FULL-LENGTH ORIGINAL RESEARCH

The diagnostic test accuracy of a screening questionnaire and algorithm in the identification of adults with epilepsy

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Summary

Objective: **Accurate estimates of the incidence and prevalence of epilepsy allow us to better assess its societal impact. Prevalence and incidence studies often use unvalidated screening tools resulting in estimates of uncertain accuracy. We present the Canadian Longitudinal Study on Aging—Epilepsy Algorithm (CLSA-EA) as well as the results of our validation study designed to estimate the diagnostic accuracy of this epilepsy ascertainment algorithm.**

Methods: **We administered English or French-language versions of the CLSA-EA questionnaire to a consecutive sample of participants from a population-based cohort of 50,000 individuals aged between 45 and 85 years at baseline, as well as a consecutive sample of individuals from an epilepsy-enriched general neurology clinic. Every participant was also assessed by a study neurologist who, blinded to the results of the CLSA-EA, determined whether the person had epilepsy or not.**

Results: **We recruited 242 consecutive participants, 34 of whom were diagnosed with epilepsy by a study neurologist. The sensitivity and specificity of the CLSA-EA for a lifetime history of epilepsy were 97.1% and 98.1%, and for active epilepsy were 100% and 98.6%, when we defined a positive screening test result as a positive response to the antiepileptic drug question and either the single self-report diagnosis or any of the symptom-based questions.**

Significance: **The CLSA-EA was found to have a high sensitivity and specificity for the identification of adults with a lifetime history of epilepsy and active epilepsy. Although validation in other settings and age groups is required, the future application of this algorithm to population-based studies such as the CLSA should help to ensure more accurate estimates of the prevalence and incidence of epilepsy in the general population when a physician assessment is impossible.**

KEY WORDS: **Epilepsy, Epidemiology, Sensitivity, Specificity, Questionnaire.**

Accurate estimates of the incidence and prevalence of epilepsy allow us to better understand the societal impact of this disease, investigate issues surrounding etiology and treatment, and allow for the informed planning of public health policy and services.

There have been important efforts to better understand the descriptive epidemiology of epilepsy.[1] Yet these studies have produced markedly variable estimates of population burden and risk. Prevalence estimates of epilepsy range from 2.2 to 41.0 per 1,000 persons, whereas annual incidence estimates range from 0.2 to 1.1 per 1,000 persons.[1–3] This broad range of estimates is likely due to differences in the prevalence of environmental risk factors (e.g., cysticer-

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cosis), age distribution, disease severity, socioeconomic status, and patterns of health care utilization. Equally as important, the accuracy of disease ascertainment may vary across studies, resulting in discrepancies that are as a result of misclassification of disease status rather than true differences between populations.

The recently launched Canadian Longitudinal Study on Aging (CLSA) is a Canada-wide prospective cohort study that will follow 50,000 participants, aged 45–85 years at baseline, for at least 20 years.[4,5] The CLSA's stated aim is to investigate biologic, social, and psychological aspects of Canada's aging population.[5] Like most large-scale population-based cohort studies, the CLSA relies on a single, self-report question to identify cases of epilepsy: "Has a doctor ever told you that you have epilepsy?" which is asked of all 50,000 participants during their baseline assessment.[4] Currently, to our knowledge, there is no single universally recommended validated tool for the detection of adults with epilepsy in a population-based cohort.

Within the CLSA, a Neurological Conditions Initiative (CLSA-NCI) was initiated with the specific goal to investigate and wherever possible enhance the assessment of Parkinson's disease, dementia, traumatic brain injury, and epilepsy in this nationwide study cohort. As part of the CLSA-NCI, we developed a new disease ascertainment algorithm, the CLSA-Epilepsy Algorithm (CLSA-EA), to identify persons with epilepsy (PWEs) in the CLSA. The purpose of the present validation study was to assess the test accuracy of the CLSA-EA in the identification of persons with a lifetime history of epilepsy as well as persons with active epilepsy in a sample of the CLSA cohort alongside an epilepsy-enriched sample of clinic-based participants.

