Estimation of the prevalence of epilepsy in the Benin region of Zinvié using the capture-recapture method

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The prevalence of epilepsy is high in tropical countries, particularly in Africa where it varies between 10 and 55 per 1000, with an estimated mean prevalence of 15 per 1000. It is estimated that 80 to 98% of the patients in developing countries are not appropriately treated. The frequency of the disease, coupled with difficulties in therapeutic management of patients, makes it a major public health problem. A global campaign to bring epilepsy ‘out of the shadows’ was recently launched by the International League Against Epilepsy (ILAE), the International Bureau for Epilepsy and the World Health Organization (WHO).

Background The prevalence of epilepsy was estimated in two villages of 3134 inhabitants, in Benin, in April and May 1997 using the capture-recapture method.

Methods Information was obtained from (i) a door-to-door cross-sectional study, (ii) a non-medical source consisting of key informants (traditional practitioners, teachers, village leaders, and religious representatives) and (iii) a medical source through evaluation of medical records in health centres. In all the three situations, the diagnosis of epilepsy was confirmed by a neurologist.

Results The door-to-door survey found 50 epileptics, i.e. a prevalence of 15.9 per 1000. The non-medical source found 26 patients. The medical source found only four patients. In total, 66 epileptics were found by combining the three sources, giving a prevalence of 21.1 per 1000. After application of the capture-recapture method, the estimated number of cases from the door-to-door survey and non-medical source was 105, and 110 cases when the medical source was considered as well. The respective prevalences were 33.5 per 1000, and 35.1 per 1000.

Conclusions The door-to-door survey has been usefully improved by using key informants. The epilepsy prevalence estimate found by capture-recapture is clearly higher than that found by traditional cross-sectional methods, and could better depict the frequency of epilepsy in Africa.

Keywords Africa, Benin, capture-recapture method, epilepsy, prevalence

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monitoring systems, could possibly be applied in tropical countries so long as an exploitable surveillance system exists. Although a few studies using this method have been carried out in developing countries, only one involved epilepsy.

Population and Methods

Study population
The study took place in the Republic of Benin, in West Africa, during the months of April and May 1997. The study was done in two villages in the Zinvié division situated about 40 km north of the capital Cotonou, in the Atlantic district: Yevié (1703 inhabitants) and Zinvié-Zoumé (1431 inhabitants) (Figure 1).

Definition of cases
The diagnosis of epilepsy was retained if the subject had at least two epileptic seizures in his lifetime, which is the international epidemiological definition recommended by the ILAE. The diagnosis of epilepsy was confirmed by the same neurologist after a detailed history and physical examination. All types of seizures were included (i.e. generalized, partial, partial with secondary generalization).

Sources of information
Three sources of information likely to notify epilepsy cases were used: a door-to-door cross-sectional study (DTD), a medical source (MS) which analysed the medical registers in the dispensaries and hospitals, and a non-medical source (NMS) including key informants.

The study was carried out in the following order: (1) Non-medical source: information was collected by interviewing the village leaders, the traditional practitioners, the religious representatives and teachers in the two villages. (2) Door-to-door survey: the screening of epileptic patients was done using the Questionnaire for Investigation of Epilepsy in Tropical Countries and according to WHO recommendations. The DTD censored 2960 inhabitants in the two villages, while the estimated population was 3134 from the 1997 projection of the 1992 census. Therefore approximately 94.5% of the population in the two villages was interrogated. The DTD was done initially in Yevié village and Zinvié-Zoumé village was addressed subsequently. Four teams each consisting of a general practitioner and a paramedical assistant were involved in the DTD. The teams were guided by the village head. The first homestead to be studied was chosen randomly. The paramedical assistant interviewed each member of the homestead to obtain demographic and screening data. A patient giving at least one positive response to the screening part of the Questionnaire was further interviewed by the physician to confirm or reject the probable diagnosis of epilepsy. The investigators spoke the local language. They were trained by the neurologist over 2 days before the beginning of the study. The training consisted of detailed explanations of the questionnaire, understanding the questions, and concordance of the diagnostic accuracy between the different teams. (3) Medical source: this brought together information from medical records on patients, obtained from Lacroix hospital in Yevié, the division health centre at Yevié-Fondji and the Neurology Unit of the Department of Internal Medicine in the Cotonou University Hospital.

