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Review article

# Top 100 cited articles on epilepsy and status epilepticus: A bibliometric analysis

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ABSTRACT

The purpose of this study is to identify the top 100-cited articles dedicated to epilepsy and status epilepticus published in journals from January, 1950 through February, 2016 that have made key contributions in the field. We performed a search of journals and selected the top 100-cited articles on epilepsy and status epilepticus, respectively, by utilizing the Institute for Scientific Information database available under the banner of the Web of Science. The top-cited articles on epilepsy and status epilepticus were all published in 24 journals, respectively. In both fields of epilepsy and status epilepticus, the most frequently cited journal was *Epilepsia* (26 articles on epilepsy and 19 articles on status epilepticus). The 100 most-cited articles in the field of both epilepsy and status epilepticus mainly originated from institutions in the United States of America. The articles on epilepsy included 25 laboratory studies, 15 pharmacotherapy studies, 13 general review studies, 12 surgery studies, 11 neuroimaging studies, eight epidemiology studies, eight neuropsychiatry studies, six genetic studies, and two electrophysiology studies, whereas 41 laboratory studies, 21 epidemiology studies, 16 pharmacotherapy studies, nine electrophysiology studies, nine general review studies, and four neuroimaging studies were included in the field of status epilepticus. We demonstrate that neuroimaging, genetics, and surgery are emerging topics in the field of epilepsy over the past decades. Moreover, we found that the majority of top-cited articles on epilepsy and status epilepticus originated from institutions in the United States of America and most were published in *Epilepsia*.



## 1. Introduction

Epilepsy is a disease that is as old as human existence. It was first described in a text from 2000 B.C written in the Akkadian language [1]. Currently, epilepsy is one of the most common chronic neurological diseases and affects approximately 50 million people worldwide [2]. In addition, status epilepticus is a relatively common medical and neurologic emergency that requires prompt evaluation and treatment [3]. Over a lifetime, up to 10 percent of adults with epilepsy and 20 percent of children with epilepsy will go on to have status epilepticus [3,4]. The research in the field of epilepsy and status epilepticus has shown impressive development over the past 50 years and research articles published in this field reflect its evolution.

In 1962, the Science Citations Index was initiated at the Institute for Scientific Information (ISI) by Eugene Garfield, which is now owned by the Thomson Corporation of Toronto. The purpose was to maintain a systematic ongoing measurement of the citation counts for scientific journals [5]. The ISI database, via the Science Citation Index Expanded and the Journal Citation Reports, contains more than 11,000 international journals and provides the complete bibliographical information of these indexed publications [5]. It is a multidisciplinary index to the journal literature of the science. The number of citations of previously published work is an indicator of its subsequent recognition and impact in an area of study [6–8]. Reviewing articles that are frequently cited can provide information about the dominant areas of a discipline, as well as highlight the growth of particular fields. Furthermore, top-cited articles are often written by recognized experts who can offer insight into the future directions of the discipline. The study and analysis of

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citation indexes have resulted in the development of various metrics to assess the impact of scientific journals or individual investigators based on the number of citations to their respective works [6–8].

Several recent studies have identified and analyzed citation classics and top-cited articles in various medical fields including general surgery [9], anesthesiology [10], emergency medicine [11], plastic surgery [12], dermatology [13], obstetrics and gynecology [14], orthopedic surgery [15], critical care medicine [16], and essential tremor [17]. However, to the best of our knowledge, no comprehensive study of the top-cited articles in the field of epilepsy or status epilepticus has been available to date, especially using the ISI database. The purpose of this study was to identify the 100 most-cited articles published in journals from January, 1950 through February, 2016 dedicated to epilepsy and status epilepticus that have made key contributions in the field. Identifying a reliable and unified set of core journals in the field of epilepsy and status epilepticus may be of interest to investigators in the field.

## 2. Methods

We did a citation analysis in the field of epilepsy and status epilepticus, respectively. The citation analysis is a bibliometric method that examines the frequency and patterns of citations in articles.

