.5], $p=0.017$) while controlling for the effect of subspecialty involvement as a possible confounding variable.

Conclusions: Average quality of care but not defect-free care was associated with seizure control in this retrospective cohort.

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Abbreviations: AAN, American Academy of Neurology; EQM, epilepsy quality measures; SC, seizure control; DRE, drug resistant epilepsy; DFC, Defect Free Care; PHS, Partners Healthcare System; RPDR, Research Patient Data Registry; ASD, anti seizure drug; PI, Principal Investigator; IOM, Institute of Medicine.

* Corresponding author at: Wang 720 Neurology, Massachusetts General Hospital, 55 Fruit Street, Boston, MA 02114, USA.

E-mail addresses: lidia.moura@mgh.harvard.edu, lmoura@partners.org (L.M.V.R. Moura), dymendez@partners.org (D.Y. Mendez), jdejesus5@partners.org (J.D. Jesus), raandrade@partners.org (R.A. Andrade), jweissman@partners.org (J.S. Weissman), bvickrey@ucla.edu (B.G. Vickrey), dhoch@partners.org (D.B. Hoch).

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1. Introduction

There has been substantial interest in the impact of health policy reform on quality of care and patient outcomes (Kaplan and Porter, 2011; McWilliams et al., 2013; Hesdorffer and Begley, 2013). Policy and research alike have aimed to develop evidence-based methods of consistently high quality care for all patients with a given medical condition (Fitzsimons et al., 2012; Kaplan and Porter, 2011; Harden et al., 2009).

In an effort to further these goals in the field of epilepsy, the American Academy of Neurology (AAN) partnered with the American Epilepsy Society to publish the epilepsy quality measures

(EQM) in 2011, and a revised version of these in 2015. EQM are intended to assist clinicians in providing high quality care (Fountain et al., 2015). The current EQM span the spectrum of epilepsy care, including measures of clinical documentation of seizure frequency, type, etiology and syndrome; screening for psychiatric or behavioral health disorders, asking about and intervening in side effects of anti-seizure therapy, personalized safety counseling, and discussion about pregnancy and referral for surgery where appropriate. If proven effective, these measures may be used in pay-for-performance programs and to develop educational programs for care-improvement (Fountain et al., 2015).

Past studies have attempted to address physician's adherence to quality indicators in epilepsy (Cisneros-Franco et al., 2013; Fitzsimons et al., 2013; Hesdorffer and Begley, 2013; Moura et al., 2015; Pourdeyhimi et al., 2014; Pugh et al., 2011, 2007; Veeravigrom et al., 2013; Wasade et al., 2012; Wicks and Fountain, 2012). It remains unclear whether adherence to the EQM leads to improved clinical outcomes for people living with epilepsy.

Our group started to address this question with a retrospective cohort that explored the association of adherence to epilepsy quality measures with one outcome, recommending or prescribing folate to women with epilepsy. The analysis showed that even with strict adherence to a single item in the EQM (annual documentation of women's counseling), the "action" of prescribing or recommending folic acid was frequently omitted (Moura et al., 2015). However, the relationship between adherence to either the original or the revised EQM (Fountain et al., 2011, 2015) and clinical outcomes such as seizure control have yet to be demonstrated empirically.

To quantify these associations, we assessed adherence to EQM in two academic settings where people with epilepsy are seen in general neurology or epilepsy outpatient units. We tested whether quality of care as measured by EQM adherence was associated with seizure control over 2–3 years. We also explored whether the involvement of an epilepsy specialist might account for any association of epilepsy process-of-care quality measures and reduction in seizure frequency.

2. Material and methods

2.1. Participants

The retrospective cohort study used abstraction of medical records. Eligible medical records were identified using the Partners Healthcare Research Patient Data Registry (RPDR), a clinical data registry that aggregates records from sources throughout the Partners Healthcare System (PHS), including the narrative, reporting, laboratory, and administrative systems (Partners Healthcare, 2011). The PHS covers a four-state area and consists of primary care and specialty physicians, community hospitals, managed care organizations, specialty facilities, community health centers, and other health-related entities. Inpatient and outpatient records are collected on every patient in the PHS. Patient's medical records from two PHS academic medical centers, the Brigham and Women's Hospital and the Massachusetts General Hospital, were screened for this study.