Methods

Protocol and study report

This was a prospective diagnostic study. A complete study protocol was developed a priori. The Standards for Reporting of Diagnostic Accuracy (STARD) statement and guidelines were followed in preparing the study report.[6,7]

Participants

Participants were drawn from two sources. The first source was a consecutive sample of CLSA participants recruited at the Montreal Data Collection Site (DCS). The Montreal DCS is one of 11 such sites across Canada where local CLSA participants undergo in-depth physical and psychological assessments as well as biospecimen sampling. We recruited subjects who had previously participated in the CLSA pilot study, which had occurred in February and March 2012, as well as regular CLSA study participants who were recruited to, and will be followed at, the Montreal DCS and who underwent their baseline evaluation between August 2012 and June 2013. Detailed methods, including sampling strategy, for the CLSA have been published elsewhere.[4,5] The CLSA inclusion criteria are the following: age between 45 and 85 years, not living in a long-term care institution that provides 24-h nursing care, and the absence of any cognitive impairment that would preclude a person's ability to provide informed consent. We stratified our consecutive sampling procedure by language (English and French) in order to have roughly equal numbers of English- and French-speaking participants.

Preliminary analyses early in the recruitment for the CLSA (analyses conducted only after the initial design of this validation study) suggested that the lifetime prevalence of epilepsy in the CLSA cohort is likely to be quite low. This raised concerns about our ability to complete this validation study within a reasonable time frame and with the available resources. We thus decided to recruit an additional sample of participants from a second source, one which was enriched with PWEs. This second source was consecutive persons followed in an ambulatory general neurology clinic at the Montreal Neurological Institute and Hospital (MNI). The inclusion criteria used to recruit MNI participants were the same as those used for the CLSA.

All data were collected through face-to-face interviews and recorded on standardized data report forms created for the purposes of this validation study. All interviews occurred between May 13 and October 23, 2013. Each CLSA participant received CAD$30 to reimburse any transportation costs incurred by coming to the Montreal DCS. Written and informed consent was obtained from all study participants.

Target condition

We designed a screening questionnaire and disease ascertainment algorithm that would estimate two target conditions: a lifetime history of epilepsy (i.e., people who have ever had epilepsy) and active epilepsy (i.e., people who currently have epilepsy). Based on recent standards from the International League Against Epilepsy (ILAE) Commission on Epidemiology, epilepsy was operationally defined as two or more unprovoked epileptic seizures occurring at least 24 h apart; an individual was considered to have active epilepsy if they reported an epileptic seizure within the last 5 years and/or continued use of antiepileptic drugs (AEDs) for the purpose of seizure prevention.[8]

Index test

The CLSA-EA is presented in Figure 1, and the English- and French-language questionnaire items are presented in Tables 1 and S1, respectively. The exact questionnaire script that was read aloud to all participants during their interview is presented in Appendix S1. We built the CLSA-EA questionnaire upon a previously published nine-item questionnaire developed to estimate the lifetime prevalence of epilepsy.[9] Acceptable answers to each of the items were: "yes," "no," "possible," or "don't know." A response to any of the items was coded as a "positive