First, we performed a search of journals and selected the most cited articles by utilizing the ISI database available under the banner of the Web of Science, providing the most relevant bibliometric information from published scientific articles since 1950. Based on the Journal Citation Reports Science Edition 2014, the following three subject categories of journals were included: 192 journals on "clinical neurology", 252 journals on "neuroscience", and 110 journals on "medicine, general & internal". For each included journal, we retrieved all articles that were cited more than 100 times at the time of search (February, 2016) using the "cited reference search" facility of the Science Citation Index Expanded of the ISI Web of Science. In general, an article that has been cited more than 100 times is considered a "classic". Classic articles tend to represent historical landmarks in the evolution of a specific area.

Second, to identify frequently cited epilepsy- and status epilepticus-specific articles, we searched the following terms in the selected articles that have been cited more than 100 times: "epilepsy" and "status epilepticus", respectively.

Third, we identified the 100 top-cited articles in the field of epilepsy and status epilepticus, respectively, and we manually reviewed the contents of these articles. We examined the characteristics of the articles, such as number of citations, ranking, authorship, article title, year of publication, publishing journal, publication type, and topic categories. The publication types were categorized into original article, case series, and systemic review/guidelines, and the topic types were sub-typed as epidemiology, pharmacotherapy, surgery, laboratory, electrophysiology, neuroimaging, genetics, neuropsychiatry, and general review. When the authors of an article had more than one affiliation, the department, institution, and country of origin were defined by the affiliation of the first author. Data are presented using descriptive statistics, and no tests of statistical significance were performed. This study did not need to be reviewed by an ethics committee because it performed a bibliometric analysis of existing published studies and did not involve human subjects.

## 3. Results

Nine hundred eighty-eight articles on epilepsy and 117 articles on status epilepticus that were cited more than 100 times in the ISI database retrieved. Of the 988 articles and 117 articles, we selected the 100 most frequently cited articles for further analysis and ranked them according to the number of citations, respectively (Table 1, Supplementary Tables 1 and 2). The most cited article on epilepsy received 1,711 citations, and the least cited article received 271 citations. The majority of articles (77 articles) received more than 300 citations. The most cited article on status epilepticus received 611 citations, and the least cited article received 108 citations.

The top-cited articles on epilepsy were all published in 24 journals (Table 2). Of the 24 journals, the most frequently cited journal was *Epilepsia* (26 articles), followed by *Annals of Neurology* (16 articles) and *Brain* (12 articles). More than half of the articles (54 articles) were retrieved from these three journals. In addition, half of the 10 top-cited articles were published in *Epilepsia*. The top-cited articles on status epilepticus were also all published in 24 journals (Table 2). Of the 24 journals, the most frequently cited journal was *Epilepsia* (19 articles), followed by *Neurology* (18 articles) and *The Journal of Neuroscience* (11 articles). About half of the articles (48 articles) were retrieved from these three journals.

The top 100-cited articles on epilepsy originated from institutions in 14 countries, with the United States of America contributing 46 articles, followed by the United Kingdom (19 articles), Canada (13 articles), and France (5 articles) (Table 3). Fifty-nine of the articles originated from the North American continent, including the United States of America and Canada, 37 articles originated from the countries of Europe, including the United Kingdom, France, Finland, Italy, Germany, Switzerland, Denmark, Netherlands, and Sweden, and only four articles originated from the countries on Asia and Oceania, including Australia, China, and Japan. The top 100-cited articles on status epilepticus originated from institutions in 16 countries, with the United States of America contributing 62 articles, followed by France (6 articles), Germany (6 articles), and the United Kingdom (6 articles) (Table 3). More than two-thirds (69 articles) of the articles originated from the American continent, including the United States of America, Canada, and Brazil, 28 articles originated from the countries of Europe, including France, German, the United Kingdom, Sweden, Switzerland, Austria, Czech Republic, Finland, Italy, and Netherlands, and only three articles originated from the countries on Asia and Oceania, including India, Israel, and New Zealand.

