The correlation among *Y*-index and other scientometric indicators

Maryam Shekofteh*, Maryam Mohseny, Azam Shahbodaghi, Farid Zayeri and Forough Rahimi

Department of Medical Library and Information Sciences,
Faculty of Paramedical Sciences,
Shahid Beheshti University of Medical Sciences, Tehran, Iran

Scientometric analysis of research outputs is important in universities for research evaluation as it provides necessary inputs for decision makers. Common scientometric indicators are the number of publications, average citation per document, *h*-index and the number of authors. *Y*-index is also an indicator considering both the quantity and quality of scientific products, based on first author and corresponding author publications. This study aims at determining these indicators in first-grade universities of medical sciences in Iran and investigating the correlation among *Y*-index and other mentioned indices, and comparison between *Y*-index and *h*-index. The population under study comprised of all scientific productions of fourteen top universities of medical sciences in Iran, indexed in *Web of Science* in 2012 (7435 documents). The Tehran University of Medical Sciences is ranked first considering five indicators under investigation. A significant positive relationship was obtained among *Y*-index with the number of publications, the number of authors, and *h*-index. This indicates that *Y*-index can be a potential proper index, for qualitative and quantitative evaluation of universities along with other scientific and research institutions.

Keywords: Average citations, *h*-index, Iran, medical universities, scientific publications, *Y*-index.

SCIENTIFIC publications are of crucial importance to understand the output of researcher and faculty members at different institutional, national and international levels[1]. In research evaluation, policy-makers pay particular attention to the quality and quantity of these publications[2,3]. The most commonly used indicators are the number of publications, the citations received, the average citation per publication, *h*-index, etc.[4,5]. The number of publications may be qualitative but the other ones indicate the quantity of researches to some extent[6–8]. But these indicators do not take the authorship into consideration[5]. On the other hand, scientific collaboration is one of the fast growing characteristics of a research system. This can be an effective solution for improving scientific technology and knowledge for different countries. Co-authorship and collaboration in publishing articles is one of the indices for assessing the validity of scientific articles[9–12].

Scientific collaboration among authors was first created by French chemists in the early 19th century and it grew slowly until World War I, when it grew faster. Some researchers believe that there is a significant relationship between scientific collaboration and scientific publications which means that scientific output will increase as a result of enhanced scientific collaboration[13].

Presently, researchers tendency toward working independently has decreased while the number of co-authored articles has increased rapidly in many scientific spheres[14]. Authors play varied roles in publishing articles in scientific collaborations and it is clear that not all authors can be given the same credit. Studies indicate that the first and corresponding authors of an article are more important and accredited than the others. The first author participates actively in conceiving, designing, analysing and interpreting the data and publishing the article while the corresponding author supervizes the work directly and is responsible for correspondence with the journal and readers of the article. Other authors may not play the same important role as the first and corresponding authors[15–17]. Hence, authorship analysis can help to identify leaders among individual researchers, institutions, or countries[14].

Considering the important role of the first and the corresponding authors, the top first and corresponding authors of adsorption-related articles were examined by Ho[18]. Other researchers evaluated countries, institutions and domains based on the number of first and corresponding authors[19–21]. In 2012 Ho suggested *Y*-index for solving the deficiencies of previous indices and evaluating the validity of the researchers' scientific publications in an organization or a country, in *Chinese Journal of Chemical Engineering* and then in *Scientometrics*. *Y*-index is considered as a proper criterion for evaluating and ranking institutions based on first author publications (FP) and corresponding or reprint author publications (RP). Unlike other existing indices such as *h*-index which is mono-parametric, *Y*-index is the first one using two parameters (j, θ) and the formula is

$$j = (FP^2 + RP^2)^{1/2},$$

$$\theta = \tan^{-1}(RP/FP).$$

j shows the quantity of production based on important situations which depend on the number of first authors and corresponding author publications. If j in a university is greater, it means that the authors of that university have published more articles as the first author or the corresponding author. Another parameter (θ) is calculated to make sure who plays an important role among the authors. θ indicates the distribution of the first and the corresponding authors' publications. If $\theta \geq 0.7854$, it

*For correspondence. (e-mail: shekofteh_m@yahoo.com)

means more RP. If $\theta \leq 0.7854$, it means more FP. If $\theta = 0.7854$ it means the same quantity of FP and RP. When $\theta = 0$ means j = number of FP and $\theta = \infty$ it means j = number of RP[14,22].