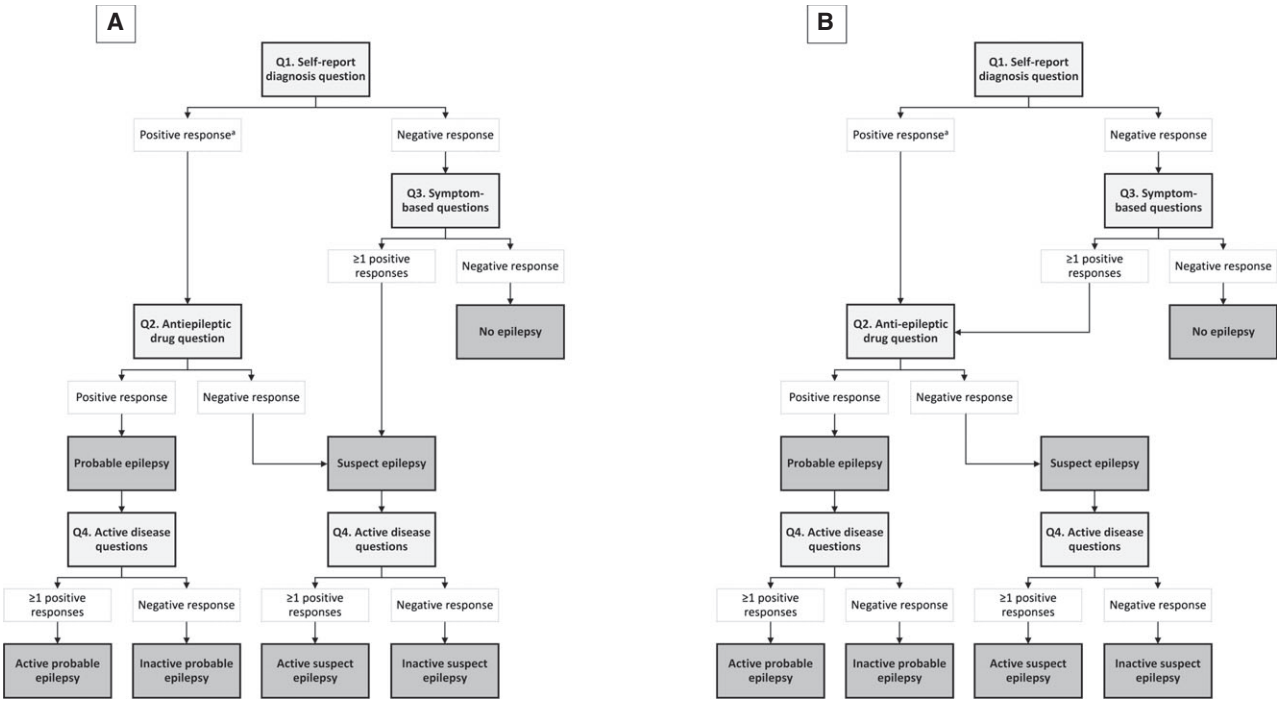

Figure 1.
Canadian Longitudinal Sudy on Aging—Epilepsy Algorithm (CLSA-EA). (**A**) CLSA-EA1. (**B**) CLSA-EA2. Refer to Table 1, Table S1, and Appendix S1 for the CLSA-EA questionnaire items. [a]A response to any of the questions was coded as positive if the respondent answered either "yes" or "possible."

Table 1. English-language screening questions[a]

Q1. Self-reported diagnosis question: [Other than seizure[s] you had because of a high fever], have you ever had, or has anyone ever told you that you had, a seizure disorder or epilepsy?[b,c,d]
Q2. Antiepileptic drugs question: Have you ever taken medications for seizures?[d]
Q3. Symptom-based screening questions[d]
a. Did anyone ever tell you that you had a seizure or convulsion caused by a high fever when you were a child?
b. [Other than seizure[s] you had because of a high fever], have you ever had, or has anyone ever told you that you had, any of the following. . .[c]
i. A seizure, convulsion, fit, or spell under any circumstances?
ii. Uncontrolled movements of part or all of your body such as twitching, jerking, shaking, or going limp?
iii. An unexplained change in your mental state or level of awareness; or an episode of "spacing out" that you could not control?
iv. Did anyone ever tell you that when you were a small child, you would daydream or stare into space more than other children?
v. Have you ever noticed any unusual body movements or feelings when exposed to strobe lights, video games, flickering lights, or sun glare?
vi. Shortly after waking up, either in the morning or after a nap, have you ever noticed uncontrollable jerking or clumsiness, such as dropping things or things suddenly "flying" from your hands?
vii. Have you ever had any other type of repeated unusual spells?
Q4. Active disease questions
a. Have you had a ___ within the last 5 years?[e]
b. Do you currently take medications for seizures?

[a]The questions are in this order for the sake of clarity. Please refer to the CLSA-EA questionnaire script (Appendix S1) to see the actual order in which the questions were asked when interviewing participants.
[b]Acceptable answers to the each of the questions include: "yes," "no," "possible," or "don't know."
[c]Phrase "Other than the seizure[s] you had because of a high fever" added only if the participant responded "yes" or "possible" when asked if they ever had a seizure due to a high fever.
[d]Adapted from Ottman et al.[9]
[e]The symptom(s) to which the participant responded to with "yes" or "possible" in Q1 or Q3 were inserted in the space provided.

response" if the participant answered either "yes" or "possible." In order to also estimate the point prevalence of active epilepsy, we created two new questions and added them to the questionnaire: "Have you had an epileptic seizure within the last 5 years?" and "Do you currently take medications for seizures?"

In large-scale, population-based prevalence studies, a maximally sensitive screening tool (sensitivity is estimated by the proportion of cases that screen positive) is generally preferable to avoid underestimation, whereas a second stage of more resource-demanding screening limits overestimation. In resource-limited settings where a second screen is impractical, investigators may favor a maximally specific screening tool (specificity is estimated by the proportion of controls that screen negative). In an attempt to address these competing demands, we designed two separate screening pathways within the CLSE-EA: one that leads to the identification of "probable epilepsy" and another that leads to the identification of "suspect epilepsy" (Fig. 1). We defined a priori two definitions of a "positive screen": (1) those who screened as either probable or suspect epilepsy (in order to create a maximally sensitive "positive screen"); and (2) those who screened as probable epilepsy only (in order to create a maximally specific "positive screen").