Tables 4 and 5 list the top-ranked institutions and authors for the published epilepsy and status epilepticus citation classics associated with two or more articles. The 19 institutions provided two or more top-cited articles on epilepsy. The institution associated with the largest number of epilepsy citation classics was McGill University in Canada (8 articles), followed by the University of California, Los Angeles in the United States of America (5 articles), and University College of London in the United Kingdom (5 articles). J. Engel, Jr, who was the first author of 6 articles, was listed most frequently in the epilepsy citation classics. The decade of publication with the most relevant articles identified is listed in Table 6. The publication years were concentrated in the 1990s, where 40 of the citation classics were published. Further, 68 of the 100 top-cited articles were published throughout the 1990s and 2000s. The earliest recorded article was published in 1964, and the most recent article was in 2014. The 15 institutions provided two or more top-cited articles on status epilepticus. The institution associated with the largest number of status epilepticus citation classics was University of California, Los Angeles in the United States of America (15 articles), followed by Columbia University in the United States of America (8 articles), University of California, San Francisco in the United States of America (6 articles), University of Virginia in the United States of America (6 articles), and Virginia Commonwealth University in the United States of America (6 articles). Lowenstein DH, who was the first

**Table 1**
The top 10-cited articles in the field of epilepsy and status epilepticus.

| Rank | First author | Journal | Title | Number of citations |
|---|---|---|---|---|
| Epilepsy | | | | |
| 1 | Kwan P | N Engl J Med 2000;342:314–9. | Early identification of refractory epilepsy | 1,711 |
| 2 | Ben-Ari Y | Neuroscience 1985;14:375–403. | Limbic seizure and brain damage produced by kainic acid: mechanisms and relevance to human temporal lobe epilepsy | 1,385 |
| 3 | Wiebe S | N Engl J Med 2001;345:311–8. | A randomized, controlled trial of surgery for temporal-lobe epilepsy | 1,157 |
| 4 | Engel J Jr | Epilepsia 2001;42:796–803. | A proposed diagnostic scheme for people with epileptic seizures and with epilepsy: Report of the ILAE Task Force on Classification and Terminology | 1,148 |
| 5 | Hauser WA | Epilepsia 1993;34:453–68. | Incidence of epilepsy and unprovoked seizures in Rochester, Minnesota: 1935–1984 | 999 |
| 6 | Margerison JH | Brain 1966;89:499–530. | Epilepsy and the temporal lobes. A clinical, electroencephalographic and neuropathological study of the brain in epilepsy, with particular reference to the temporal lobes | 945 |
| 7 | Fisher RS | Epilepsia 2005;46:470–2. | Epileptic seizures and epilepsy: Definitions proposed by the International League against Epilepsy (ILAE) and the International Bureau for Epilepsy (IBE) | 807 |
| 8 | Hauser WA | Epilepsia 1975;16:1–66. | The epidemiology of epilepsy in Rochester, Minnesota, 1935 through 1967 | 782 |
| 9 | Flor-Henry P | Epilepsia 1969;10:363–95. | Psychosis and temporal lobe epilepsy. A controlled investigation | 642 |
| 10 | Gloor P | Ann Neurol 1982;12:129–44. | The role of the limbic system in experiential phenomena of temporal lobe epilepsy | 610 |
| Status epilepticus | | | | |
| 1 | Treiman DM | N Engl J Med 1998;339:792–8. | A comparison of four treatments for generalized convulsive status epilepticus. Veterans Affairs Status Epilepticus Cooperative Study Group | 611 |
| 2 | Sloviter RS | Hippocampus 1991;1:41–66. | Permanently altered hippocampal structure, excitability, and inhibition after experimental status epilepticus in the rat: the "dormant basket cell" hypothesis and its possible relevance to temporal lobe epilepsy | 557 |
| 3 | DeLorenzo RJ | Neurology 1996;46:1029–35. | A prospective, population-based epidemiologic study of status epilepticus in Richmond, Virginia | 514 |
| 4 | Delgado-Escueta AV | N Engl J Med 1982;306:1337–40. | Current concepts in neurology: management of status epilepticus | 376 |
| 5 | Towne AR | Epilepsia 1994;35:27–34. | Determinants of mortality in status epilepticus | 375 |
| 6 | Scharfman HE | J Neurosci 2000;15:6144–58. | Granule-like neurons at the hilar/CA3 border after status epilepticus and their synchrony with area CA3 pyramidal cells: functional implications of seizure-induced neurogenesis | 372 |
| 7 | Aicardi J | Epilepsia 1970;11:187–97. | Convulsive status epilepticus in infants and children. A study of 239 cases | 345 |
| 8 | Alldredge BK | N Engl J Med 2001;30:631–7. | A comparison of lorazepam, diazepam, and placebo for the treatment of out-of-hospital status epilepticus | 340 |
| 9 | Lowenstein DH | Epilepsia 1999;40:120–2. | It's time to revise the definition of status epilepticus | 336 |
| 10 | Towne AR | Neurology 2000;25:340–5. | Prevalence of nonconvulsive status epilepticus in comatose patients | 317 |