Ho applied *Y*-Index to study top cited articles in chemical engineering in *SCI-Expanded* and examined different countries, institutes, and authors[14]. In another study, he analysed top cited articles published in *SCI-Expanded* from 1991 to 2010 using *Y*-index[22]. Fu and Ho[23] studied the scientific rank of China in the world and top cited articles and authors of this country using *Y*-index. This study extracted independent articles published in *SCI-Expanded* from 1980 to 2011, and it also compared them to the articles published in seven industrial countries. Fu and Hu[5] studied top cited articles in adsorption research using *Y*-index. The main contributors of authors, institutions and countries and their contribution characters were revealed by *Y*-index. The findings indicated that corresponding authors had received the highest citation and the number of the first and the corresponding authors is almost the same in most organizations and countries. Most top authors had more corresponding author articles. They concluded *Y*-index might be a better choice for evaluation. Ivanović and Ho[24] studied the independent publications in Serbia. Chuang and Ho[25] evaluated the highly cited publications in Taiwan using *Y*-index. They indicated: '*Y*-index is especially useful, in an era with an increasing number of authors, when unethical authorship practices are more likely, and when contributions of authors are diluted.' It reveals major contributors, ignoring unethical authors, such as gift authors, but also provides deep insights into the features of contributions.

The use of *Y*-index can encourage researchers to look at the extent of contribution, as well as the character of contribution. It can be used to complement existing indicators[4] and broadens current evaluation system with the consideration of authorship to reduce the problem of increasing multi-authorship and unethical authorship. It can be applied to examine important contributors and look further into the contribution characters of authors, institutions and countries of other fields[5].

Research into the evaluation of Iranian scientists' scientific publication started since the last two decades and is expanding. During recent years a noticeable number of theses and research projects have been conducted in this regard which signify growth of science in Iran[26]. Many of these studies are on the evaluation and ranking of Iranian universities using criteria such as number of scientific publications, citations received, *h*-index, impact factor, and *g*-index[27–31]. It is obvious that results achieved may be different if the universities are compared and ranked based on various scientometric indicators. As such, usually various indicators are used together for evaluating the activities of research institutes[32].

It is inevitable that the method of evaluation of scientific publications will impact on the behaviour and approach of researchers and authors in a way that authors will be directed towards the evaluation method. Findings indicate that in 1992 in England, scientists were intrinsically and normally inclined towards increasing the number of publications when the evaluation criterion was the number, but when in 1996 it was announced that the evaluation criterion has been changed from quantity to citation-based quality, the authors tried to increase publications with greater citation index[33]. Thus use of *Y*-index for evaluating scientific productions of universities may cause an increase in first and corresponding author publications.

Since *Y*-index is almost new and important, the present study aims at determining *Y*-index as well as common scientific indicators (the number of scientific publications, average citations and *h*-index) in the first-grade universities of medical sciences in Iran and studying the relationship between these indicators. The present results can affect future planning and policy makings of universities and institutions and research evaluation at different levels of authors, institutions and countries.

The research population in the present study encompassed all scientific publications (7435 documents) of 14 top-ranked universities of medical sciences in Iran, which were indexed in *Web of Science* in 2012. The data were collected on 2 December 2014 based on CU = Iran and PY = 2012 in *Web of Science Core Collection* including *Science Citation Index-Expanded*, *Social Science Citation*, *Art and Humanities Citation Index and Conference Proceedings Citation Index*. All medical sciences, universities names were individually selected and refined in Organization-Enhanced section. The number of citations, average citations and *h*-index were retrieved from citation report section of *WOS*. Spearman's Correlation Coefficient was used to determine the relationship between different indices.