Using the RPDR, patients seen in either of the two academic medical centers between June 1st, 2011 and May 31st, 2014 were identified. Each center included both a general neurology clinic and a comprehensive epilepsy center. We used the following inclusion criteria: age 18–85 years, one or more outpatient visits at each medical center, epilepsy as the principal or secondary diagnosis assigned to the visits: ICD-10 code G40 (epilepsy and recurrent seizures) or ICD-9 codes 345.0–345.9 (epilepsy) (Reid et al., 2012; St Germaine-Smith et al., 2012). Partners Healthcare employees were automatically excluded from this query.

2.2. Procedures

The Principal Investigator (PI) trained two research assistants to abstract relevant medical records to code information related to patient demographics, provider, and EQM documentation. When conflicting or incomplete information was encountered, the medical record was discussed and reviewed by the PI. In addition, data reliability was assessed using a random sample of 10% of charts reviewed by each research assistant. Inter-rater reliability revealed a good level of agreement between both research assistants and the PI (kappa above 0.8 for EQM measures 1A, 1B, 2, 3, 6 and 7, and kappa ranging from 0.6 to 0.8 for EQM measures 4 and 5).

2.3. Measurements

Socio-demographic data were abstracted including age at first visit, gender, primary language, race, education level, type of insurance (private vs. public), number of visits for epilepsy care, academic medical center and epilepsy specialist involvement. Neurologists with formal subspecialized training in epilepsy or those working as attending physicians in an epilepsy specialized clinic were considered epilepsy specialists; the academic background information of each neurologist were obtained from the Partners website (Partners Healthcare, n.d.). All other neurologists were classified as general neurologists. Epilepsy specialist involvement was considered present when a neurologist with formal subspecialized training in epilepsy cared for the patient at least once within the study evaluation period (Cheng et al., 2007; Reid et al., 2012).

The medical record abstraction was operationalized for each quality measure based on the 2015 AAN's EQM performance guidelines (8 measures) (Fountain et al., 2015). Quality of care was assessed at the first outpatient visit where epilepsy-related issues were addressed and at all subsequent follow-up visits within a two to three-year follow-up window. These criteria assured that the patient had established care with the provider (Bakaki et al., 2013).

Four epilepsy quality measures were only applicable to patients with a diagnosis of epilepsy with a seizure frequency >0 (EQM 1B), to patients without diagnosis of intellectual disability (EQM 5), to women of childbearing potential (EQM 6) and to patients with intractable epilepsy (EQM 7) and were only included in calculations of adherence in these cases. Other considerations included the required frequency of each measure within the treatment period (i.e. annually vs. every visit). Table 1 details the specifications for each measure (Nolan and Berwick, 2006).

Quality of care was assessed as the mean EQM scores, obtained as the percent adherence to up to 8 EQM that were applicable for an individual patient. In addition, because the Institute of Medicine (IOM) recommends consideration of whether all "critical aspects of care" are achieved (Choi et al., 2014), we derived a binary measure of defect free care (DFC), defined as the adherence to all applicable quality measures within the study timeframe (DFC = 100% adherence to all applicable EQMs, non-DFC = failure to adhere to at least one applicable EQM). This approach has been widely used in the literature (e.g. stroke care) and has excellent sensitivity to inter-provider performance variability (Nolan and Berwick, 2006).

Seizure frequency control was the clinical outcome for our analyses, chosen because epilepsy care aims to achieve reduction in seizure frequency and – ideally – seizure freedom (Choi et al., 2014). Seizure frequency was abstracted at all visits and defined as seizure frequency during the six months preceding the visit.

Seizure frequency control (Seizure Control = SC vs. non-SC) was defined as the proportion of patients who showed a $\geq 50\%$ reduction in seizure frequency between the initial and final visits. This metric has been commonly used to reflect a significant clinical improvement in seizure frequency (Bae et al., 2011; Paquette et al., 2015).