**Table 2**
Journals of the top 100-cited articles in the field of epilepsy and status epilepticus.

| Epilepsy | | | Status Epilepticus | | |
|---|---|---|---|---|---|
| Rank | Journal | Number of articles | Rank | Journal | Number of articles |
| 1 | Epilepsia | 26 | 1 | Epilepsia | 19 |
| 2 | Annals of Neurology | 16 | 2 | Neurology | 18 |
| 3 | Brain | 12 | 3 | The Journal of Neuroscience | 11 |
| 4 | Neurology | 9 | 4 | Brain Research | 7 |
| 5 | New England Journal of Medicine | 5 | 4 | Epilepsy Research | 7 |
| 5 | The Lancet | 5 | 6 | Brain | 4 |
| 7 | Neuroscience | 4 | 6 | New England Journal of Medicine | 4 |
| 8 | Lancet Neurology | 3 | 8 | JAMA Neurology | 3 |
| 9 | JAMA Neurology | 2 | 8 | Annals of Neurology | 3 |
| 9 | Brain Research | 2 | 8 | Hippocampus | 3 |
| 9 | Experimental Neurology | 2 | 8 | Journal of Comparative Neurology | 3 |
| 9 | Nature Neuroscience | 2 | 8 | Neuroscience | 3 |
| 13 | Annual Review of Neuroscience | 1 | 13 | European Journal of Neuroscience | 2 |
| 13 | Current Opinion in Neurology | 1 | 13 | Experimental Neurology | 2 |
| 13 | Epilepsy Research | 1 | 13 | Neuroscience Letters | 2 |
| 13 | Hippocampus | 1 | 16 | American Journal of Medicine | 1 |
| 13 | Journal of Neurology, Neurosurgery, and Psychiatry | 1 | 16 | European Journal of Neurology | 1 |
| 13 | Journal of the Neurological Sciences | 1 | 16 | Experimental Brain Research | 1 |
| 13 | The Journal of Neuroscience | 1 | 16 | JAMA | 1 |
| 13 | Journal of Neurosurgery | 1 | 16 | Journal of Neurology, Neurosurgery, and Psychiatry | 1 |
| 13 | Mayo Clinic Proceedings | 1 | 16 | Lancet | 1 |
| 13 | Nature Reviews Neurology | 1 | 16 | Lancet Neurology | 1 |
| 13 | Nature Reviews Neroscience | 1 | 16 | Neurocritical Care | 1 |
| 13 | Trends in Neurosciences | 1 | 16 | Progress in Brain Research | 1 |

author of 4 articles, was listed most frequently in the status epilepticus citation classics. The decade of publication with the most relevant articles identified is also listed in Table 6. The publication years were concentrated in the 2000s, where 38 of the citation classics were published. Further, 75 of the 100 top-cited articles were published throughout the 1990s and 2000s. The earliest recorded article was published in 1965, and the most recent article was in 2012.

**Table 3**
Country of origin of the top 100-cited articles in the field of epilepsy and status epilepticus.

| Epilepsy | | | Status Epilepticus | | |
|---|---|---|---|---|---|
| Rank | Country | Number of articles | Rank | Country | Number of articles |
| 1 | United States of America | 46 | 1 | United States of America | 62 |
| 2 | United Kingdom | 19 | 2 | France | 6 |
| 3 | Canada | 13 | 2 | Germany | 6 |
| 4 | France | 5 | 2 | United Kingdom | 6 |
| 5 | Finland | 3 | 5 | Canada | 4 |
| 5 | Italy | 3 | 6 | Brazil | 3 |
| 7 | Australia | 2 | 6 | Sweden | 3 |
| 7 | Germany | 2 | 8 | Swizerland | 2 |
| 7 | Swizerland | 2 | 9 | Austria | 1 |
| 10 | China | 1 | 9 | Czech Republic | 1 |
| 10 | Denmark | 1 | 9 | Finland | 1 |
| 10 | Japan | 1 | 9 | India | 1 |
| 10 | Netherlands | 1 | 9 | Israel | 1 |
| 10 | Sweden | 1 | 9 | Italy | 1 |
| | | | 9 | Netherlands | 1 |
| | | | 9 | New Zealand | 1 |