Each person found in the primary screening by NMS and DTD was examined by the neurologist to confirm or reject the diagnosis of epilepsy. The patients found by the MS had confirmed epilepsy as they were followed up in a health care centre.

The capture-recapture method

Identification of common cases
The cases found by NMS, DTD and MS were compared in order to find out the common cases, and the cases specific to each source. For this comparison, five variables were used including residence, sex, name, first name, and age. Cases were considered as common when: (i) they had the same name and first name, sex, residence and were compatible in age ± 5 years; (ii) they were identical in the first three letters of their name, identical phonetically by name, identical by first name, sex, residence and compatible in age ± 5 years; (iii) the phonetic name was non-identical but with variation in spelling, or with various written first names, when sex and residence were identical, and compatible in age ± 5 years.

All cases not considered as common cases were considered as specific to their source.

Statistical analysis
The description of the sources according to sex, age, residence and type of seizure was done using Statview 4.5 (Abacus Concept Inc, Berkeley, CA, USA). Comparisons of proportions were done by Pearson \( \chi^2 \) test. The estimation of the number of cases not identified by these sources was then done using capture-recapture method.

From the DTD and NMS
Each of these sources brought R and S number of cases respectively; their crossing forms a contingency table where C is the number of common cases, \( x \) the number of not identified cases, \( N_{\text{NMS}} \) the number of specific cases in the NMS and \( N_{\text{DTD}} \) the cases specific to the DTD survey. The total number of observed cases was \( N_{\text{obs}} = N_{\text{NMS}} + N_{\text{DTD}} + C \). Sekar and Deming first proposed formulae for calculating the total number of cases and its variance. This study used Chapman and Seber estimations.
(non-biased approximate estimation [NBA]), that can be used when the numbers are small and when C has a non null probability to be equal to zero.

\[ N_{\text{NBA}} = \frac{(R + 1)(S + 1)}{(C + 1)} - 1 \]

\[ \text{Var}(N_{\text{NBA}}) = \frac{(R + 1)(S + 1)N_1N_2}{(C + 1)^2(C + 2)} \]

The exhaustivity level of each source, i.e. the proportion of identified cases in each could be estimated by

\[ P_{\text{NMS}} = \frac{R}{N} \quad \text{and} \quad P_{\text{DTD}} = \frac{S}{N} = \frac{C}{R} \]

and that of the two systems combined by

\[ P_{\text{NMS,DTD}} = \frac{R + S - C}{N} \]

From the three sources

The estimation of the total number of epileptics and the evaluation of the dependence of the different sources were determined using log-linear models analysis with BMDP procedure 4F (Statistical Software Inc, Los Angeles, CA, USA). The best model was the one having less interaction terms, and best goodness-of-fit with the observed data (likelihood ratio statistic non-significant; lowest Akaike Information Criterion [AIC], Bayesian Information Criterion [BIC] and Draper Information Criterion [DIC]).

Results

The patient distribution according to the sources of information was 26 (NMS), 50 (DTD) and 4 (MS). The prevalence found by the DTD was therefore 15.9 per 1000. In all, 66 epileptics were identified from the three sources, giving an observed prevalence of 21.1 per 1000. The distribution of specific and common cases according to the sources is shown in Figure 2. In the DTD, the screening and the first confirmation by the general practitioners found 74 subjects with probable epilepsy but only 50 were retained by the neurologist. The reasons for rejection by the neurologist were that 20 subjects (5 males, 15 females) suffered from other diseases (cardiovascular diseases, vertigo, hypoglycaemia, tremor, ...) and 4 had had only one seizure in their lifetime.