Table 1 shows that 47.8% of total scientific publications of Iran in 2012 was published by medical universities and more than one-fourth of these publications was published by 14 top medical universities under study. This shows that 57.3% of the publications of medical universities were published by these top medical universities.

Table 2 shows that the Tehran University of Medical Sciences has the highest number of publications and citations, followed by Shahid Beheshti and Shiraz universities of medical sciences. However, the average citations per document and *h*-index show a different result. Tehran, Kerman and Shahid Beheshti universities of medical sciences are ranked first to third based on average citation and Tehran and Shahid Beheshti universities received the first and second ranks which Tabriz and Mashhad received the third rank.

Table 3 indicates that the Tehran University of Medical Sciences published more articles by the first and corresponding authors. Tehran, Shahid Behehshti and Shiraz universities of medical sciences are ranked first to third

Table 1. Scientific publications of universities in Iran based on WOS in 2012

Scientific publications	Number	Percentage
Scientific publication	27,136	100
Scientific publication of universities of medical sciences	12,968	47.8
Scientific publication of 14 top universities of medical sciences	7435	27.4

Table 2. The number of publications, citations and *h*-index of medical universities in Iran based on *WOS* in 2012

University of medical sciences	Number of pub. (rank)	Number of received citations (rank)	Average citations per doc. (rank)	*h*-index (rank)
Tehran	2797 (1)	9194 (1)	3.29 (1)	24 (1)
Shahid Beheshti	1806 (2)	4635 (2)	2.57 (3)	18 (2)
Shiraz	649 (3)	1276 (3)	1.96 (9)	12 (4)
Isfahan	646 (4)	1214 (4)	1.88 (11)	12 (4)
Tabriz	511 (5)	1211 (5)	2.35 (7)	13 (3)
Mashhad	484 (6)	1121 (6)	2.42 (5)	13 (3)
Baqiyatallah	223 (7)	530 (7)	2.38 (6)	9 (6)
Mazandaran	206 (8)	366 (10)	1.78 (12)	8 (7)
Kerman	196 (9)	515 (8)	2.63 (2)	10 (5)
Kermanshah	154 (10)	395 (9)	2.56 (4)	8 (7)
Urmia	138 (11)	273 (11)	1.98 (8)	6 (9)
Kashan	135 (12)	261 (12)	1.93 (10)	6 (9)
Ahvaz Jundishapur	131 (13)	201 (13)	1.52 (13)	7 (8)
Shahid Sadoughi	115 (14)	173 (14)	1.5 (14)	5 (10)

Table 3. *Y*-index and its parameters in universities of medical sciences in Iran based on *WOS* in 2012

University of medical sciences	Total publication	Total authors	First author	Reprint (corresponding) author	First and reprint author	One author	*j* (rank)	θ
Tehran	2797	9154	852	578	490	42	1774.13 (1)	0.67
Shahid Beheshti	1806	5100	640	495	378	27	1379.13 (2)	0.86
Isfahan	646	1915	386	368	295	23	982.96 (3)	0.97
Shiraz	649	1896	272	200	208	3	634.20 (4)	0.85
Tabriz	511	1515	226	213	115	8	484.45 (5)	0.96
Mashhad	484	1638	203	61	74	11	323.89 (6)	1.35
Urmia	138	335	29	29	74	5	152.73 (7)	1
Kermanshah	154	522	44	49	49	0	135.10 (8)	1.05
Kerman	196	802	62	45	41	0	134.18 (9)	0.83
Ahvaz Jundishapur	131	450	70	42	29	0	121.82 (10)	0.71
Mazandaran	206	754	45	45	36	2	117.42 (11)	1
Baqiyatallah	223	224	33	55	22	0	94.62 (12)	1.03
Kashan	135	234	36	23	18	2	70.60 (13)	0.76
Shahid Sadoughi	115	370	22	32	31	0	32.82 (14)	1.18

