

Review Article

Quality and quantity of research publications by Iranian neurosurgeons: Signs of scientific progress over the past decades

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Abstract

Background: This is an analysis of papers published by Iranian neurosurgeons while working in Iran until the year 2010.

Methods: We collected bibliometric data and assigned a level of evidence (LOE) for each paper and compared neurosurgical research productivity across three time periods (before 1990, between 1991 and 2000, and after 2000). For further illustration, the annual growth rates of Iranian publications were calculated for all papers published after 1995.

Results: We found a total of 1196 papers by 422 Iranian neurosurgeons. Five authors accounted for 22.9% of the papers. The average number of authors for each published manuscript was 3.48 and increased significantly from 2.0 to 4.0 across the three investigated periods ($P < 0.001$). 58.9% of Iranian papers were published in local journals only. A total of 74.6% articles were published after 2000, which was a significant increase compared with the decades before ($P < 0.001$). Original articles and case reports accounted for 63.8% and 31.1% of the publications, respectively. The proportion of case reports decreased while the proportion of original articles increased across the three time periods ($P < 0.001$). The adjusted growth rate for the total number of publications, original articles, case reports, clinical trials, and randomized clinical trials (RCTs) were 14.4%, 16.6%, 10.7%, 13.46%, and 14.7% per year, respectively. Overall, the four most frequently investigated topics were spine (27.3%), trauma (22.3%), tumor (19.1%), and vascular diseases (13.5%). The mean impact factor for journals publishing these studies and average number of citations for each paper (obtained from web of science) were found to be 1.2 and 5.46, respectively. A partitioning of these publications into assigned categories reflecting the LOE of each paper yielded the following LOE distribution for all assessed publications: Ib: 6.02%, Ic: 0.3%, IIa: 0.2%, IIb: 5.4%, IIc: 0.41%, IIIb: 4.8%, IV: 22.5%, and V: 1.2%. The relative number of publications categorized into higher LOE classes increased over the three investigated periods ($P = 0.003$). Based on growth curve model, the rate of increase in total numbers of publications following each position change from

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nonuniversity affiliated neurosurgeon to university affiliated and from university affiliated neurosurgeon to chairman university affiliated neurosurgeon was 81%.

Conclusions: A considerable increase in amount and quality of Iranian papers was observed during the past decade as reflected in a higher number of papers categorized in upper LOE classes.

Key Words: Iran, level of evidence, neurosurgery, publication

INTRODUCTION

Neurosurgery is a comparatively young specialty in the world of medicine and was not on a firm footing until the early 20th century.^[5] The joint efforts of Prof. N.O. Ameli and Prof. E. Samiy established the first service of neurosurgery at Tehran University of Medical Sciences in 1950.^[1,2] Gradually after establishment of this institute, more neurosurgical services began to work and more neurosurgeons were trained in the country. At the moment, seven universities within the country have neurosurgical training programs, among which two are located in Tehran (Tehran University of Medical Sciences with five affiliated medical centers and Shahid Beheshti University of Medical Sciences with three affiliated medical centers), whereas the other five are located in Tabriz, Mashad, Isfahan, Shiraz, and Kerman (each university has one affiliated medical center for training neurosurgical residents). Each year 26 applicants are accepted in neurosurgical residency programs, with nearly half accepted in Tehran-located programs. No other medical universities in the country offer training through a complete 5-year period of neurosurgical residency. Many of these medical universities do not have any other residency programs either and train medical students only. Recently, a spine fellowship program has been established within the country. Currently, around 120 neurosurgeons are teaching in residency programs in Iran and almost half of them are practicing in Tehran. The first two international neurosurgical papers from Iran were published in 1948 by Profs. Samiy and Ameli.

Traditionally, neurosurgeons around the world practiced with a patient-care oriented emphasis with little interest in research and publication.^[4] Only recently, with the development of evidence-based medicine, neurosurgeons became more interested in research and publications.^[6] Iranian neurosurgeons were not an exception in this regard.

In recent years, there was a dramatic improvement in the quality and increase in quantity of publications authored by Iranian scientists. In 2011, Iran had the highest annual growth rate of scientific publications in the world.^[16] Since there are no previously published data available regarding the quality and quantity of publications by Iranian neurosurgeons, this study is aimed to investigate

and analyze the metrics of neurosurgical scientific contributions of Iranian authors to the world of neurosurgery.

MATERIALS AND METHODS

Authors

By contacting the Iranian Association of Neurological Surgeons' office in Tehran, a list of all Iranian neurosurgeons, who have been members of this association, was compiled. Neurosurgeons who were well-established prior to the foundation of the society but who were not members of the association were also included. This was accomplished by personal communications of the authors with the chairmen of the neurosurgical programs in the country, and asking the names of all prior and present practicing neurosurgeons since the establishment of each neurosurgery service. Moreover, websites of all medical schools in the country were surveyed. Name of all the attending neurosurgeons practicing in different university hospitals affiliated to each medical school were reviewed, and the missing names were added to the primary list. Neurosurgeons who were found to be coauthors in the collected papers, but who were not affiliated to any specific institution, were also added. Private hospitals were also directly contacted by phone to ask for the names of their practicing neurosurgeons. A total number of 422 Iranian neurosurgeons were found to be affiliated to Iran either permanently during their practice, or at some point in their medical career, between the years 1948 and 2010. Finally, e-mails were sent out by one of the authors of the current paper to any neurosurgeon whose email could have been accessed through either the Iranian Association of Neurological Surgeons' contact information list (provided by the neurosurgeons themselves), or the medical schools websites' attending list. A few additional e-mail addresses were also accessed through PubMed, by finding the contact information of the corresponding author (this only applied to certain neurosurgeons who had published a paper in which they were the corresponding author). In the e-mail text, the aim of the study had initially been described. Afterwards, neurosurgeons were invited and encouraged to send their own list of all publications with the aim of preparing a more comprehensive list of all publications. A total of 190 e-mails were sent out. Although a total of 53 responses were received, only 16 neurosurgeons sent their specific list of publications. A total of 13 of these 16 neurosurgeons were

university affiliated neurosurgeons, 5 of whom were among the top 20 most prolific practicing neurosurgeons in the country. The majority of the neurosurgeons, who did not respond back, had no coauthorship in any published paper in the final paper database. It is worthwhile to mention that the low general response rate is largely due to the fact that in Iran, e-mail communication is still not as well established as in other highly developed countries, especially in cities other than Tehran. The provided lists of publication were reviewed and any missing paper was added to the master database.