**Table 4**
Institution of origin of the first authors with two or more the top 100-cited articles in the field of epilepsy and status epilepticus.

| Epilepsy | | | Status Epilepticus | | |
|---|---|---|---|---|---|
| Rank | Institutions | Number of articles | Rank | Institutions | Number of articles |
| 1 | McGill University at Canada | 8 | 1 | University of California, Los Angeles at US | 15 |
| 2 | University of California, Los Angeles at US | 5 | 2 | Columbia University at US | 8 |
| 3 | University College London at UK | 5 | 3 | University of California, San Francisco at US | 6 |
| 4 | Columbia University at US | 4 | 3 | University of Virginia at US | 6 |
| 4 | University of California, San Francisco at US | 4 | 3 | Virginia Commonwealth University at US | 6 |
| 6 | The national center for scientific research at France | 3 | 6 | The national center for scientific research at France | 3 |
| 6 | Veterans Administration Medical Center at US | 3 | 6 | University College London at UK | 3 |
| 6 | Yale University at US | 3 | 6 | Federal University of São Paulo at Brazil | 3 |
| 9 | Mario Negri Institute for Pharmacological Research at Italy | 2 | 9 | Carleton University at Canada | 2 |
| 9 | University Hospital Zurich at Swizerland | 2 | 9 | Charité University at Germany | 2 |
| 9 | Cleveland Clinic at US | 2 | 9 | Emory University at US | 2 |
| 9 | Mayo Clinic at US | 2 | 9 | Helen Hayes Hospital at US | 2 |
| 9 | National Hospital for Neurology and Neurosurgery at UK | 2 | 9 | McGill University at Canada | 2 |
| 9 | Stanford University at US | 2 | 9 | School of Veterinary Medicine at Germany | 2 |
| 9 | University of Glasgow at UK | 2 | 9 | University of Pennsylvania at US | 2 |
| 9 | University of Liverpool at UK | 2 | | | |
| 9 | University of minnesota at USA | 2 | | | |
| 9 | University of Oulu at Finland | 2 | | | |
| 9 | The Walton Centre at UK | 2 | | | |

US: The United States of America, UK: United Kingdom.

Regarding the type of articles on epilepsy, 74 were original articles, 25 were systemic review/guidelines articles, and only one was a case series. The topics included 25 laboratory studies, 15 pharmacotherapy studies, 13 general review studies, 12 surgery studies, 11 neuroimaging studies, eight epidemiology studies, eight neuropsychiatry studies, six genetic studies, and two electrophysiology studies (Table 6). Many of the laboratory studies evaluated the pathophysiologic mechanism of epilepsy. The pharmacotherapy studies usually compared the efficacy or effectiveness among the antiepileptic drugs (AEDs). The surgery studies assessed the efficacy and safety of various surgeries, such as temporal lobectomy, deep brain stimulation, vagal nerve stimulation, or multiple subpial transection. Most of the neuroimaging studies investigated the utilization of brain magnetic resonance imagings (MRI) for investigation and treatment of epilepsy. Half of the epidemiology studies based on the Rochester Epidemiology Project medical records, and two third of genetic studies focused on genes related with drug resistance in epilepsy. Twenty-five of the top 100-cited articles specifically dealt with temporal lobe epilepsy, which was the most common subject among citation articles on epilepsy.

Regarding the type of articles on status epilepticus, 90 were original articles, nine were systemic review/guidelines articles, and only one was a case series. The topics included 41 laboratory studies, 21 epidemiology studies, 16 pharmacotherapy studies, 9 electrophysiology studies, 9 general review studies, and 4 neuroimaging studies (Table 6). The laboratory studies evaluated the pathophysiologic mechanism of status epilepticus, pharmacoresistance in status epilepticus, or neuronal injury by status epilepticus. Most of the epidemiology studies focused on incidence, prevalence, cause, or outcome of status epilepticus. The pharmacotherapy studies compared the efficacy of the AEDs as initial or subsequent therapy. The electrophysiology studies usually assessed the changes of electroencephalography during status epilepticus. All of the neuroimaging studies investigated structural changes related with status epilepticus using brain MRI.