Table 1
Epilepsy quality measures adapted from the AAN's 2014 Epilepsy Update Quality Measurement Set (Fountain et al., 2015).

| EQM # | Numerator (fulfilled measure) | Denominator | Numerator/denominator (percent adherent) |
|---|--|---|--|
| EQM 1A – Seizure frequency | Documentation or description of seizure type in all visits. Documentation of seizure frequency ^a in all visits. Reason not to document (i.e. patient unable to provide information) | All patients | 138/162 (85%) |
| EQM 1B – Seizure intervention | Patient visits where an intervention to reduce seizure frequency ^a was offered/discussed with patient or caregiver. | All patients with a diagnosis of epilepsy with a seizure frequency >0. | 110/113 (97.35%) |
| EQM 2 – Etiology, seizure type, or epilepsy syndrome | Patient visits with seizure type and epilepsy etiology or syndrome documented or where testing was ordered to determine epilepsy etiology, seizure type or epilepsy syndrome. | All patients. | 80/162 (49.38%) |
| EQM 3 – Querying and/or intervention for side effects of anti-seizure therapy | Patients receiving anti-seizure therapy for whom querying about side effects was documented or patients with anti-seizure therapy side effects for whom an intervention was discussed. | All patients with a diagnosis of epilepsy actively receiving anti-seizure therapy. | 86/162 (53.09%) |
| EQM 4 – Personalized epilepsy safety issue and education provided | Patients or their caregivers were provided personalized epilepsy safety issue and education and resources at least once a year. | All patients. | 91/162(56.17%) |
| EQM 5 – Screening for psychiatric or behavioral health disorders | Patient visits where patient was screened for psychiatric or behavioral health disorders. | All patients without a diagnosis of intellectual disability. | 64/158 (40.51%) |
| EQM 6 – Counseling for women of childbearing potential with epilepsy | Female patients or caregivers counseled at least once a year about how epilepsy and its treatment may affect contraception or pregnancy. | All females of childbearing potential (12–44 years old) with a diagnosis of epilepsy. | 36/64 (56.25%) |
| EQM 7- Referral to comprehensive epilepsy center | Patients who were referred for consultation to a comprehensive epilepsy center for additional management of epilepsy. | All patients with a diagnosis of treatment resistant (intractable) epilepsy. | 32/39 (82.05%) |
| Defect Free care DFC ^b | | All patients. | 12/162 (7.41%) |

^a Seizure frequency: Seizure frequency was abstracted at all visits and defined as seizure frequency during the six months preceding the visit.

^b Defect Free Care (DFC) – defect free care (DFC), was defined as adherence to all quality measures within the study timeframe for which the patient was eligible (Yes = adherence to all EQM, No = failure to adhere to at least one EQM).

Clinical characteristics potentially associated with seizure control were also gathered: age at first seizure, types of seizures, epilepsy syndrome and etiology, co-morbidities and baseline history of drug resistant epilepsy (DRE) (Kwan et al., 2010). Psychiatric comorbidities included anxiety, depression, bipolar disorder and previous suicidal attempts. DRE at initial presentation for care was defined as a failure of adequate trials of two tolerated antiepileptic drugs (whether as monotherapy or in combination) to achieve sustained seizure freedom and was assessed at the first visit (Kwan et al., 2010). Duration of epilepsy was calculated as the difference between the age at initial visit and age at first seizure.

2.4. Statistical analysis

Analyses were conducted using STATA/SE version 12.0 (Statacorp, 2013). *t*-Test was used to compare baseline demographic and clinical characteristics between SC and non-SC when the variable was continuous (i.e. age, duration of epilepsy, number of visits for epilepsy care). A chi-square test was used when the variables were categorical (i.e. gender, specialist involvement).

The proportion of adherence to each EQM was calculated (0–100) serving as the continuous independent variable. The proportion of SC vs. non-SC, as defined above, served as the main binary outcome.

A *t*-test examined the relationship of the mean total EQM scores with our dichotomous measure of seizure control. A chi-square test analyzed the relationship between defect free adherence to each quality indicator and the proportion of SC.