Eligibility criteria

Any article having at least one neurosurgeon affiliated with an Iranian institution was included. Publications that were entirely based upon data acquired outside Iran, or articles that were published by Iranian neurosurgeons during times when they were not affiliated with an Iranian institution were excluded. The study aimed at including all articles published by Iranian neurosurgeons in all fields of medicine.

Search strategy

For international publications, the PubMed database was searched and for national publications IranMedex (<http://www.iranmedex.com>) was searched using all possible different spellings for the names of Iranian neurosurgeons. All Iranian neurosurgeons who had been identified as authors were also contacted via e-mail to provide their own complete list of journal publications.

Extraction of the data

The following variables were tabulated: Number of authors, article's type, article's subject, level of evidence (LOE), location of publishing journal (Iran or foreign countries) and impact factor (IF) of the journal publishing the article, number of citations per article, journal's language, corresponding neurosurgeon's name and gender, and his/her affiliation. Specialized study type and methodology tags were also preserved (e.g., randomized clinical trial [RCT]).

Article's type

The articles were categorized into five different groups: Original articles, case reports, review articles, brief reports, and letters to editor. The categorization was done based on the title page or content of each full-text article, or the main source from which each article had primarily been taken.

Article's subject

The subject of the paper was categorized into following topics: Trauma, pediatrics, tumor, degenerative disease, vascular, stereotactic, peripheral nerve, other neurosurgery, and other topics. Among the neurosurgery articles, some were related only to one field, whereas the others had subjects related to two or more fields. The results were reported with regard to the subject overlap (i.e., an article

was counted in more than one topic group if different topics were identified for the same paper content).

Impact factor and number of citations

For each article, the IF of the journal (at the time of publication) and the number of citations were obtained from the Institute for Scientific Information, ISI web of science (www.isiknowledge.com/wos; Thomson Reuter Journals) and SCOPUS Neurosurgical Journals. The IF and citations could not have been evaluated for most local journals and also for foreign journals that were not indexed in the ISI. Citations to local journals that were not indexed in ISI were evaluated from other sources such as Google scholar and the official website of the journal in which the paper appeared in. Not applicable (N/A) was designated to those papers for which no information regarding the IF of the journal or the number of citations was available.

Corresponding (primary) neurosurgeon

In a number of papers published by the Iranian neurosurgeons, the corresponding author was a nonneurosurgeon physician – most commonly a neurologist or a pathologist – in the current study, we defined a certain term as the corresponding (primary) neurosurgeon. For those articles that an Iranian neurosurgeon (affiliated with an Iranian medical center) was listed as the corresponding author, the same person was considered as the article's corresponding neurosurgeon. However, in articles in which a nonneurosurgeon was the corresponding author, as well as those where the corresponding author's name could not have been determined with certainty (this obscurity stemmed from the fact that in a number of papers, the corresponding author's name could have been determined with certainty only if there would be access to the full-text of that paper and full-texts were not available for all papers), the first neurosurgeon on the list of authors was considered as the primary neurosurgical author and was determined as the corresponding neurosurgeon of the article.

The university or medical center, to which each article's corresponding author was affiliated with, was determined for each article. Affiliation was reported only by extracting the accurate affiliation from the text of each article.

Level of evidence

The LOE was derived using the criteria developed by the Research and Development Center in Oxford, UK.^[11] Based on these criteria, papers were divided into four categories: (1) therapy/prevention or etiology/harm, (2) prognosis, (3) diagnosis, and (4) symptom prevalence. LOE for each paper was derived based on the type of the paper. Full-text of the papers was used for scoring. Two independent raters rated the papers. If any disagreement existed, it was discussed to arrive at a consensus.

Papers for which a definite LOE could not be established (e.g., case reports, papers about technical procedures, nonsystematic reviews, epidemiologic studies, and

anatomical studies) did not have any score assigned. Moreover, study protocols, papers introducing scientific figures, pure radiologic studies concerning quality of images or pharmacological studies evaluating pharmacokinetics of certain drugs also did not have any score assigned. Similar to this, correlation studies evaluating the association between several markers or symptoms did not receive any score. Interventional studies in animals were considered as experimental studies and are not included in this analysis. Studies evaluating molecular characteristics of tumors or other cell lines or evaluating basic regulators of physiologic and pathologic conditions were also considered basic science studies and are not included in this analysis of clinical research productivity. Experimental and basic science papers were classified under one subgroup and did not receive any score. Beyond this, there were some studies regarding the knowledge, view point, and the quality of learning of medical students, which did not receive any score and were hence excluded from this study.

Class IV evidence was assigned to the interventional studies with no control groups, as well as studies in which postoperative results had been simply reported without any relevant information and comparison with the preoperative state. Case series that presented data about more than one of the previously mentioned four categories but without any domination of a particular category received a level score of IV.

Statistical analysis

Based on the observed number of publications at each time point, we decided to divide publications into a larger interval and grouped the manuscripts into three groups: Those published before 1990, those published between 1991 and 2000, and those published after 2000. Different variables were then compared across these three periods. For comparing categorical data, the Chi-square test was used. For comparing continuous variables, *t*-test, analysis of variance (ANOVA), and Spearman correlation coefficient were used when appropriate.

Growth regression model was used to derive annual growth percentage rates for all publications and also for each different type of publication. Review articles, brief reports, and letter to editors were so scarce that we did not calculate an annual growth rate for these article categories. To make our analysis comparable with the article by Hauptman, *et al.*,^[7] we then calculated annual growth rates for publications appearing after 1995 only, which allowed us to avoid lots of zero cells in our data set from the early years. Kappa statistics was calculated for evaluating the agreement obtained by two independent raters in assigning LOE to the papers. We analyzed the publications' growth rate in the academic spectrum, including nonuniversity affiliated neurosurgeons, university affiliated neurosurgeons, and university affiliated neurosurgeons who were chairmen, and estimated it using the growth curve model. Multiple

regression model was used to find the possible predictors of total publications of authors. Suitable transformations were made to conform to assumptions of multiple regressions. Collinearity was assessed using tolerance and variance inflation factor (VIF). Constant variance of residuals was assessed by drawing appropriate graphs. F test was utilized to test for statistically significant addition of independent variables to the model. Here, the level of significance was considered at 0.05 and each analysis used two-sided tests of statistical significance. Statistical Package for the Social Sciences, Version 17.0, (SPSS Inc. Chicago, IL, USA) was used for each analysis.