Although the initial disease ascertainment algorithm was designed to achieve extremes in sensitivity and specificity, we also explored different definitions of "probable epilepsy" in an attempt to achieve a greater balance between sensitivity and specificity. The initial algorithm that used the more restrictive definition of "probable epilepsy" (designed to achieve extremes in sensitivity and specificity), is heretofore referred to as CLSA-EA1. The second algorithm that included a more inclusive definition of probable epilepsy (designed to achieve a greater balance between sensitivity and specificity) is heretofore referred to as CLSA-EA2. In summary, with the CLSA-EA1, only those participants who gave a positive response to the self-report epilepsy diagnosis question and the AED question were coded as "probable epilepsy," whereas those who gave a negative response to the self-report epilepsy diagnosis question but then gave a positive response to any of the symptom-based questions were coded as "suspect epilepsy." With the CLSA-EA2, unlike the CLSA-EA1, participants who gave a negative response to the self-report epilepsy diagnosis question but a positive response to any one of the symptom-based questions as well as a positive response to the AED question were also counted as "probable epilepsy." The differences between the CLSA-EA1 and CLSA-EA2 are graphically illustrated in Figure 1.

To create the French-language version of the questionnaire, the original English-language questionnaire was translated into French by a professional translator with extensive experience in epidemiologic questionnaires. This French-language version was then back-translated into English by another professional translator, blinded to the original English-language version and compared to the original English-language version by one of the bilingual study investigators (MK) to ensure the accuracy of the French translation. This strategy is recommended for instrument translation in cross-cultural research.[10]

The CLSA-EA questionnaire was administered to every participant by three research assistants, all of whom had prior training and experience in research methods and data collection. None of the research assistants had medical, para-medical, or nursing background in order to minimize the risk of interviewer bias.[11,12] The research assistants attended a training session with the study's principal investigator (MK) to review the study protocol and to ensure standardized administration of the questionnaire items and further minimize interviewer bias. Among the CLSA participants, the questionnaire was administered no more than 30 min prior to the reference standard. Among the MNI participants, the questionnaire was administered no more than 30 min after the reference standard. To further minimize the risk of interviewer bias and consequent inflated sensitivity and specificity estimates, the MNI research assistants were blinded to the results of the reference standard. Blinding was ensured by purposefully recruiting MNI patients irrespective of whether they had epilepsy.

Reference standard

It should be noted that we have intentionally avoided use of the term "gold standard," since this is generally reserved for a reference standard that is error-free,[13] something that arguably does not exist for epilepsy.

For the CLSA participants, the reference standard was a standard clinical interview and neurologic physical examination, done by one neurologist, a fellow of the Royal College of Physicians and Surgeons of Canada and who has a primary clinical interest in epilepsy (MK). For the MNI participants, their usual treating neurologist, who previously completed an epilepsy fellowship and has >20 years of experience as an epileptologist attached to the epilepsy service at the MNI (MV), administered the reference standard. Both assessors were blinded to the results of the index test. Epilepsy, as defined by the ILAE, is a disease defined by clinical criteria and tests such as EEG and MRI are neither required nor sufficient to make the diagnosis.[14] Previous epilepsy validation studies have similarly relied on clinical history and examination as their reference standard.[15–17]

The clinical interview records and results of the neurologic exam of a sample of CLSA participants were selected and reviewed by a third neurologist (NJ) who previously completed an epilepsy fellowship and has nearly 10 years of experience as an epileptologist attached to the epilepsy service at the University of Calgary. These reviewed participants included all of those diagnosed with epilepsy or a history of other epilepsy-related events (single unprovoked seizure or febrile seizure), as well as a random sample of 20 participants without epilepsy.

If applicable, the epilepsy type was recorded as per the 2010 ILAE etiologic classification scheme for epilepsies.[18]

In addition, indicators of epilepsy severity were recorded (number of AEDs, mean seizure frequency, any history of intracranial EEG monitoring or epilepsy surgery).

Statistical methods

Sensitivity and specificity estimates were calculated. The Wilson method was used to calculate 95% confidence intervals (CI) for each validity parameter.[19] Analyses were stratified by interview language to assess for any heterogeneity. Comparisons of the sensitivity and specificity parameters within the same population (i.e., matched pairs) undergoing different index tests were assessed with McNemar's test.[20,21] Pearson's chi-square test was used to test for heterogeneity of sensitivity and specificity between English-speaking and French-speaking participants. The significance level was set at 5%. Kappa was estimated to assess the interrater agreement between the primary assessor (MK) and the reviewing assessor (NJ).