Descriptive analysis

Among the 66 cases, 30 were males and 36 females (sex ratio 0.83). The mean age was 22.8 ± 19.1 years. Children under 15 years represented 52.4% of all cases. There was no age difference between the genders. In Yevié village, 44 epileptics were found and in Zinvié-Zoumé (P < 0.05).

Clinically, 68.1% (45 cases) had tonic-clonic seizures while 6.1% (4 cases) had absences. Four cases (6.1%) had simple partial seizures, 13.6% (9 cases) had partial seizures with secondary generalization and 6.1% (4 cases) had other types of seizures. Of the cases, 38% had had a seizure within the last month. The neurological exam was abnormal in 24.2% of cases. The main signs found were hemiplegia, monoplegia, oculomotor palsies, speech and language problems and mental retardation. Past history showed that 24.2% of the parents had consanguinity.

Family history of epilepsy was positive in 23 cases (34.8%), among them, 7 (30.4%) were first-degree relatives of the cases.

The 26 epileptics from NMS

In all, 12 females and 14 males were found from the NMS. Their mean age was 23.9 ± 18.5 years. Sixty-nine per cent had generalized tonic-clonic seizures, 11.5% had generalized absences and 11.6% partial seizures with secondary generalization; 7.7% of the cases had other seizures. Teachers from Yevié village gave nine names for epileptic children. Three of them had absences. The traditional practitioners gave 14 names of patients. All had confirmed epilepsy with generalized tonic-clonic seizures. The religious representatives gave three names of epileptics, two of whom had been reported by the traditional healers. Two other names were reported by the village chiefs.

The 50 cases from DTD

The mean age of cases from the DTD survey was 23.9 ± 20.4 years, the sex ratio being 0.66 (20 males and 30 females). Four per cent had absences and they were children under 15 (mean age 9.3 ± 5.1 years). The generalized tonic-clonic seizures accounted for 70.0% of all seizures, simple partial seizures for 2.0% and secondary generalized partial seizures for 16.0%; 8% of the cases had other seizures.

The four cases from MS

One case was common with the DTD and another one with the NMS. Two patients were specific to this source, one male and one female. The mean age was 36.7 ± 16.8 years. All of them had generalized tonic-clonic seizures.

Application of the capture-recapture method

From two sources (NMS and DTD)

The total number of estimated cases was 105 (95% CI: 70–139). The prevalence estimated from the two sources was therefore 33.5 per 1000 (95% CI: 22.3–44.3 per 1000). The estimated exhaustivity rates were 24.8% for NMS, 47.6% for the DTD and 61.0% in the two groups combined.

From three sources (NMS, DTD, MS)

The goodness-of-fit of the log-linear models and the estimations of the total number of epileptic cases are summarized in Table 1. The model used showed no dependence among the three
The prevalence estimated from the capture-recapture method was 33.5 per 1000 when two sources are considered (NMS and DTD). The capture-recapture method estimated the prevalence of epilepsy to be between 33.5 per 1000 when two sources are considered (NMS and DTD) and 35.1 per 1000 when three sources are considered. These prevalences correspond with those found in many studies performed in developing countries, which range from 10 to 55 per 1000. The prevalence calculated only from DTD (15.9 per 1000) is close to that found using the same methodology in the Savalou region of Benin or in Togo, neighbouring Benin. The prevalence found combining DTD and NMS (20.1 per 1000) is similar to the prevalence in Kenya, Tanzania and Congo. The prevalence estimated from the capture-recapture method is close to those found in Nigeria and Democratic Republic of Congo.