RESULTS

Multi-approach search for the names of neurosurgeons fulfilling all the inclusion criteria, yielded in a list with a total of 422 neurosurgeons. Among them, 146 neurosurgeons had one or more published papers in which they were the corresponding (primary) neurosurgeon. Analysis of the affiliation of these 146 neurosurgeons, the data of which was primarily obtained from the corresponding author's contact information in their published papers, indicated that 86.3% (126) of the neurosurgeons were university affiliated, whereas only 13.7% (20) had solely focused on private practice. Although the city and the state of practice for each neurosurgeon were available in the database, this did not necessarily mean that the neurosurgeon had the university affiliation of that city. As a result, university/nonuniversity affiliation could have been reported only for those neurosurgeons who had at least one published paper.

A total of 1196 published papers by 422 Iranian neurosurgeons affiliated with an Iranian medical center were found in the scientific journals between the years 1948 and 2010. Overall, 476 articles (39.8%) were identified from PubMed and 662 articles (55.4%) from IranMedex and the 58 remaining articles (4.8%) were obtained from other sources including direct neurosurgeon's contacts.

The highest number of papers originating in Iran 82 (6.8%) was written by a young female neurosurgeon, Dr. Farideh Nejat who has been affiliated to Tehran University of Medical Sciences as an attending pediatric neurosurgeon in Children's Medical Center, since 2000. Despite her relatively short practice compared with many senior neurosurgeons across the country, she succeeded in developing a very successful career in her field within only a decade. At the moment, she is among the top pediatric neurosurgeons in the entire country with one of the highest referral rates from all over Iran. Interestingly, in addition to her surgical skills, Dr. Farideh Nejat is very enthusiastic about research and has been the most prolific neurosurgeon in the country. Her remarkably busy practice at the Children's Medical Center yielding a high referral rate has been an important factor for her

achievements, by providing an extensive amount of data available for research. Among her publications, 85% have been published in foreign journals and the other 15% in local journals. She has had several collaborative studies with neurosurgeons in other countries. However, the vast majority of authors were male (96.2%).

Corresponding authors were affiliated to nonuniversity affiliated private hospitals in 79 papers (6.6%). By assuming the same percentage of increase in total numbers of publications following each step of academic promotion, numbers of publications showed a nearly 81% increase following each position change in the academic spectrum from nonuniversity affiliated neurosurgeon to university affiliated and from university affiliated neurosurgeon to chairman university affiliated neurosurgeon ($P < 0.001$). There were 48 (4.0%) papers where only nonuniversity-affiliated neurosurgeons

contributed (foreign journals: 6.4% and local journals: 2.3%). A little less than one-quarter (22.9%) of all articles found in this study were published by only five neurosurgeons: Dr. Nejat, the attending pediatric neurosurgeon affiliated to Tehran University of Medical Sciences contributing the most (with 77 publications), followed by Dr. Rahimi-Movaghar, the attending trauma neurosurgeon affiliated to Tehran University of Medical Sciences and the research deputy of Sina Trauma and Surgery Research Center (with 63 publications), Dr. Faraji-Rad, the attending neurosurgeon affiliated to Mashad University of Medical Sciences and the Assistant Dean for Research at the Neurosurgery department (with 51 publications), Dr. Amirjamshidi, the attending neurosurgeon affiliated to Tehran University of Medical Sciences (with 46 publications), and Dr. Shokouhi, chairman of neurosurgery department at Tabriz University of Medical Sciences.

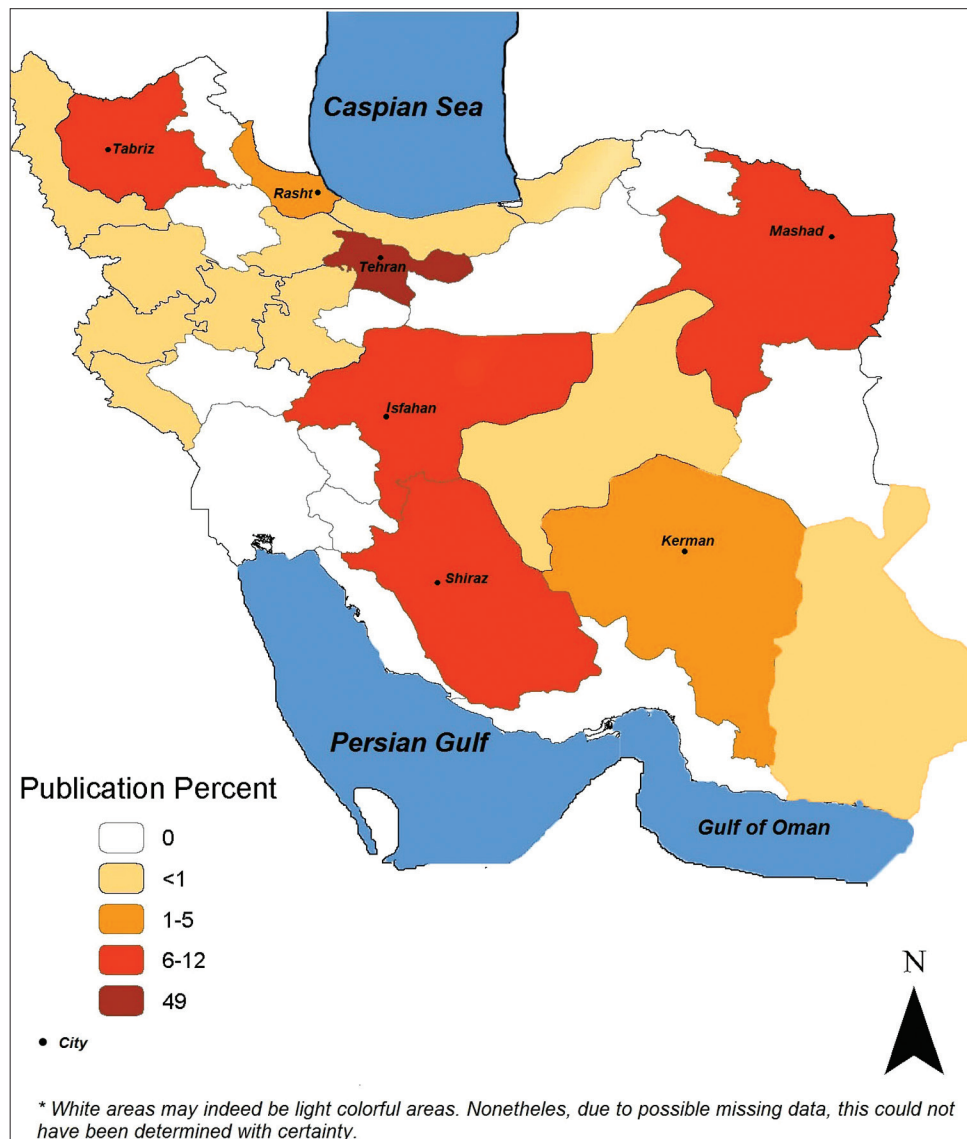


Figure 1: Distribution of publications by Iranian neurosurgeons throughout the country