Positive and negative predictive values (PPVs and NPVs) were calculated using the following formulas:

$$\mathrm{PPV} = (\text{sensitivity})(\text{prevalence}) / [(\text{sensitivity})(\text{prevalence}) + (1 - \text{specificity})(1 - \text{prevalence})]$$

$$\mathrm{NPV} = (1 - \text{sensitivity})(\text{prevalence}) / [(1 - \text{sensitivity})(\text{prevalence}) + (\text{specificity})(1 - \text{prevalence})]$$

The PPV and NPV estimates were calculated using three different methods: the prevalence of epilepsy in our study cohort, assuming a lifetime prevalence of epilepsy equal to 1% and 2%, or a point prevalence of active epilepsy equal to 0.5% and 1%, based on previous reports.[1,22]

All statistical analyses were carried out using STATA/SE, version 12.0 (StataCorp LP, College Station, TX, U.S.A.).

This study was reviewed and approved by the Research Ethics Office (institutional review board [IRB]) of McGill University.

Results

The STARD flow diagram is presented in Figure 2. Of the 328 individuals identified for recruitment, 44 were ineligible because they either could not be reached by telephone or were not available to be interviewed within the time frame of this study. Of these 284 eligible individuals, 242 (85.2%) agreed to participate. There were no missing data or any indeterminate index test or reference standard results. There was perfect agreement in the identification of participants with and without epilepsy between the primary assessor (MK) and the reviewer (NJ) ($\kappa = 1.0$).

The participant characteristics are presented in Table 2. The mean age of participants with a lifetime history of epilepsy was 58.9 (standard deviation [SD] 8.9) years and 20 (58.8%) were women. Among those without epilepsy, the mean age was 64.5 (SD 9.3) years and 130 (62.5%) were women. Furthermore, of the 34 participants with a lifetime history of epilepsy, the etiology was presumed to be genetic/idiopathic in 4 (11.8%), structural/symptomatic in 23 (67.6%), and unknown/cryptogenic in 7 (20.6%). Eighteen participants (52.9%) with a lifetime history of epilepsy had not had seizures within 12 months of their interview, 20 (58.8%) were on a single AED, and 8 (23.5%) had previously undergone invasive intracranial electroencephalography recordings or epilepsy surgery. Among those with active epilepsy (n = 33), the mean number of epileptic seizures per annum was 7.8 (SD 21.5).

The diagnostic accuracy of the CLSA-EA is presented in Table 3, with the complete raw data presented in Tables 4 and S2. As expected, the sensitivity of CLSA-EA1 for a lifetime history of epilepsy was much greater when a screen positive was defined as either probable or suspect epilepsy compared to probable epilepsy alone (97.1% vs. 73.5%; percent difference 23.5, 95% CI 0.1–40.7), whereas the reverse was true for the specificity (60.6% vs. 99.5%; percent difference −38.9%, 95% CI −46.0, −31.8). On the other hand, although the specificity of CLSA-EA2 similarly increased with the more specific definition of a screen positive (60.6% vs. 98.1%; percent difference −37.5%, 95% CI −44.6, −30.4), the sensitivity of the screening tool was unchanged (97.1% vs. 97.1%; percent difference 0%, 95% CI −2.9, 2.9). The findings were similar when active epilepsy was investigated (Table 3).

There was no evidence of language-based differences in the sensitivity or specificity of the CLSA-EA1 in the identification of persons with a lifetime history of epilepsy or active epilepsy (sensitivity for the lifetime history of epilepsy: $p = 0.5123$; specificity for the lifetime history of epilepsy: $p = 0.4287$; sensitivity for active epilepsy: $p = 0.2660$; specificity for active epilepsy: $p = 0.0915$).

The estimated sensitivity and specificity of the single self-report diagnosis questionnaire item (when used without the AED or symptom-based questions) in identifying those with a lifetime history of epilepsy were 73.5% (95% CI 56.9–85.4) and 99.0% (95% CI 96.6–99.7), respectively.

The PPV of the CLSA-EA, assuming a 1% lifetime prevalence of epilepsy and a 0.5% point prevalence of active epilepsy, ranged from 1.7% to 100%, whereas the NPV was consistently >99.7% (Table 3). Additional PPV and NPV estimates, calculated using the "natural" prevalence of epilepsy in our cohort as well as assuming a number of hypothetical epilepsy prevalences, are presented in Table S3.