based on *j* parameter. In addition, θ shows that most of the publications in 11 universities are related to corresponding authors. Its largest number is related to Mashhad University of Medical Sciences followed by Shahid Sadoughi and Kermanshah universities of medical sciences. Only in three universities of medical sciences (Tehran, Kashan and Ahvaz Jundishapur) its number is less than 0.7854. It shows that most of the authors of these universities have been first authors.

According to values in different indices presented in Tables 2 and 3, the correlation coefficient between parameter *j* of *Y*-index and *h*-index with other indicators was calculated. The diagram of correlation is presented in Figures 1 and 2.

The correlation coefficient between *Y*-index (*j* parameter) and the number of scientific productions was 0.855; between *Y*-index and *h*-index was 0.839; between *Y*-index and total authors was 0.881 ($P \leq 0.001$) which indicates a direct and significant relationship between *j* parameter and mentioned indicators.

The correlation coefficient between *Y*-index and the mean of received citations was 0.525 ($P = 0.054$). The

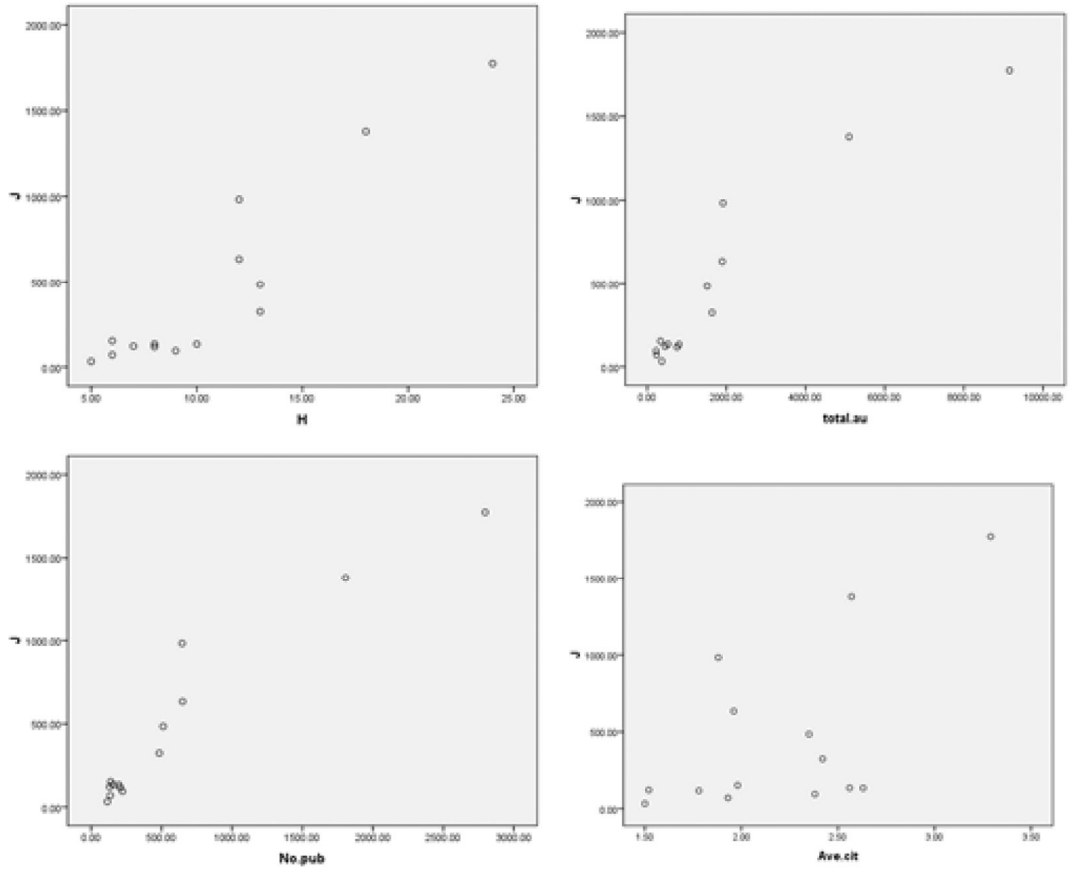

Figure 1. Scatter plot between *Y*-index and *h*-index, total authors, number of publications and average citations.

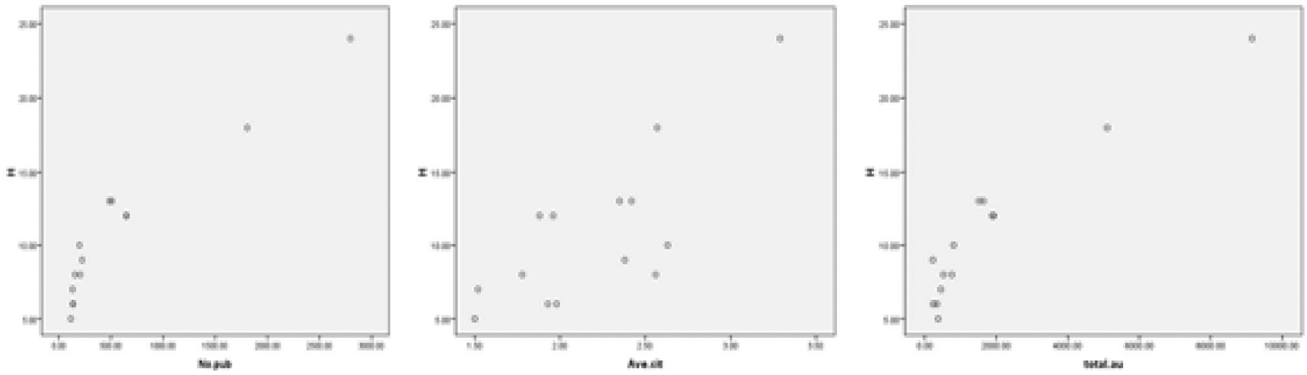

Figure 2. Correlation diagram between *h*-index and total authors, publication number and average citations.

P-value indicates that there is no significant relationship between *j* parameter and the mean of citations received.

The correlation coefficient between *h*-index and the number of scientific publications was 0.932; between *h*-index and total authors it was 0.854; and between *h*-index and the mean of citations it received was 0.66 ($P \leq 0.001$) which indicates a direct and significant relationship between these parameters.

These findings show that Tehran and Shahid Beheshti universities of medical sciences have a larger number of scientific publications and citations. It indicates that since these universities have larger faculty and students, research centres, colleges, libraries and hospitals, they publish more articles and play a key role in science output. In addition, the faculty members' rankings and the antiquity of the university are two other factors that may affect this issue.

The results of the evaluation of medical universities' research activities in 2006 emphasize the point that universities of medical sciences with more facilities had

more scientific publications and greater citations as compared to other universities[34].

The average number of citations received per document varies between 1.5 and 3.29 which is almost negligible. This shows that the importance of articles published is low. The *h*-index values indicate that Tehran University of Medical Sciences is ranked first. Other studies also showed that *h*-index is a simple function of citations and with an increase in the number of citations this index also increases[35,36]. It can be said that the reason for low values of *h*-index, like average citations, is the short time interval between the date of publication of these articles and their retrieval dates.

The findings indicate that Tehran, Shahid Beheshti and Isfahan universities of medical sciences ranked first to third respectively, regarding *Y*-index. If a university's total number of publications is higher but its authors are neither the first nor corresponding authors, such publications will not provide any advantage for that university regarding *Y*-index.