## 4. Discussion

In this article, we identified and characterized the top 100-cited articles in the field of epilepsy and status epilepticus using the ISI

**Table 5**
The first authors with two or more the top 100-cited articles in the field of epilepsy and status epilepticus.

| Epilepsy | | | Status Epilepticus | | |
|---|---|---|---|---|---|
| Rank | First Authors | Number of articles | Rank | First Authors | Number of articles |
| 1 | Engel J Jr | 6 | 1 | Lowenstein DH | 4 |
| 2 | Hauser WA | 4 | 2 | DeLorenzo RJ | 3 |
| 3 | Ben-Ari Y | 3 | 3 | Claassen J | 2 |
| 4 | Cendes F | 2 | 3 | Covolan L | 2 |
| 4 | Duncan JS | 2 | 3 | Fujikawa DG | 2 |
| 4 | French JA | 2 | 3 | Hesdorffer DC | 2 |
| 4 | Gloor P | 2 | 3 | Le Gal La Salle G | 2 |
| 4 | Houser CR | 2 | 3 | Lothman EW | 2 |
| 4 | Isojarvi JI | 2 | 3 | Rossetti AO | 2 |
| 4 | Marson AG | 2 | 3 | Sloviter RS | 2 |
| 4 | Matsumoto H | 2 | 3 | Towne AR | 2 |
| 4 | Palmini A | 2 | 3 | Treiman DM | 2 |
| 4 | Scheffer IE | 2 | | | |
| 4 | Sloviter RS | 2 | | | |
| 4 | Vezzani A | 2 | | | |
| 4 | Wieser HG | 2 | | | |

**Table 6**
The number of publications of the top 100-cited articles in the field of epilepsy and status epilepticus according to topics.

| Epilepsy | | | | | | | Status Epilepticus | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Topics | Decade | | | | | | Topics | Decade | | | | | |
| | 1960–1969 | 1970–1979 | 1980–1989 | 1990–1999 | 2000–2009 | 2010–2016. Feb. | | 1960–1969 | 1970–1979 | 1980–1989 | 1990–1999 | 2000–2009 | 2010–2016. Feb. |
| Electrophysiology | | | 1 | 1 | | | Electrophysiology | | 1 | 1 | 4 | 3 | |
| Epidemiology | | 2 | | 4 | 2 | | Epidemiology | | 2 | 1 | 10 | 8 | |
| Genetics | | | | 3 | 3 | | Genetics | | | | | | |
| Laboratory | 2 | 1 | 10 | 6 | 5 | 1 | Laboratory | | 1 | 7 | 14 | 19 | |
| Neuroimaging | | | 2 | 9 | | | Neuroimaging | | | 1 | 1 | 2 | |
| Pharmacotherapy | 1 | 2 | 2 | 5 | 4 | 1 | Pharmacotherapy | 1 | 1 | 5 | 4 | 4 | 1 |
| Neuropsychiatry | 1 | | 1 | 5 | 1 | | Neuropsychiatry | | | | | | |
| Review | | 1 | 1 | 4 | 7 | | Review | | | | 4 | 2 | 3 |
| Surgery | | | 2 | 3 | 6 | 1 | Surgery | | | | | | |
| Total | 4 | 6 | 19 | 40 | 28 | 3 | Total | 1 | 5 | 15 | 37 | 38 | 4 |

database. These citation classics may enable the identification of a seminal advance in epilepsy and may provide a historical perspective on the scientific progress in the field of epilepsy and status epilepticus. It is remarkable that the majority of these old articles are still cited and continue to have an influence in the field of epilepsy and status epilepticus.

Citation analysis is based on the premise that top-cited articles are likely to be championed by recognized experts, to demonstrate emerging topics within their particular field and to offer a useful indication of relevant trends in that field [7,8]. In the present study, we took advantage of these tools to identify the important works in the field of epilepsy. Topics of the classic articles varied from decade to decade, and we could discover some interesting trends in the topics over time. We noted that the most-cited articles concerning laboratory and pharmacotherapy studies in the field of epilepsy were published throughout the 1960s–2010s, but the peak were published around the 1990s. However, we found that most of the studies concerning neuroimaging, genetics, and surgery were conducted after the 1990s (studies published before and after 1990s included 2 vs. 9 studies in neuroimaging, 0 vs. 6 studies in genetics, and 2 vs. 10 studies in surgery, respectively). This trend may be attributed to the development of research techniques in the fields. This result is consistent with a recent study that used bibliometric analysis, which also demonstrated that 69% of the most-cited neuroimaging articles were published between 1995 and 2004 [18]. In addition, we found that the highly cited neuropsychiatry studies were published after the 1990s, and so we could infer that many researchers were interested in neuropsychiatric problems after the 1990s. However, there were no most cited-articles regarding surgery, neuropsychiatry, and genetic studies in the field of status epilepticus.