Discussion

We examined several different formulations of the CLSA-EA in this validation study. The CLSA-EA2, with a "positive screen" defined as probable epilepsy alone, produced the highest overall diagnostic test accuracy for a

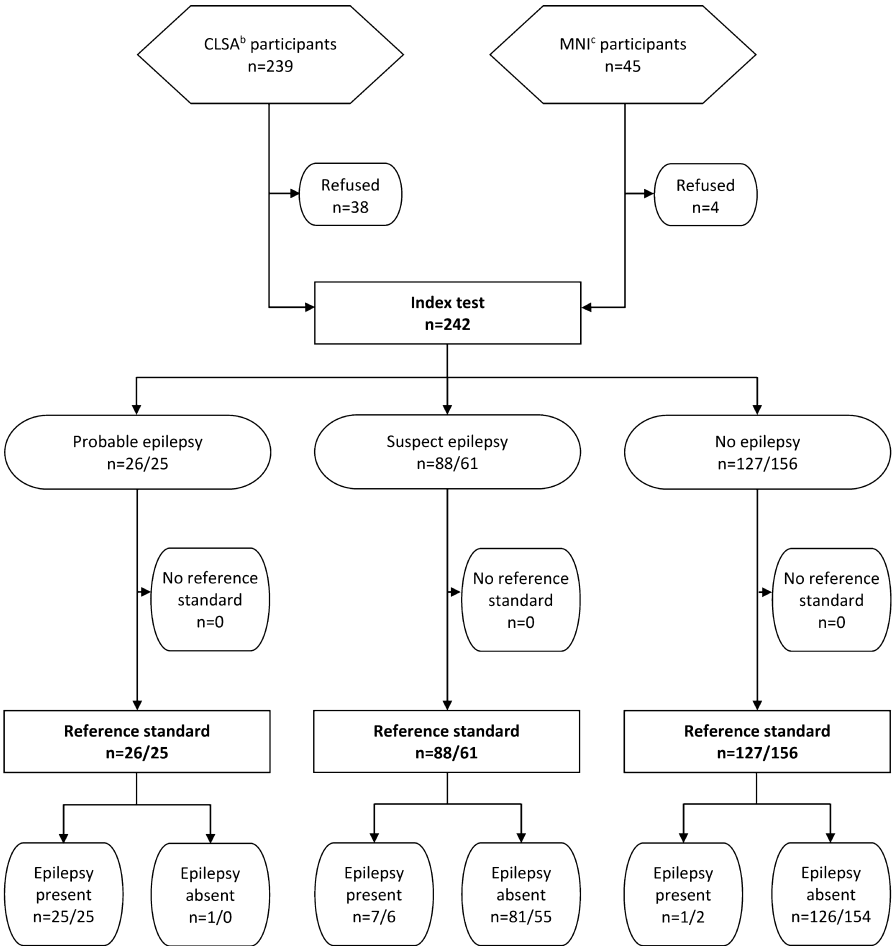

Figure 2.
STARD flow diagram. [a]When applicable, counts are presented as: n (lifetime history of epilepsy)/n(active epilepsy). [b]CLSA, Canadian Longitudinal Study on Aging. [c]Montreal Neurological Institute and Hospital.
Epilepsia © ILAE

lifetime history of epilepsy (sensitivity = 97.1%; specificity = 98.1%) as well as for active epilepsy (sensitivity = 100.0; specificity = 98.6%). In comparison to the single self-report diagnosis question (with a reported sensitivity of 73.5%) this translates into an estimated 120 fewer missed cases of epilepsy (false negatives) of a total of 500 cases, if both screening tools were applied to the 50,000 participants of the CLSA and assuming that the true lifetime prevalence of epilepsy is 1%.

In most applications, the screening test with the highest sensitivity is preferred, ensuring that no cases of epilepsy are missed. In situations where it is more important to ensure there are few false positives, it may be most appropriate to use a test with the highest specificity, which translates into a high PPV. The data presented in Tables 3 and S3 demonstrate how even small changes in specificity have a great impact on the PPV when testing for a relatively rare condition such as epilepsy.