With regard to the value of θ, it is recommended that universities pay more attention to publishing articles with organizational affiliation of the first author. The θ values indicated that only three universities had the highest number of publications by the first author.

These findings indicate a direct and significant relationship between *Y*-index and scientific publications, number of authors, and *h*-index which confirm the results of Ho indicating that *Y*-index increases with increase in the number of scientific productions of a country or an institute[22]. This means if the number of authors and the number of publications increase then *j*-parameter increases. And if the *j*-parameter increases, *h*-index also increases.

Fu and Ho[23] demonstrated that *j* parameter is higher in articles with higher citations which is contradictory to the present results indicating that there is no relationship between *j* parameter and the average citations per document.

Comparison of *Y*-index and *h*-index with other indicators shows that these two indicators are the same if compared with number of publications and the number of authors. A strong correlation between *h*-index and average citations was obtained, but there was no relationship between *y*-index and average citations.

The correlation coefficients indicate, as Fu and Ho[5,23] have mentioned *Y*-index shows both quantity and quality at the same time and can be used as a new index for ranking universities, countries and faculty members from a different angle of authorship. It can be used in research evaluation systems to decrease the problem of increasing multi-authorship.

Considering the present research population and the correlation results obtained, it is recommended that these relations be investigated in a study with larger samples, which can be selected amongst authors or universities. If a positive relationship is achieved between *Y*-index and other indices, it can increase the validity of the *Y*-index.

1. Geuna, A. and Martin, B. R., University research evaluation and funding: An international comparison. *Minerva*, 2003, **41**, 277–304.
2. Moed, H. F., Citation analysis in research evaluation (Vol. 9), Dordrecht: Springer Science and Business Media, 2006.
3. Van den Besselaar, P. and Sandström, U., Does quantity make a difference? The importance of publishing many papers. http://www.researchgate.net/profile/Ulf_Sandstroem/publication/280110798_Does_Quantity_Make_a_Difference/links/55ab981608ae815a-0427b624.pdf; accessed on 2 September 2015.
4. Rehn, C., Kronman, U. and Wadsko, D., Bibliometric indicators definitions and usage at Karolinska Institutet, Stockholm: Karolinska Institutet University Library, 2007.
5. Fu, H. Z. and Ho, Y. S., Top cited articles in adsorption research using Y-index. *Res. Eval.*, 2014, **23**, 12–20.
6. Avkiran, N. K., Scientific collaboration in finance does not lead to better quality research. *Scientometrics*, 1997, **39**, 173–184.
7. Cole, J., and Cole, S., Measuring the quality of sociological research: problems in the use of the Science Citation Index. *Am. Sociol.*, 1971, **6**, 23–29.
8. Hirsch, J. E., An index to quantify an individual's scientific research output. *Proc. Natl. Acad. Sci. USA*, 2005, **102**, 16569–16572.
9. Lu, H. and Feng, Y., A measure of authors' centrality in co-authorship networks based on the distribution of collaborative relationships. *Scientometrics*, 2009, **81**, 499–511.
10. Sonnenwald, D. H., Scientific collaboration. *Ann. Rev. Info. Sci. Tech.*, 2007, **41**, 643–681.
11. Wang, Y., Wu, Y., Pan, Y., Ma, Z. and Rousseau, R., Scientific collaboration in China as reflected in co-authorship. *Scientometrics*, 2005, **62**, 183–198.
12. Mali, F., Kronegger, L., Doreian, P. and Ferligoj, A., Dynamic scientific co-authorship networks. In *Models of Science Dynamics*, Berlin, Springer, 2012, pp. 195–232.
13. Harzing, A. W., Australian research output in economics and business: high volume, low impact? *Aust. J. Manage.*, 2005, **30**, 183–200.
14. Ho, Y. S., Top-cited articles in chemical engineering in Science Citation Index Expanded: A bibliometric analysis. *Chinese J. Chem. Eng.*, 2012, **20**, 478–488.
15. Mattsson, P., Sundberg, C. J. and Laget, P., Is correspondence reflected in the author position? A bibliometric study of the relation between corresponding author and byline position. *Scientometrics*, 2010, **87**, 99–105.
16. Slone, R. M., Coauthors contributions to major papers published in the AJR: frequency of undeserved coauthorship. *AJR Am. J. Roentgenol.*, 1996, **167**, 571–579.
17. Burman, K. D., Hanging from the masthead: reflections on authorship. *An. Inter. Med.*, 1982, **97**, 602–605.
18. Ho, Y. S., Bibliometric analysis of adsorption technology in environmental science. *J. Envir. Protect. Sci.*, 2007, **1**, 1–11.
19. Mao, N., Wang, M. H. and Ho, Y. S., A bibliometric study of the trend in articles related to risk assessment published in Science Citation Index. *Hum. Ecol. Risk. Assess.*, 2010, **16**, 801–824.
20. Wang, M. H., Fu, H. Z. and Ho, Y. S., Comparison of universities' scientific performance using bibliometric indicators. *Malays. J. Libr. Inf. Sci.*, 2011, **16**, 1–19.
21. Ho, Y. S., Satoh, H. and Lin, S. Y., Japanese lung cancer research trends and performance in Science Citation Index. *Intern. Med.*, 2010, **49**, 2219–2228.
22. Ho, Y. S., The top-cited research works in the Science Citation Index Expanded. *Scientometrics*, 2013, **94**, 1297–1312.