In an exploratory analysis, a *t*-test was used to examine the relationship between the mean total EQM scores among epilepsy specialist vs. general neurologist involvement. We used logistic regression with epilepsy specialist involvement as a covariate to explore the relationship between EQM and seizure control. We also

tested whether baseline history of drug resistant epilepsy (DRE) would be a pertinent covariate in the relationship between EQM and seizure control.

2.5. Standard protocol approvals, registrations, and patient consents

This study was conducted under a protocol approved by the Partners Healthcare Institutional Review Board with a waiver of informed consent for the chart extraction.

3. Results

3.1. Descriptive data

Two research assistants independently screened all medical records identified by the RPDR query (6150). 162 medical records were selected for further data abstraction and a total of 1055 clinical notes were reviewed, 5988 medical records were excluded as follows: 72 (1.1%) deceased patients, 3328 (54.1%) patients that had established care (first visit) before June of 2011 or after May 31st of 2012, 1349 (21.9%) patients with unconfirmed diagnosis of epilepsy; 4 (0.06%) that were exclusively seen by other providers (e.g. primary care), 310 (5%) that received care by one of the study investigators. We further excluded 857 (13.9%) patients who did not establish care in either academic medical center (e.g. patients that had less than one visit per year over a three year period), 18 (0.29%) who were not prescribed at least one anti seizure drug (ASD) and, in order to assess the outcome of interest, we excluded 50 (0.81%) patients whose seizure frequency was not documented at either the initial or final visit.

Fourteen physicians treated the 42 patients seen in one site, 9 were epilepsy specialists and 6 were general neurologists. Eighteen

Table 2
Demographic and clinical characteristics of the population according to seizure control.

| Variables/total of unique patients N = 162 (%) | Seizure control | | p-Value |
|---|-----------------|-------------|---------|
| | Yes | No | |
| Mean age at first visit in years (SD) | 38.1 (11.8) | 37.4 (12.2) | 0.70 |
| Gender (%) | 68 | 94 | .98 |
| Female | 37 (54.4) | 51 (54.2) | |
| Male | 31 (45.6) | 43 (45.8) | |
| Language (%) | 68 | 94 | 0.70 |
| English | 64 (94.1) | 87 (93) | |
| Other | 4 (5.9) | 7 (7) | |
| Race (%) N = 159 | 67 | 92 | 0.87 |
| White | 56 (84) | 76 (82.6) | |
| Other | 11 (16) | 16 (7.4) | |
| Education (%) N = 148 | 60 | 88 | 0.70 |
| Secondary education or less | 23 (38.3) | 31 (35.2) | |
| Higher education | 37 (61.7) | 57 (64.8) | |
| Type of insurance (%) | 78 | 94 | 0.76 |
| Private | 45 (58) | 60 (64) | |
| Public | 33 (42) | 34 (36) | |
| Drug resistant epilepsy ^a (%) N = 39 | 13 (19) | 26 (28) | 0.21 |
| Co-morbidities (SD) | 2.3 (2.3) | 2.0 (2.1) | 0.36 |
| Concurrent psychiatric disease (%) N = 55 | 25 (45.5) | 30 (54.5) | 0.54 |
| Duration of epilepsy in years (SD) N = 145 | 13 (12) | 16 (13) | 0.16 |
| Seizure type (%) N = 156 | 68 | 88 | 0.42 |
| Simple partial | 6 (9) | 4 (4.5) | |
| Complex partial | 5 (7) | 7 (8) | |
| Secondarily generalized | 31 (46) | 38 (43.2) | |
| Generalized tonic-clonic | 19 (28) | 25 (28.4) | |
| Absence | 1 (1.5) | 0 (0) | |
| More than one | 5 (7) | 14 (15.9) | |
| Other | 1 (1.5) | 0 (0) | |
| Epilepsy etiology (%) N = 140 | 63 | 77 | 0.04 |
| Symptomatic | 21 (33.3) | 29 (37.6) | |
| Cryptogenic | 30 (47.7) | 22 (28.6) | |
| Idiopathic | 12 (19) | 26 (33.8) | |
| Location (%) | 68 | 94 | 0.86 |
| Academic Medical Center A | 17 (25) | 25 (27) | |
| Academic Medical Center B | 51 (75) | 69 (73.4) | |
| Provider (%) | 68 | 94 | 0.38 |
| Epilepsy specialist | 60 (88.2) | 78 (83) | |
| General neurologist | 8 (11.8) | 16 (17) | |
| Mean number of visits over study observation period (SD) | 6.1 (2) | 6.7 (3) | 0.16 |

^a Drug resistant epilepsy was defined by a failure of adequate trials of two, appropriately chosen, tolerated and taken ASD (whether as monotherapy or in combination) to achieve sustained seizure freedom and was assessed at the first visit.

physicians treated the 120 patients seen in the other site; of these physicians, 12 were classified as epilepsy specialists and 6 were general neurologists.