Overall, the CLSA-EA offers several advantages over previously published disease ascertainment algorithms. First, the CLSA-EA is to our knowledge the only disease ascertainment algorithm for epilepsy that maintains both a sensitivity and specificity >97% unlike all others where any increase in sensitivity is at the expense of specificity[9,15–17,23–25] (or vice versa). Second, the CLSA-EA distinguishes between individuals with a lifetime history of epilepsy and those with active epilepsy, whereas the majority of other screening tools measure only the former,[9,15,17,24] which is generally of less clinical interest.[8] Third, the CLSA-EA is the only screening tool to our knowledge that has been validated to be used in a French-speaking population. Finally, 96.2% (200 of 208) of participants without a lifetime history of epilepsy were a consecutive sample of a population-based cohort, resulting in a specificity estimate that is unlikely to be affected by spectrum bias and estimate overestimation. This is in contrast to previous validation studies that relied exclusively on clinic-based cohorts.[17,23–25]

Given the potentially low prevalence of epilepsy within the CLSA and our relatively limited resources, 97.1% (33 of 34) of participants with a lifetime history of epilepsy were recruited from a general neurology clinic, introducing possible selection bias and inflated sensitivity estimates. Sixty-seven percent of epilepsy cases were structural/symptomatic, which may be high relative to what is found in the general population, although a recent review reported that some

Table 2. Participant characteristics

	Total (n = 242)	Epilepsy[a] (n = 34)	No epilepsy (n = 208)
Age (years)[b]	63.7 (9.4)	58.9 (8.9)	64.5 (9.3)
Sex[c]			
Male	92 (38.0)	14 (41.2)	78 (37.5)
Female	150 (62.0)	20 (58.8)	130 (62.5)
Language of the interview[c]			
English	112 (46.3)	10 (29.4)	102 (49.0)
French	130 (53.7)	24 (70.6)	106 (51.0)
Highest level of education[c]			
No high school diploma	12 (5.0)	3 (8.8)	9 (4.3)
High school diploma only	23 (9.5)	9 (26.5)	14 (6.7)
Postsecondary education but less than bachelor's degree	78 (32.2)	12 (35.2)	66 (31.7)
Bachelor's degree only	75 (31.0)	5 (14.7)	70 (33.7)
University degree or certificate above bachelor's degree	54 (22.3)	5 (14.7)	49 (23.6)
Household income (Canadian dollars)[c]			
<20,000	20 (8.3)	4 (11.8)	16 (7.7)
20,000–<50,000	65 (26.9)	12 (35.3)	53 (25.5)
50,000–<100,000	93 (38.4)	9 (26.5)	84 (40.4)
100,00–<150,000	33 (13.6)	5 (14.7)	28 (13.5)
≥150,000	21 (8.7)	2 (5.9)	19 (9.1)
Don't know or refused	10 (4.1)	2 (5.9)	8 (3.8)

[a]Diagnosed with a lifetime history of epilepsy.
[b]Mean (SD).
[c]n (%).

studies, many done before magnetic resonance imaging (MRI) was widely available and in cohorts much younger than our own, have reported that up to 40% of epilepsies in the general population may be related to a known structural brain lesion.[1] The proportion of epilepsy participants who were seizure-free in the last year as well as the proportion on drug monotherapy in our study are comparable to previously reported population-based cross-sectional studies.[26] In addition, our reported sensitivity of 73.5% for the single self-report diagnosis question and 73.5% for the CLSA-EA1 (probable only) are similar to the 76.2% and 69.6% reported by Ottman et al.[9] where the identical questions were applied to a population-based cohort. These similarities suggest that any improvement of the CLSA-EA over the Ottman et al. questionnaire is as a result of our disease ascertainment algorithm rather than selection bias. The high proportion of participants whose epilepsy was still active may have biased the sensitivity estimates for the identification of persons with a lifetime history of epilepsy but should have had no impact on the sensitivity estimate for the identification of persons with active epilepsy.

Another possible limitation of this validation study was our modest sample size of 242 participants. That said, the CIs for our sensitivity and specificity estimates are relatively narrow, reflecting the relatively high precision of our estimates, which suggests that our sample size was sufficiently large to mitigate against the potential effect of random error. Finally, the CLSA-EA includes 13 questionnaire items. We acknowledge that this number of questionnaire items may prove to be a practical limitation in certain studies. In our experience the entire questionnaire may be administered by an experienced interviewer in <10 min.