Most publications by Iranian neurosurgeons originated in the large cities of the country [Figure 1]. Tehran as the capital of Iran, accounted for 50% of all publications. Tehran University of Medical Sciences and Iran University of Medical Sciences, which has recently been integrated with Tehran University of Medical Sciences, were the affiliation of the corresponding neurosurgeons in 38% of all publications. Other cities with considerable number of publications were in order of frequency: Tabriz, Shiraz, Mashad, Isfahan, and Kerman, each of which accounted for 6-12% of all publications.

A total of 154 articles (12.9%) were published by one single author only. Articles with three listed coauthors 315 (26.3%) were most frequently encountered. A total of 705 (58.9%) of all papers were published in local Iranian journals. The languages of local journals were English, Farsi, or Farsi/English. Farsi/English journals generally had Farsi articles with accompanying English abstracts. Most of the local journals are not indexed in internationally known databases. The minority were indexed in established international databases may furthermore be overlooked due to unavailability of Farsi papers for most readers of international English journals.

Almost all of the foreign papers have been written in English except seven papers published in German and four in French.

Approximately three-quarters (74.6%) of all articles were published after 2000 [Figure 2]. The maximum IF for Iranian neurosurgeons' publications related to a specific paper was 9.49 (published in "Brain"). IFs were presented by excluding letter to editors, which were published in higher IF journals (such as Lancet). The maximum number of citations to a specific paper was 77. For the papers published in local journals, the minimum and maximum citations were 0 and 4 and the mean and median of citations were 1 and 0, respectively. This was

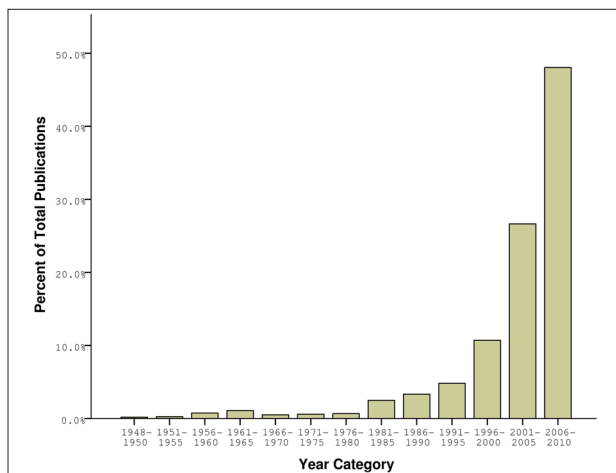


Figure 2: Five-year frequency of Iran-affiliated neurosurgeon's papers

evaluated in 39 papers (5%) of the locally published papers and might not necessarily be representative of the 705 locally published papers; nonetheless, the data on the number of citations were available only for this small number of papers. Data regarding the trend of authorship, location of publication, numbers of publications, IF, and citations are presented in Table 1. Average total numbers of publication and H index of authors based on the academic spectrum or location are presented in Table 2.

There was a strong correlation between total numbers of publications and total years of working as an university staff neurosurgeon ($r_s = 0.296$, $P = 0.001$), total years of practice ($r_s = 0.239$, $P = 0.008$), and total years of working as a chairman ($r_s = 0.412$, $P < 0.001$). There was also a very strong correlation between total numbers of publications and H index of the authors ($r_s = 0.636$, $P < 0.001$). Interestingly, there was no significant correlation between H index of the authors and years of working as a university staff neurosurgeon ($r_s = -0.063$, $P = 0.491$), total years of practice ($r_s = -0.026$, $P = 0.772$) and total years of working as a chairman ($r_s = 0.159$, $P = 0.076$).

Multiple predictors were entered into the multiple

Table 1: Bibliographic characteristics of Iranian neurosurgeons' publications and their trend in three time periods

Bibliographic characteristics	Total	Before 1990	1991-2000	After 2000	P value
Papers	1196 (100%)	105 (10.8%)	199 (14.6%)	892 (74.6%)	<0.001 ²
IF*	1.2	-	0.83	1.22	NS ³
Citation ¹ (median)	5.46 (2)	15.4 (11.5)	14.75 (11)	3.4 (1)	<0.001 ³
Authors ¹	3.48	2	2	4	<0.001 ³
Local publications	41.1%	63.6%	17.2	43%	<0.001 ²

¹Data presented as mean, ²P value obtained from Chi square test, ³P value obtained from ANOVA. *Excluding "Letter to Editors" related to comments to previously published articles in the journal

Table 2: Numbers of publications by academic spectrum and location

Iranian neurosurgeons	Total publications	H index
Nonuniversity affiliated authors	4.15 (2) ¹	0.23 (0.0)
University affiliated (not chief) authors	11.43 (7.0)	1.29 (1.0)
Chairman authors	20.37 (16.0)	2.16 (1.0)
Authors from Tehran	13.55 (7.0)	1.55 (0.0)
Authors from Shiraz	13.72 (11.0)	3.36 (2.0)
Authors from Isfahan	11.0 (8.0)	0.66 (1)
Authors from Tabriz	19.7 (16)	1.6 (1.0)
Authors from Mashad	19.45 (21.0)	0.36 (0.0)
Authors from other places	6.87 (6.0)	0.57 (0.0)

¹Data presented as mean (median)

regression model to evaluate their effect on total numbers of publications by each author. Total numbers of publications transformed into its logarithmic form (Log10) to normalize its values. There were strong correlation between total years of practice and total years of working as a chairman in our data ($r_s = 0.436$, $P < 0.001$). Because of colinearity it was not possible to enter both variables in the multiple regression model, so we decided just to enter total years of practice in the model. The same problem of colinearity was solved with changing the years of working as university staff neurosurgeon into a binary variable of being a university or nonuniversity affiliated neurosurgeon. Location of the authors dichotomized into big cities (Tehran, Isfahan, Shiraz, Mashad, and Tabriz) and other smaller cities. Being university affiliated and location of the authors in the country were significant predictors of total numbers of publications by each author, but total years of practice was only marginally significant when controlled for two previously mentioned variables [Table 3].