The validity of the results obtained by this method necessitates that certain conditions are fulfilled. Case definition was identical in all the three sources, and all the notified cases from the DTD and NMS were confirmed by a neurologist. The MS cases were considered as true positives, the diagnosis having already been confirmed by a neurologist. The identification of the common cases was based on a combination of several criteria, the most important being the patient’s name. In the two villages, Fon is the dialect used. No written transcription exists of the names of the epileptic patients in the medical records from the MS was disappointing. The consultation and hospital reports are handwritten. Furthermore, the registers are recent and not exhaustive and epileptic patients rarely present to health centres. In Benin, as elsewhere in West Africa, because epilepsy is held as a supernatural happening, epileptics initially consult village healers in order to receive a traditional treatment and to be exorcised. These traditional practitioners are a significant source of patient identification. In order to conduct the study confidence building between the investigator and the traditional healers was necessary. All the traditional healers receiving patients in the study region participated in the survey. This source was uniquely oral, without supportive documentation and the fear of losing patients probably limited the number of names given by these practitioners. Data from teachers allowed us to find several patients among the children.

### Table 1 Goodness-of-fit of the log-linear models and estimation of the total number of epilepsy, Benin, 1997

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<th>Degrees of freedom</th>
<th>Model</th>
<th>G²</th>
<th>P</th>
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<tr>
<td>0</td>
<td>NMS/DTD.NMS/MS/DTD/MS</td>
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<td>0</td>
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<td>140</td>
<td>0–320</td>
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<tr>
<td>2</td>
<td>NMS/DTD.NMS/MS</td>
<td>0.14</td>
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a NMS = non-medical source; DTD = door-to-door survey; MS = medical source; NMS/DTD.NMS/MS/DTD/MS = interaction between the three sources; NMS/DTD.NMS/MS = interaction between non-medical source and door-to-door survey and between non-medical source and medical source; NMS/DTD/DTD/MS = interaction between non-medical source and door-to-door survey and between door-to-door survey and medical source; NMS/MS/DTD/MS = interaction between non-medical source and door-to-door survey and medical source; DTD/MS = interaction between non-medical source and medical source; MS = three independent sources.

b G² = likelihood ratio statistic; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; DIC = Draper Information Criterion

Discussion

This study found 66 epileptic cases in the two villages studied, giving a minimal observed prevalence of 21.1 per 1000. The DTD found 50 cases among the 66. The capture-recapture method estimated the prevalence of epilepsy to be between 33.5 per 1000 when two sources are considered (NMS and DTD) and 35.1 per 1000 when the three sources are considered. The ages given by patients were approximated since birth certificates are not issued. A case was considered as common when the ages differed by less than 5 years. The population could be considered as a closed one during the study period because the majority of the villagers are farmers and do not travel and only epileptics residing in the region were included.

Ascertainment of the three sources were done sequentially to avoid creating artificial dependence among them. We were able to test the independence within the sources which is the principal condition underlying this method. Independence is achieved when the probability of a case being reported by a source does not influence the probability of it being reported by another source. All but one criteria advocated by Hook and Regal when the sample size is small, indicated that the best model was the one with complete independence between the three sources. We can therefore reasonably assume that this condition was achieved in our study.

In the DTD, some difficulties were encountered: a few people refused to participate because of fear of a modern trained doctor. It was sometimes necessary for an investigator to return several times to certain households in order to interview all the inhabitants (who were away during the first or second visit). Research into the names of the epileptic patients in the medical records from the MS was disappointing. The consultation and hospital reports are handwritten. Furthermore, the registers are recent and not exhaustive and epileptic patients rarely present to health centres. In Benin, as elsewhere in West Africa, because epilepsy is held as a supernatural happening, epileptics initially consult village healers in order to receive a traditional treatment and to be exorcised. These traditional practitioners are a significant source of patient identification. In order to conduct the study confidence building between the investigator and the traditional healers was necessary. All the traditional healers receiving patients in the study region participated in the survey. This source was uniquely oral, without supportive documentation and the fear of losing patients probably limited the number of names given by these practitioners. Data from teachers allowed us to find several patients among the children.