This validation study was conducted in Montreal, Canada, in two consecutive samples of people aged 45–85. We

Table 3. Diagnostic accuracy and predictive value of the CLSA-EA

	Sensitivity (95% CI)	Specificity (95% CI)	Sensitivity and specificity comparisons[a]	PPV[b]
Lifetime history of epilepsy				
CLSA-EA1[c] (probable or suspect)	97.1 (85.1–99.5)	60.6 (53.8–67.0)	vs. CLSA-EA1 (probable only) 23.5 (6.3, 40.7); −38.9 (−46.0, −31.8)	2.4
CLSA-EA1 (probable only)	73.5 (56.9–85.4)	99.5 (97.3–99.9)	vs. CLSA-EA2 (probable only) −23.5 (−40.7, −6.3); 1.4 (0.7, 3.5)	59.8
CLSA-EA2[d] (probable or suspect)	97.1 (85.1–99.5)	60.6 (53.8–67.0)	vs. CLSA-EA1 (probable or suspect) 0.0 (−2.9, 2.9); 0.0 (−0.5, 0.5)	2.4
CLSA-EA2 (probable only)	97.1 (85.1–99.5)	98.1 (95.2–99.2)	vs. CLSA-EA2 (probable or suspect) 0.0 (−2.9, 2.9); 37.5 (30.4–44.6)	34.0
Active epilepsy				
CLSA-EA1 (probable or suspect)	90.9 (76.4–96.9)	73.2 (66.8–78.8)	vs. CLSA-EA1 (probable only) 15.2 (0.1–30.4); −26.8 (−33.3, −20.3)	1.7
CLSA-EA1 (probable only)	75.8 (59.0–87.2)	100 (98.2–100.0)	vs. CLSA-EA2 (probable only) −24.2 (−41.9, −6.6); 1.4 (−0.7, 3.5)	100
CLSA-EA2 (probable or suspect)	100 (89.6–100.0)	73.2 (66.8–78.8)	vs. CLSA-EA1 (probable or suspect) −9.1 (−21.9, 3.7); 0 (−0.5, 0.5)	1.8
CLSA-EA2 (probable only)	100 (89.6–100.0)	98.6 (95.9–99.5)	vs. CLSA-EA2 (probable or suspect) 0 (−3.0, 3.0); 25.4 (19.0–31.7)	26.4

[a]Comparisons reported as: sensitivity difference (95% CI); specificity difference (95% CI).
[b]Positive predictive value calculated assuming a 1% lifetime prevalence of epilepsy and 0.5% point prevalence of active epilepsy.
[c]Canadian Longitudinal Study on Aging — Epilepsy Algorithm 1.
[d]Canadian Longitudinal Study on Aging — Epilepsy Algorithm 2.

Table 4. Number (%) of participants who responded "yes" or "possible" to specific questions

	Lifetime history of epilepsy (n = 34)	Active epilepsy (n = 33)	No history of epilepsy (n = 208)
Q1. Self-reported diagnosis	25 (73.5)	25 (75.8)	6 (2.9)
Q2. Antiepileptic drugs	31 (91.2)	30 (90.9)	8 (3.8)
Q3a. Febrile convulsion	5 (14.7)	5 (15.2)	8 (3.8)
Q3b i. Fit or spell	28 (82.4)	28 (84.8)	14 (6.7)
Q3b ii. Shaking or going limp	25 (73.5)	25 (75.8)	44 (21.2)
Q3b iii. Spacing out	26 (76.5)	26 (78.8)	14 (6.7)
Q3b iv. Daydream or stare	13 (38.2)	12 (36.4)	25 (12.0)
Q3b v. Flickering lights	11 (32.4)	11 (33.3)	28 (13.5)
Q3b vi. "Flying" from your hands	8 (23.5)	8 (24.2)	17 (8.2)
Q3b vii. Repeated unusual spells	12 (35.3)	12 (36.4)	21 (10.1)
Q4a. Last 5 years	22 (64.7)	22 (66.7)	58 (27.9)
Q4b. Current medications	32 (94.1)	33 (100.0)	5 (2.4)

suspect that our results are generalizable to other English- or French-speaking adult populations in high-income countries, although replication studies confirming this would be helpful. That said, we would strongly recommend additional validation studies before the CLSA-EA is used in certain populations where one would reasonably expect its performance to be different from our cohort such as among children or in low-income countries.

We have presented a questionnaire and disease ascertainment algorithm that appears to be both highly sensitive and specific for the identification of persons with a lifetime history of epilepsy as well as active epilepsy. Such a screening tool is important to ensure accurate estimates of prevalence and incidence in large population-based studies in which physician assessment is not feasible. Plans are underway to apply the CLSA-EA to all 50,000 participants in the CLSA cohort. This questionnaire and algorithm may prove useful in other population-based cohorts as well.

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Disclosure

None of the authors have any conflict of interest to disclose. We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. French-language screening tool.

Table S2. Number (%) of participants who screened positive according to each algorithm pathway.

Table S3. Predictive value of the CLSA-EA.

Appendix S1. CLSA-EA questionnaire script.