We also demonstrated that the most-cited articles on epilepsy were published in the journal *Epilepsia*. This is perhaps related to the fact that the highest impact factors among the epilepsy-specific journals belong to *Epilepsia*, *Epilepsy and Behavior*, *Epilepsy Research*, *European Journal of Epilepsy*, and *Epileptic Disorders*. Previous studies have found that the impact factor of the original publishing journal was the strongest predictor of citations [19]. In addition, *Epilepsia* was one of the official journals of the International League Against Epilepsy (ILAE), and definitions, classifications, and guidelines proposed by ILAE were usually distributed by *Epilepsia*. These types of articles tend to be cited more frequently than original articles and have had a high impact in recent years because the number of references allowed in most journals is limited [20]. Thus, the articles in *Epilepsia* may be more cited than others. This was consistent in the field of status epilepticus, and the most frequently cited journal was also *Epilepsia*.

Moreover, we found that about half of the 100 top-cited articles on epilepsy and more than half of the articles on status epilepticus originated from institutions in the United States of America, which is consistent with the overwhelming American influence in health science research reported by other top-cited articles in different clinical disciplines [9–12]. The institutions in the United States of America have greatly contributed to the development of research

in the field of epilepsy. This can be explained by the large size of the American scientific community and a higher research budget. Moreover, it was reported that the authors in the United States of America usually prefer to publish in journals of the United States of America and preferentially cite local papers [21]. However, interestingly, the institution associated with the largest number of epilepsy citation classics was McGill University in Canada (not in the United States of America). The Montreal Neurologic Institute is a part of McGill University, and the researchers at the Montreal Neurologic Institute have been leading groups in various studies about neuroimaging, electrophysiology, and surgery. We also found that only two articles of the 100 top-cited articles on epilepsy originated from Asian countries, China and Japan, despite recently increasing number of articles originating from Asian countries in the field of neurology research [22]. Moreover, this was consistent in the field of status epilepticus. Of the 100 top-cited articles on status epilepticus, only two articles originated from Asian countries, including India and Israel.

The top-ranked article in the field of epilepsy was study regarding pharmacotherapy. The top-ranked article on epilepsy was authored by P Kwan and MJ Brodie in 2000, which was an observational cohort study of newly diagnosed epilepsy suggesting that once a patient had failed trials of two appropriate AEDs, the probability of achieving seizure freedom with subsequent AEDs was modest [23]. It was cited 1,711 times. This article influenced a consensus regarding the definition of drug-resistant epilepsy proposed by the ad hoc Task Force of the ILAE commission. Drug-resistant epilepsy was defined as the failure to achieve sustained seizure freedom after adequate trials of two tolerated, appropriately chosen and used AED schedules [24]. Because this definition might be useful to compare findings across studies and to make practice recommendations, it could be frequently cited in many articles. The 1st ranked article in the surgery category were cited 1,157 times, authored by Wiebe [25]. This study evaluated the therapeutic usefulness of surgery for temporal lobe epilepsy, and demonstrated the superiority of surgery over medial therapy in terms of the control of seizures and the quality of life in patients with poorly controlled temporal lobe epilepsy [25]. From this landmark study, surgery is considered a valuable option for medially intractable temporal lobe epilepsy. There have been also great strides made in the structural and functional imaging of the brain in epilepsy in the last decade, resulting in a wealth of scientific data and clinical applications [26]. Especially, since application of brain MRI, the investigation and treatment of patients with epilepsy has been revolutionized. A previous volumetric study may diminish the need for invasive methods of investigation in patients with epilepsy [27], and activation imaging technique using function MRI can provide direct observation of brain activity during language processes and determine the language dominance without the intracarotid amobarbital procedure [28]. Interestingly, we found that of the top 100-cited articles, 25 were temporal lobe epilepsy specific articles, which was the most common subject among these citation articles. This might be a result of the high prevalence of temporal lobe epilepsy, constituting 30–35% of all epilepsies.