The distribution of the socio-demographic and clinical characteristics of the sample in relation to the proportion of SC vs. non-SC is shown in Table 2. The SC group (N = 68, 42%) and non-SC group (N = 94, 58%) were comparable in demographical characteristics. The SC group had cryptogenic epilepsy (N = 30, 47.7%) and the non-SC group had symptomatic (N = 29, 37.6%) as the most common etiology, $p = 0.04$.

3.2. Quality measure adherence

Overall levels of quality of care are shown in Table 1. When DFC was not rendered, it was most often due to omission of documentation of epilepsy etiology, seizure type, or epilepsy syndrome, querying and intervention for side effects of anti-seizure therapy, personalized epilepsy safety counseling, care processes specific to women of childbearing potential and screening for psychiatric or

EQM adherence by seizure control

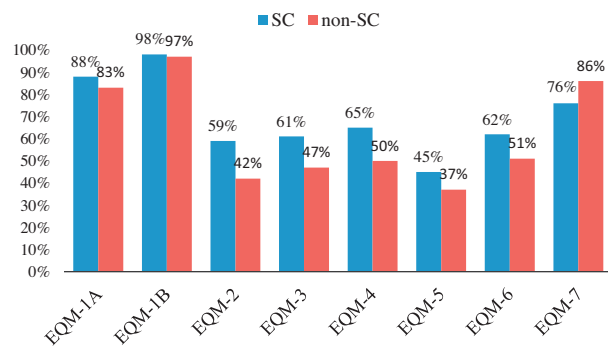


Fig. 1. Epilepsy quality measures adherence by seizure control. Legend: physician's adherence to epilepsy quality measures according to seizure control (SC vs. non-SC). SC: $\geq 50\%$ reduction in seizure frequency between the initial and final visits. Adherence to the EQM 2 was different in the SC group (59%) compared to the non-SC group (42%), $p = 0.04$.

behavioral health disorders (all with adherence rates between 40 and 57%). Overall, we found a high rate of documentation of seizure frequency, epilepsy care intervention and comprehensive epilepsy center referral (all above 82%).

3.3. Association between quality measure adherence and seizure control

A detailed description of adherence to each quality measure according to seizure control (SC vs. non-SC) is provided in Fig. 1 and Table 3. The mean EQM scores were different in the SC (63 SD: 24) and the non-SC groups (52 SD: 28), $p = 0.0098$. The proportions of SC vs. non-SC strictly adherent to EQM (defect free care or DFC) were 8% (CI: 1–15) and 6% (CI: 1–11), respectively ($p = 0.55$).

Exploratory analysis showed that specialty involvement was associated with quality of care as measured by mean EQM, with those 138 patients having epilepsy specialist involvement having mean EQM higher than those 24 patients without epilepsy specialty involvement in their care over the study period (mean EQM = 60 SD: 24 for epilepsy specialty involvement vs. mean EQM = 37 SD: 34 for those without specialty involvement; $p < 0.0001$).

Logistic regression in which specialty involvement was added as a covariate to the modeling of mean overall EQM by seizure control showed that the significant association of epilepsy care quality with seizure control persisted, even adjusting for specialty involvement (OR = 4.9 [1.3–18.5], $p = 0.017$). Additional analysis adding baseline history of drug resistant epilepsy as a covariate continued to show that EQM was still significantly associated with seizure control (OR = 5.1 [1.4–19.2], $p = 0.015$).

4. Discussion

This study examined adherence to the revised epilepsy quality indicators (2015 AAN's EQM 2015) in the establishment of care and suggests that quality of care, measured by documentation of the 8 AAN EQM, was associated with seizure control.