Original articles accounted for 63.8% (local: 72.1%,

foreign: 56.7%) of the articles while 31.1% (local: 24.2%, foreign: 32.2%) were case reports (28.4% case report and 2.5% case report and an ensuing review of the pertinent literature). Other categories consisted of review articles (1.8%), brief reports (0.9%), and letters to editor (2.6%). Based on our observations, it is clear that gradually, the number of original articles increased and the number of published case reports decreased over time [Figure 3]. The number of each type of publication differed significantly between the three observation periods ($P < 0.001$). The overall growth rate of papers was 14.4%. The growth rate for different types of publications is presented in Figure 2.

Of the total number of articles, 27.3% were related to spine, 22.3% to trauma, 19.1% to tumor, 13.5% to vascular diseases, 13.2% to pediatrics, 5.5% to peripheral nerves, 1.6% to stereotactic neurosurgery, and 1% to degenerative diseases. In addition, 6.2% of the articles were nonneurosurgery scientific articles and 17.8% articles were related to miscellaneous neurosurgery subjects.

Level of evidence

Overall, a LOE was assigned for 1178 papers. For the 18 remaining papers, the available data were not adequate for scoring and were published before 1990. The Kappa statistics demonstrated a high agreement (0.85) of two independent raters prior to final decision.

Finally, 59% of the papers could have not been scored based on the evaluation criteria, as they belonged to

Table 3: Summary of multiple regression analysis of predictors of total publications by each author

Predictors of publications	B	Seβ	P value
Total years of practice ¹	-0.383	0.262	0.066
University/nonuniversity affiliated	0.508	0.136	<0.001
Location	0.200	0.095	0.037
Constant	-0.382	0.262	0.148

¹Total years of practice was transformed into logarithmic form

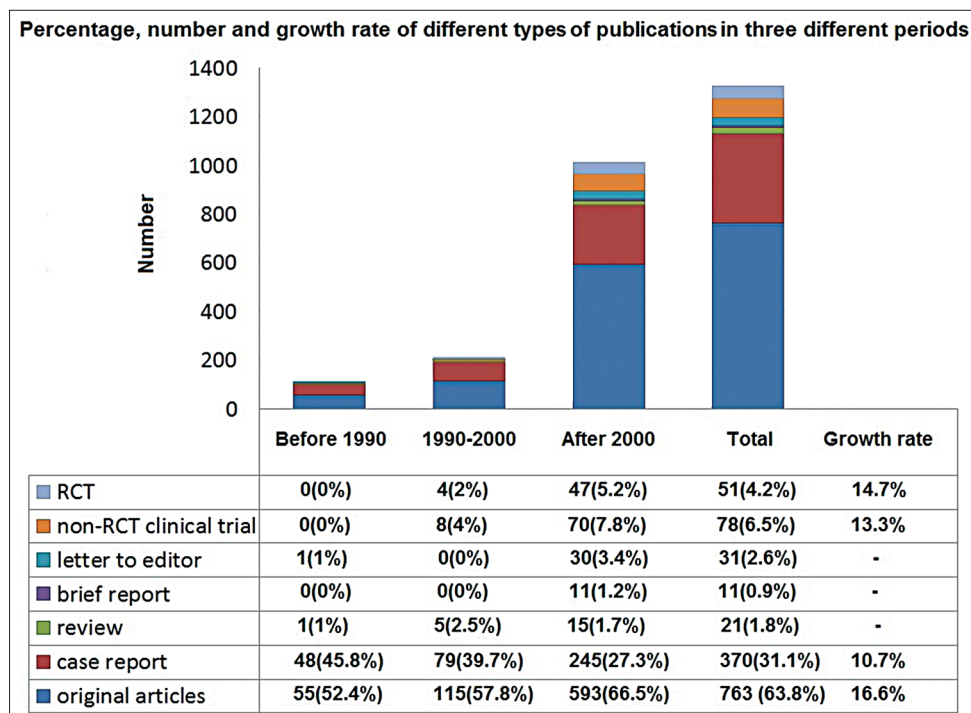


Figure 3: Type of articles published by Iranian neurosurgeons and their growth rate

article types for which their LOE could not be evaluated based on our criteria. The LOE of the papers that could be assigned increased significantly over the three time periods ($P < 0.001$). Figure 4 shows the LOE of published papers in total and each time period. Different topics had different LOE ($P < 0.001$). Among the evaluated topics, spine and trauma had the highest LOE. In

contrast, articles on stereotactic procedures had the lowest LOE [Table 4]. Most of the papers in the category of “all topics” were in the Therapy/Prevention, Etiology/Harm category [Table 5]. Nonneurosurgical articles, which had been published in other fields of medicine by neurosurgeons, had comparable LOE when compared with other neurosurgical papers.