The top-ranked articles in the field of status epilepticus was also study regarding pharmacotherapy. Because rapid seizure control in status epilepticus is crucial to avoid the development of pharmacoresistance and ongoing neurological injury, the articles related with pharmacotherapy might be frequently cited. The top-ranked article on statue epilepticus was authored by DM Treiman, which was a multicenter randomized comparison of four different intravenous treatments, lorazepam, diazepam followed by phenytoin, phenobarbital, and phenytoin alone, in patients with status epilepticus. From the result of this study, initial treatment of choice for status epilepticus is intravenous lorazepam [29]. There are many laboratory studies in status epilepticus citation articles (more than one third of articles) compared to epilepsy citation articles, which mainly focused on pathophysiology of status epilepticus. This could be resulted from high incidence of treatment failure by initial AEDs with high mortality rate in status epilepticus [30]. Although much of the pathophysiology of status epilepticus is still poorly understood, these studies have led to substantial advances in the understanding of the basic mechanism underlying status epilepticus including molecular and cellular processes, which may produce appropriate management of status epilepticus.

Previously only one study investigated the most cited works in the field of epilepsy [31]. However, the previous study did not use the ISI database, which is used in majority of bibliometric research projects, but only used an internet-based search engine, Harzing's Publish. In addition, the previous study did not investigate the country or institution of origin of the first author unlike the present study. Moreover, because the previous study performed a citation search using all of the terms "seizure", "epilepticus" as well as "epilepsy", the result of it was different from that of the present study. The seizure is a sign or symptom, whereas the epilepsy is a disorder of the brain [32]. Therefore, the previous study included more wide range of articles than the present study, and it included more laboratory studies than the present study (48 vs. 25 articles). The top-ranked article in the previous study was also an animal study investigating the relationship between the epileptiform after-discharge activity and the development of motor seizures [33]. This difference resulted that the most frequently cited journal on epilepsy in the present study was *Epilepsia*, followed by *Annals of Neurology* and *Brain*, whereas the previous study included *Epilepsia*, followed by *Science*, and *Nature*. We could infer that the list of the present study might include the articles which are more useful for clinical practice, and more properly reflects the most cited works in the field of epilepsy and status epilepticus. In addition, this is the first study to investigate the top-cited articles in the field of status epilepticus.

There were inherent limitations in the current citation classics. There is obviously considerable debate regarding the value of citation rates. The argument is that the greater the value of the article, the more times it will be cited [34]. In addition, citations do not distinguish between positive and negative Ref. [34]. Moreover, the method of the use of the total citations favors older publications and older journals [35]. The citation of a scientific article usually follows a time lapse and is usually not cited until 1 to 2 years after publication, reaches a peak after 3 to 10 years, and then declines [19]. This normal life span of a publication shows that evaluating the rank and significance of recent publications is limited. However, the use of citation rates is widely accepted as the best method of judging the merits of specific journals. The impact factor is widely indicative of the importance of a given journal in its specific field of interest, and has emerged as a marker of the quality and rank of the journal [36]. Thus, although citation statistics have been frequently criticized, the analysis of citation rates can allow for the identification of advances in a specialty and may provide a historical perspective of its scientific progress.

## 5. Conclusion

The present study provides a detailed list of the most-cited articles on epilepsy and status epilepticus, respectively. We demonstrated that neuroimaging, genetics, and surgery are emerging topics in the field of epilepsy over the past decades, whereas the landmark studies in these topics are rare in the field of status epilepticus. Moreover, findings of the study suggest that the majority of top-cited articles on epilepsy and status epilepticus originated from institutions in the United States of America and most were published in *Epilepsia*. This currently relevant approach pro-

vides an opportunity to recognize the classic articles on epilepsy and status epilepticus, provides useful insights into international leaders, and describes research trends in the field of epilepsy and status epilepticus.

## Conflicts of Interest/Disclosures

The authors declare that they have no financial or other conflicts of interest in relation to this research and its publication.

## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jocn.2017.02.065.

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