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particularly those suffering from generalized absences (frequently missed in a DTD as they are totally overlooked or hidden by parents). The majority of the affected children were male (78%), in contrast to adults (males 44%). This may be explained by the fact that fewer girls are sent to school than boys.

Key-informant methods have been used previously in epidemiological studies. A study done in Kenya tested two methods for screening epilepsy: cluster sampling and key informants (community leaders including doctors, midwives, teachers, traditional birth attendants, healers,...). Their results showed that the cluster sampling method was more effective than the key-informant approach. A prevalence of 18.2 per 1000 was found using the cluster sampling method while the key-informant method estimated epilepsy to be 3.6 per 1000. Other studies using key informants to find patients were done by Thorburn et al. and Wig et al. with similar conclusions to Kaamugisha et al. The NMS source in our study found a prevalence of 7.9 per 1000 using a similar approach. This is double the prevalence found by Kaamugisha et al. based on key informants, while the DTD found a prevalence ratio (16.0 per 1000) quite close to their result by cluster sampling method which found 18.2 per 1000. This may be because the study zone was much smaller in Benin than in Kenya hence facilitating the relationship between the investigators and the subjects in the Benin study. However, the key informant source was more effective in Yevié than in Zinvié-Zoumé as shown by the significant difference between the numbers of cases found in each village. Their participation was poor in Zinvié-Zoumé where for example teachers were not able to identify any epileptic schoolchildren. This was due to inadequate briefing of the key informants by the village leader.

Several studies have used capture-recapture for evaluation of the incidence and prevalence of diverse pathologies. All these studies have uncovered a significant underevaluation of prevalence by traditional methods and have found more realistic prevalence figures. Two studies on the prevalence of epilepsy in the US have used the capture-recapture method. A study carried out in Atlanta observed a prevalence of epilepsy in children below 10 years of 6.0 per 1000 (95% CI: 5.5–6.5) while the estimated prevalence was 7.7 per 1000 (95% CI: 7.3–8.4). Twenty-two per cent of epileptics were not registered either by the ECG laboratory or by the paediatric department of the regional hospital. Bobo et al. found a prevalence of infantile spasms of 10 per 100 000 children, and of non-lebrile convulsions of 159 per 100 000. The capture-recapture method allowed them to note 6.5–31.0% of these cases were not notified by the information sources. Capture-recapture has been used mainly in industrialized countries where the surveillance systems are reliable and easy to use. Few studies using this method have been done in tropical countries. In developing countries one encounters several difficulties when using this method including an unstable population, poor medical infrastructure and cultural and linguistic difficulties. Our study is the second study using the capture-recapture method to estimate the prevalence of epilepsy in a developing country. The first one was done in India. The authors compared the efficacy and the cost of two sources of information in studying epilepsy in children; one source used the door-to-door method and one source comprised key informants (village chiefs, health agents, teachers and schoolchildren). The observed prevalence of epilepsy rose from 3.3 per 1000 (95% CI: 2.8–3.4) to 5.5 per 1000 (95% CI: 3.8–7.2) by capture-recapture estimation method. In this study, although the use of key informants appeared to be effective from a cost-benefit viewpoint, teachers were apparently not a useful source of information in the screening of epileptics. The difference in the contribution of teachers compared to the present study is notable; indeed some sources of information might make a positive contribution in one country but not in another.

All in all, a DTD cross-sectional method remains indispensable in the evaluation of epilepsy in Africa. However, this method is usefully supplemented by data from a source of information comprised of teachers, opinion leaders and traditional practitioners. The capture-recapture estimates an elevated prevalence over a DTD survey alone and it yields a more realistic picture of the impact of this disease. It can be an indicator of the non-diagnosed non-treated patients at a regional level and therefore could be used as a surrogate marker for the treatment gap. In the global campaign against epilepsy, it could be a useful tool for educating governments and raising awareness of epilepsy, and in improving surveillance systems, patient care and preventive measures.

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