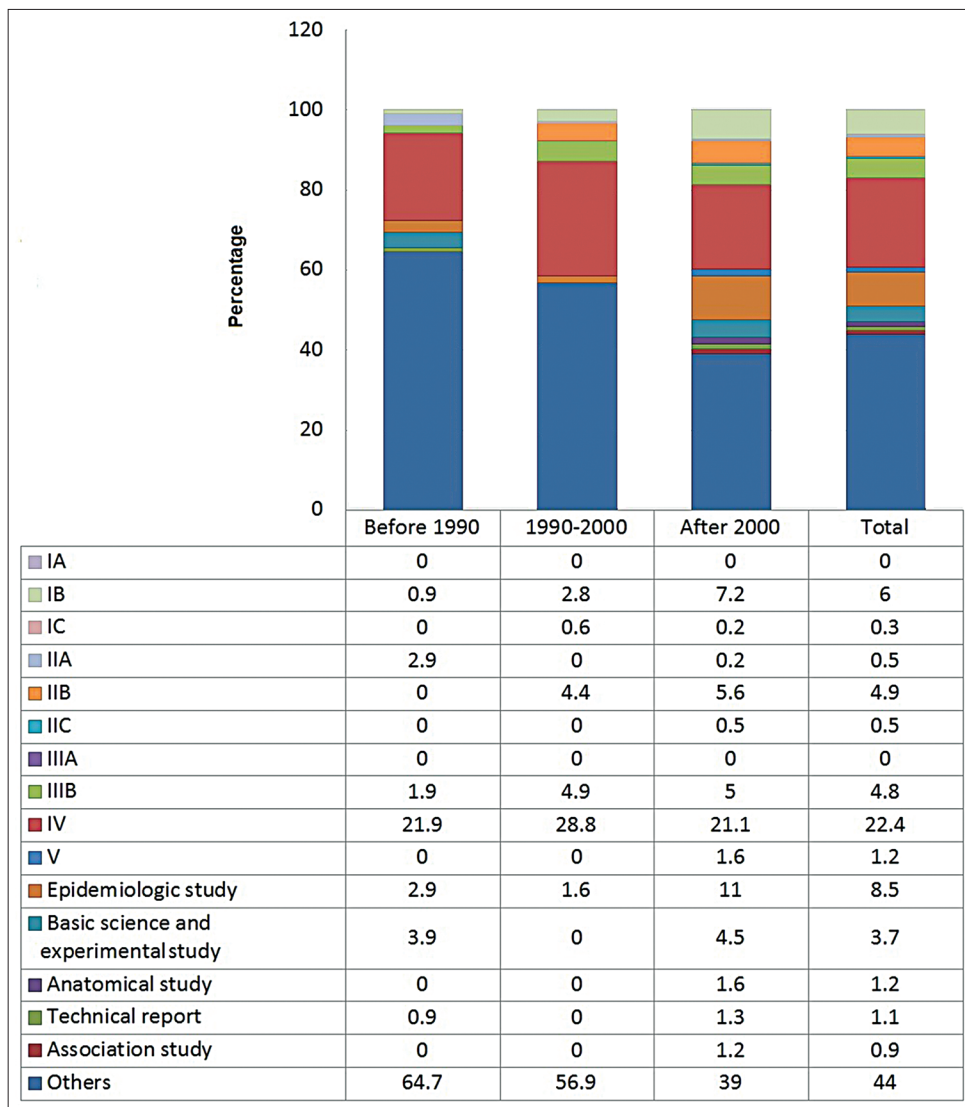


Figure 4: Level of evidence in Iranian neurosurgeons' publications in total and three time periods

Table 4: Level of evidence in Iranian neurosurgeons' publications in different topics

Level of evidence (LOE)	Trauma	Spine	Pediatrics	Tumor	Degenerative disease	Vascular	Stereotactic	Peripheral nerve	Other neurosurgery	Other
I ¹	8.2	8.3	4.44	2.24	0	5.22	0	4.75	3.37	6.75
II	10.3	5.5	5.8	3.97	16.6	3.9	0	0	2.84	5.4
III	8.8	4.9	3.86	2.22	16.6	4.75	0	11.1	3.37	2.7
IV	22.8	24.7	21.22	21.8	25	17.61	57.89	31.55	22.19	20.26
V	1.1	0.9	0	0	0	0.65	0	3.17	2.36	1.35
Other	48.8	55.7	64.68	69.77	41.68	67.87	42.11	49.43	65.87	63.54

¹Due to lots of zero cells, subgroups in major five categories were combined

Table 5: Percentage of Iranian neurosurgeons' publications in total three different periods based on type of study

Level of evidence (LOE)	Before 1990*			1990-2000*			After 2000*			Total		
	Total	For ¹	Loc ²	Total	For	Loc	Total	For	Loc	Total	For	Loc
Therapy/prevention, etiology/harm												
Ia	0	0	0	0	0	0	0	0	0	0	0	0
Ib	0	0	0	2.21 ²	0	2.21	4.84	2.25	2.59	3.99	1.7	2.29
Ic	0	0	0	0.55	0	0.55	0.22	0	0.22	0.25	0	0.25
IIa	0	0	0	0	0	0	0.22	0	0.22	0.17	0	0.17
IIb	0.95	0.95	0	2.76	0.55	2.21	3.93	0.68	3.25	3.49	0.68	2.81
IIc	0	0	0	0	0	0	0.56	0.22	0.34	0.42	0.17	0.25
IIIa	0	0	0	0	0	0	0	0	0	0	0	0
IIIb	0.95	0	0.95	2.76	0.55	2.21	4.03	1.68	2.35	3.56	1.36	2.2
IV	7.62	4.76	2.86	20.44	0.55	19.89	17.6	4.82	12.78	17.15	4.16	12.99
V	0	0	0	0	0	0	1.57	0.91	0.66	1.19	0.67	0.52
Prognosis												
Ia	0	0	0	0	0	0	0	0	0	0	0	0
Ib	0	0	0	0.55	0	0.55	0.56	0.56	0	0.5	0.42	0.08
IIa	0	0	0	0	0	0	0	0	0	0	0	0
IIb	0	0	0	0.55	0	0.55	0.9	0.56	0.34	0.76	0.42	0.34
IIc	0	0	0	0	0	0	0	0	0	0	0	0
IIIa	0	0	0	0	0	0	0	0	0	0	0	0
IIIb	0	0	0	1.1	0.55	0.55	0	0	0	0.16	0.08	0.08
IV	0	0	0	2.22	0	2.22	0.78	0.33	0.45	0.93	0.25	0.68
Diagnosis												
Ia	0	0	0	0	0	0	0	0	0	0	0	0
Ib	0.95	0.95	0	0	0	0	1.35	0.34	1.1	1.1	0.34	0.76
IIa	0	0	0	0	0	0	0	0	0	0	0	0
IIb	0	0	0	0.55	0	0.55	0.11	0	0.11	0.17	0	0.17
IIc	0	0	0	0	0	0	0	0	0	0	0	0
IIIa	0	0	0	0	0	0	0	0	0	0	0	0
IIIb	0	0	0	0.55	0	0.55	0.22	0.11	0.11	0.25	0.08	0.17
IV	1.91	1.91	0	0.55	0	0.55	1	0.11	0.89	1.02	0.25	0.77
V	0	0	0	0	0	0	0.11	0	0.11	0.08	0	0.08
Differential diagnosis/symptom prevalence												
Ia	0	0	0	0	0	0	0	0	0	0	0	0
Ib	0	0	0	0	0	0	0.44	0.22	0.22	0.34	0.17	0.17
IIa	0	0	0	0	0	0	0	0	0	0	0	0
IIb	1.9	0.95	0.95	0.55	0	0.55	0.89	0.33	0.56	0.93	0.34	0.59
IIc	0	0	0	0	0	0	0	0	0	0	0	0
IIIa	0	0	0	0	0	0	0	0	0	0	0	0
IIIb	0.95	0	0.95	0.55	0	0.55	0.79	0	0.79	0.76	0	0.76
IV	0.95	0.95	0	0	0	0	0.45	0	0.45	0.43	0.08	0.35
Not specified												
IV	11.44	3.81	7.63	5.54	2.22	3.32	1.23	0.11	1.12	2.8	0.76	2.04
Not scored												
-	72.38	48.72	23.66	58.57	12.68	45.89	58.2	29.77	28.34	59.55	29.17	30.38
Total												
-	100	63	37	100	17.1	82.9	100	43	57	100	41.1	58.9