Epilepsy quality measure adherence was similar to that of prior retrospective cohorts and a physician's survey using the previous epilepsy quality measurement set (2011 AAN's EQM) (Cisneros-Franco et al., 2013; Fitzsimons et al., 2013; Moura et al., 2015; Pourdeyhi et al., 2014; Pugh et al., 2011; Veeravignom et al., 2013; Wasade et al., 2012). The greatest adherence has been demonstrated for objective process measures, such as documentation of seizure frequency. Also consistent with the previous studies, patient education and counseling are important but neglected

Table 3
Adherence to epilepsy quality measures according to seizure control^a.

| EQM # | Seizure control ^a | | | | | | | | |
|-----------------------|------------------------------|-----------------------|----------------------|--------|-------------------------|-----------------------|------------------|--------|---------|
| | Yes | | | | No | | | | |
| | # Adherence (numerator) | # Total (denominator) | Percent adherent (%) | 95% CI | # Adherence (numerator) | # Total (denominator) | Percent adherent | 95% CI | p-Value |
| 1A | 60 | 68 | 88 | 80–96 | 78 | 94 | 83 | 75–90 | 0.35 |
| 1B | 49 | 50 | 98 | 93–100 | 61 | 63 | 97 | 92–100 | 0.70 |
| 2 | 40 | 68 | 59 | 47–71 | 40 | 94 | 42 | 32–53 | 0.04 |
| 3 | 42 | 68 | 61 | 50–74 | 44 | 94 | 47 | 37–57 | 0.06 |
| 4 | 44 | 68 | 65 | 53–76 | 47 | 94 | 50 | 40–60 | 0.06 |
| 5 | 31 | 68 | 45 | 33–58 | 33 | 90 | 37 | 27–47 | 0.25 |
| 6 | 17 | 27 | 62 | 43–82 | 19 | 37 | 51 | 34–68 | 0.35 |
| 7 | 10 | 13 | 76 | 50–100 | 22 | 26 | 86 | 69–99 | 0.55 |
| DFC ^b | 6 | 68 | 8 | 1–15 | 6 | 94 | 6 | 1–11 | 0.55 |
| Mean EQM ^c | 68 | 162 | 63 | 57–69 | 94 | 162 | 52 | 46–57 | 0.0098 |

^a Seizure control (SC) was defined as the proportion of patients who showed a $\geq 50\%$ reduction in seizure frequency from the first visit to the last visit within the follow-up period.

^b Defect Free Care (DFC) – defect free care (DFC), was defined as adherence to all quality measures within the study timeframe for which the patient was eligible (Yes = adherence to all EQM, No = failure to adhere to at least one EQM).

^c Mean EQM scores – the proportion of adherence to each EQM was calculated (0–100) serving as the continuous independent variable. The mean EQM scores were different in the SC (63 SD: 24) and the non-SC groups (52 SD: 28), $p = 0.0098$.

aspects of care (Coker et al., 2011; Fitzsimons et al., 2013; Moura et al., 2015; Wasade et al., 2012). While the focus has been to discuss ways to improve adherence to these measures, little is known about the impact of increased adherence to quality outcomes (Moura et al., 2015).

As a secondary finding of this study, even though patients having epilepsy specialist involvement were found to have a mean EQM higher than those patients without epilepsy specialty involvement, both groups received a similar degree of care and had similar seizure control rates. Quality care evaluation and appropriateness of referral patterns in epilepsy remain poorly understood.

As expected, epilepsy etiology was associated with seizure control (i.e. higher likelihood for better seizure control for symptomatic epilepsy) and patients with a history of drug resistant epilepsy (DRE) tended to have worse seizure control over time. These data support prior studies demonstrating that a baseline severity of epilepsy is an independent predictor of worse seizure control (Berg et al., 2010; Choi et al., 2014; De Tisi et al., 2011; Fisher et al., 2014; Kwan et al., 2010).