¹Foreign journals, ²Local journals, * Data presented as percentage in each period

DISCUSSION

About 1196 papers were written in scientific journals

in the past 63 years by neurosurgeons practicing in Iran and most were published in the field of neurosurgery. The scientific productivity of Iranian neurosurgeons as

measured by the amount of manuscripts generated as a contribution to the world of neurosurgery has shown a significant increase in the past decade. This increase parallels a general tendency toward more research activities among neurosurgeons in the world.^[6,12] In recent years, more governmental and institutional attention to research productivity and more available funding to such researches were the main reasons of this increase.^[10] But still, the average allocated Iranian research budget lags behind of industrialized countries. Although accurate numbers are not available, research and development expenditure percentage compared with gross domestic product (GDP) increased from 0.4 in 1994 to 0.7 in 2010. Approximately, 5% of this budget is dedicated to health care and medical service sectors. This budget in Iran is far lower than industrialized countries such as the USA where the highest extent of research is being conducted, allocating 2.7% of GDP to research and development (R and D) expenditure. Comparable annual growth rates of the amount of research publications were between 2% and 6% for USA, Germany, and UK and -1.4% for Japan as the most active contributing countries in neurosurgical literature. Among other countries in the field of neurosurgery striving for an increase in research output are: China (+121.9%), Korea (+50.5%), Turkey (+25.3%), and India (+19.4%) with quoted growth rates as assessed for the past two decades.^[7] As demonstrated in this investigation, Iran compares favorably here with an annual growth rate of 14.4%, which is higher growth rate than some forerunner countries and comparable to publication output growth in Turkey and India.

Since about 60% of Iranian neurosurgeons' articles were only published in local journals (which are not indexed in data bases like PubMed), an effort should be made to change this percentage and increase the number of PubMed indexed articles to make these manuscripts accessible to a wider audience.

Interestingly, an 81% increase rate was observed in the number of publication arising in the academic spectrum. It is important, however, to mention that in this analysis neurosurgeons with no publications were omitted. This was primarily done because in growth rate estimation, values need to be positive; as a result for neurosurgeons without any publication the analysis could not have been carried out. Hence, the growth rate considering position changes (from being a nonuniversity affiliated neurosurgeon to a university affiliated neurosurgeon) is underestimated. In terms of total publication we interestingly found that, working as a university affiliated neurosurgeon and practicing in bigger cities with more facilities are much more important factors than the total years of practice. Even total years of practice became insignificant predictor of

total publications of each author (although marginally significant) when controlled for location of practice and affiliation to the university.

We were able to show that the proportion of case reports published by Iranian neurosurgeons decreased and original research papers increased during recent years.^[6] This is consistent with the observed general trend of neurosurgical publications during recent years. Case reports consist about 30.8% of the publications of Iranian neurosurgeons, which is consistent with the publications from the other neurosurgeons across the world, which is also about 30%.^[7,14]

After 1990, clinical trials comprised 7.1% of Iranian neurosurgery research publications. The relative percentage of these publication types is comparable with research output from USA, Germany, and UK, which were 4.2%, 4.02%, and 8.8%, respectively, although the total number of manuscripts is not yet at the same level.^[7] The growth rate of case reports (10.7%) and RCTs (14.7%) by Iranian neurosurgeons were higher than the average from around the world, which were 5.76 and 8.99, respectively, whereas the growth rates of clinical trials published by Iranian neurosurgeons is comparable (13.3 compared with 13.46% per year).^[7] Multicenter clinical trials have not been published yet from Iran compared with average growth rate of 10.73% per year in publications from other parts of the world. This may be rooted in the lack of necessary research infrastructure, the associated cost, the necessary technology, and the lack of large collaborative consortiums or the smaller number of patients going for investigative treatments.

Each year very few review articles are published by Iranian neurosurgeons while this type of publication is increasing with growth rate of 7.78% per year in the world.^[7] Research in diverse topics and less focus on specific topics maybe reasons for limited number of review articles published by Iranian neurosurgeons.

Spine, trauma, tumor, pediatrics, and vascular topics were the most published research fields from Iranian neurosurgeons. In the developed world, vascular, spine, tumor, trauma, and functional surgeries were among the most popular subjects of attention in publications of the past two decades.^[7] This observation suggests that the research community in Iran should pay more attention to publications in functional neurosurgery. This type of research is comparatively resource intense and hence expensive in developing countries such as Iran. Limited availability and lesser utilization of new technologies is mainly due to financial limitations and may be the primary reason for less research in these fields. In addition to requirement of an established infrastructure and sufficient financial resources, utilization of new technologies (e.g., deep brain stimulation, is associated with additional costs for after care, availability of which

would also be a challenge in Iran in smaller medical centers. LOE of the papers by Iranian neurosurgeons seems comparable with the research papers in three major neurosurgery journals: Journal of Neurosurgery, Neurosurgery and Acta Neurochirurgica (Wien). Among Iranian neurosurgeons' publications, 32 articles were published in Neurosurgery Journal, 58 in Journal of Neurosurgery series (JNS, JNS Pediatrics, and JNS Spine) and 10 in Acta Neurochirurgica (Wien).