There are not currently data to provide an accurate estimate of the nature and time course of most seizure disorders and the development of neurological biomarkers is still in its infancy. In this study, the true prevalence of treatment-resistant epilepsy may have been underestimated, due to methodological limitations inherent to a chart abstraction study, including: (1) lack of a prospective assessment of medication compliance; (2) inability to directly verify adequacy of individual drug trials; and (3) an insufficient period of observation to assess outcome.

Although this medical record data abstraction was thorough in an effort to reliably assess adherence to quality indicators and seizure frequency, it remains a single system study (more than one institution within the same geographical region). A larger, multi-institutional prospective study is needed to assess the generalizability of these findings in broader, diverse patient populations and provider settings. It would also enable assessment of associations of these process measures of epilepsy care quality with patient centered outcomes (such as quality of life), outcomes that are frequently not included in quality indicator sets.

Similar to the commonly used definition of incident case of epilepsy for administrative data, we chose to grade the EQM from its review through the first two or three years of epilepsy care within the facilities we included in this study (Bakaki et al., 2013). Therefore, we aimed to achieve a more precise estimate of the quality of

care received by patients in the establishment of care period. Thus, in our method of analysis we may have missed the quality data in subsequent visits (e.g. the physician may have met a criterion at a later year of follow-up). Nonetheless, we believe that we were able to conservatively capture the establishment of care period and determined this time frame allowed for a reasonable assessment of provider compliance. In the near future, the combination of administrative and clinical databases with patient-centered reporting tools may reliably provide longitudinal data. We also note that the assessment of the quality measures and seizure frequency outcome was concomitantly abstracted for the 6 months prior to the final visit in the study period, so quality metrics met in this later portion of the study observation period might not have impacted seizure outcome until a point beyond that period.

The current study excluded 50 patients whose seizure frequency was not documented at either the initial or last visit. This suggests that quality of care as measured by seizure frequency documentation (EQM1A) represents an upper bound of quality care level for that measure.

This study did not capture all possible care processes that might impact seizure control, including consultations outside the Partners Healthcare System or changes in ASD doses, number or regimen. Moreover, we did not include epilepsy education topics that might have had an impact in outcomes, such as documentation of counseling about seizure triggers, social security benefits, health-care management services, insurance issues and counseling about recreational drugs. Still, the data gathered provides a platform for future prospective outcome assessment studies, such as patient perspective of care and quality of life over time. Results of such investigations would yield a more meaningful association between quality of care and outcomes in epilepsy (Choi et al., 2014).

Our study used a select population seen at two centers, each one with a general neurology clinic and a Level Four epilepsy center, as classified by the National Association of Epilepsy Centers (Labiner et al., 2010). We did not include individuals who received epilepsy care exclusively by a primary care provider. While in some regions and countries, the vast number of patients with epilepsy do not receive specialty or subspecialty care (Schiltz et al., 2013), we provide valuable information about adherence to care of high quality in a specialized setting.

Nonetheless, the care in this study's region is coordinated in a way that a patient with epilepsy almost invariably has access to a neurologist involved in their care. In our study, we selected patients

whose specialists functioned as the principal physician for epilepsy care and excluded those cases in which the epilepsy specialist had only a secondary role. This is aligned with the team-based (or value-based) model and is meant to describe the upper bound level of care (Hoch et al., 2013).

5. Conclusions

As current healthcare reforms aim to reward quality of care, it is important to identify which interventions or providers are associated with better outcomes that matter to patients (Fraser et al., 2011). This study defined meaningful seizure control as $\geq 50\%$ reduction in recent seizure frequency. However, in this area of patient-centered outcomes, seizure frequency as the sole outcome may have limited value to patients with persistent or multiple seizures (Fraser et al., 2011). Some authors have suggested that only complete seizure control may significantly improve the quality of life of these patients (Choi et al., 2014).

Ultimately, the measurement of the value of a provider or service, formulated as the ratio of quality or outcomes to cost, has been minimally explored in the field of neurologic care (Dilorio et al., 2006; Elliott and Shneker, 2008; Jarvie et al., 1993). This study provides insights for quality care interventions and related improvement of performance metrics. The findings highlight the unmet need for validated performance metrics in epilepsy, with a focus on patient's perspectives.

Disclosure of conflicts of interest

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