The overall LOE of papers published in 1999 in these three journals were as follow: I: 3.4%, II: 13.2%, III 4.1%, IV: 22%, and V: 2% (other kind of papers could have not assigned LOE).^[14] While based on our observations regarding the years between 1990 and 2000, the LOE of Iranian neurosurgeons' papers were I: 3.25%, II: 4.41%, III: 4.97, IV: 28.72%, V: 0%. The share of Iranian neurosurgeons' publications constituting level I and II papers has increased during time periods. Thus, parallel to the increase in the number of papers, also the LOE of the papers has improved over time. Most of the articles with level I evidence from Iranian neurosurgeons are related to therapy/prevention and etiology/harm category and are about pharmacological therapies rather than surgical therapies. This is consistent with publications in the above listed three neurosurgical journals.^[14] But comparative surgical studies and retrospective cohort studies in other categories (prognosis, diagnosis, and symptom prevalence and differential diagnosis) are not in proportion to published papers in those "index neurosurgical journals" and most of the papers in level II are non or quasi randomized pharmacologic trials. Lack of careful follow-up of the patients and a great percentage of patients lost to follow-up are causative for this deficit in the clinical research of Iranian neurosurgeons. One possible explanation for different LOE for different paper topics might be the different distribution of cases in Iran compared with other countries such as more trauma cases compared with more developed countries. Less common availability and utilization of new technologies, mostly due to financial limitations, are other reasons for having less research in these fields, which would translate to a lower LOE for those fields. The majority of researches take place in larger cities of the country, where main neurosurgical referral centers are located. This can be explained by the existence of residency training programs in these cities and therefore more funding resources, more international connections and more referral rates to these centers. Several patients from far areas of the country travel to larger cities solely for medical reasons. This is one of the most important reasons why there is a noticeably low follow-up rate. Another contributing factor to this unequal distribution is lack of appropriate management strategies. In addition to that, patients

with higher socioeconomic status tend not to refer to university-based hospitals and prefer to be treated in private medical centers. In addition to the above mentioned reasons, transportation expenses, missed work days, and the ensuing financial consequences are other factors contributing to the high proportion of missed follow ups. Most of the interventional studies from Iran were noncomparative studies, evident in the higher percentage of level IV evidence from publications of Iranian neurosurgeons compared with the published articles in the three above referenced neurosurgical journals. Papers published with neurosurgeons in topics other than neurosurgery had comparable LOE with papers related to neurosurgery.

The mean IF of Iranian articles did not increase significantly over the three time periods studied, which may be explained by either lack of quality of the submitted work or resistance of foreign journals to publish the papers, which could also stem from attitude and demand of reviewers toward the accuracy of third world countries' research. Thus, evaluating the IF of the journals where the papers had been published may not be the best indicator of research quality on its own. The quality of research depends on several different factors and in many occasions, making a general conclusion based only on the journals' IF, will undoubtedly lead to bias.^[15]

Other than LOE, novelty and creativity also affect the visibility of scientific papers. The number of times that an article is cited is considered a surrogate number for the impact of that article in the scientific community.^[13] We observed that the citations of Iranian neurosurgeons' articles decreased during the past two decades. In other words, although the number of publications has increased and the methodology of the papers has improved, this was not associated with an increased frequency of citations. Most of Iranian RCTs were published in local or nonhighly cited neurosurgery journals. The reasons for this need further investigation. However, the possible causes for publications of RCTs in Farsi journals might be due to three factors: (1) Residents who perform RCTs for their specialty thesis have to publish it before board examination. Therefore, it is important to submit the RCT in a journal that accepts it as soon as possible. (2) Translation, English language, and content edit take much time. (3) Most importantly, until a few years ago, standards of RCT performance especially ethical considerations and asking for RCT registration number were not the same level in Iranian and foreign countries journals. Interestingly, the number of years working as a university staff neurosurgeon or as a chairman was not correlated with the H index of the authors. It may be another finding that indicates that still innovative and cutting edge researches do not

constitute a considerable fraction of our experienced neurosurgeons' publications.

Creative and problem solving research requires well-educated research staff and sufficient funding sources, particularly in the field of neurosurgery where capability of utilizing new technologies is prevalent.^[3]

The current lack or delayed entry of new technologies into Iran contributes significantly to research projects falling below the level of standards of other international communities. Examples are: Neuroendoscopic and functional neurosurgery equipment, neuronavigation or integrated operating room magnetic resonance imaging. Primary results of a new technique or the application of such new technologies are attractive and may be published easier. After obtaining preliminary results with such novel technologies, more sophisticated research questions will attract the attentions of the international community and other funding sources. This is one aspect making it currently difficult for Iranian neurosurgeons to publish papers in fields driven by new technology.

Studies regarding the survival of the patients, symptom prevalence and prognosis of different health-related problems are scarce in our country, and neurosurgery is no exception. Despite an increase of higher quality articles with level I evidence, most of these are in the category of Therapy/Prevention, Etiology/Harm. Sophisticated multicenter RCTs with large sample sizes and longer, more elaborate and consistent follow up is scarce or absent. The office of research integrity considers data acquisition, management and collaborative works as core components of conducting such research.^[8] This is one aspect that has not yet improved in Iran to parallel the quantity and emerging quality of publications in the country.

The increase in the number of authors over the past decade mirrors the general trend of authorship proliferation in Western neurosurgical publications.^[9] The number of listed authors per article could be an indirect measure of such collaborations. Sophistication in research may be one reason for authorship proliferation, an observation which seems supported by the publication of papers with higher LOE during the past decade by Iranian neurosurgeons. However, competition for academic promotion and prestige of a sizable bibliography are among some other reasons for possible proliferation via "gifted" authorships.

Most of the Iranian papers were published by a few neurosurgeons and universities only. It is to some extent explained by fact that there is a focus available resource to the few universities. Shortage of resources in a technology-dependent field such as neurosurgery mandates centralization for offering better medical services.

Although we made an effort to gather all the publications from Iranian neurosurgeons, there still is the possibility of missing some data especially before the 1990s. We have tried to compensate for the lack of systematic listings for Iranian articles in PubMed by sending an e-mail to all identified authors, requesting them to send their published papers to us. The respective LOE for 18 such articles could not be assessed due to unavailability of the full-text. Indeed, the LOE of publication before 1990 may still be underestimated as some original articles could not be found and scored.

CONCLUSION

In conclusion, there has been steady growth of publications by Iranian neurosurgeons during recent years, especially after 2000. Associated with this increase in the total number of published papers, the methodology and the LOE of the papers have been improved. However, the impact of Iranian research has decreased during recent years. Research activity is limited to some academic neurosurgeons in the country. Most of the clinical papers are noncomparative and there is an obvious lack of multicenter clinical trials, survival studies, review articles, data management publications, and collaborative works. These are the aspects that demand particular attention in the neurosurgical community of Iranian neurosurgeons and future research will hopefully expand the scope of academic neurosurgery from this emergent country.

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