23. Fu, H. Z. and Ho, Y.-S., Independent research of China in Science Citation Index Expanded during 1980–2011. *J. Informetr*., 2013, **7**, 210–222.
24. Ivanović, D., and Ho, Y. S., Independent publications from Serbia in the Science Citation Index Expanded: a bibliometric analysis. *Scientometrics*, 2014, **101**, 603–622.
25. Chuang, K. Y. and Ho, Y. S., An evaluation based on highly cited publications in Taiwan. *Curr. Sci.*, 2015, **108**, 933.
26. Niakan, S. and Gharibi, H., Iran Knowledge: Iranian Contribution to International Knowledge. Year 2000, Tehran, Iranian Information and Documentation Center (IRANDOC), 2003.
27. Abolghassemi Fakhree, M. A. and Jouyban, A., Scientometric analysis of the major Iranian medical universities. *Scientometrics*, 2011, **87**, 205–220.
28. Yazdani, K., Rahimi-Movaghar, A., Nedjat, S., Ghalichi, L. and Khalili, M., A 5-year scientometric analysis of research centers affiliated to Tehran University of Medical Sciences. *Med. J. Islam Repub. Iran (MJIRI)*, 2015, **29**, 206–200.
29. Sharifzadeh, S., Ghasempour, M., Hajebrahimi, M., Rezaianzadeh, A. and Dehghan, S., Evaluation of the scientific output in one of the major medical universities of Iran. *Shiraz E. Med. J*., 2014, **15**.
30. Shahbodaghi, A. and Shekofteh, M., A comprehensive study of published articles by members of SBMU and their citation status as reported by the Institute for Scientific Information (ISI) from 1998–2007. *Pajouhesh Dar Pezeshki (J. Res. Med. Sci.)*, 2009, **33**.
31. Noori, R., Norouzi, A. and Mirzaee, A., Science Production of IUMS Researchers as Appeared in the Web of Science from 1976 to 2006. *Health Inf. Manage*, 2008, **3**, 73–82.
32. Ebrahimi, S. and Jowkar, A., The situation of scientific publications of Iran's universities of medical science on the basis of Scientometrics Qualitative and Quantitative Indicators 1997–2006*. *Health Inf. Manage*, 2010, **7**.
33. Ho, Y. S., Bibliometric analysis of biosorption technology in water treatment research from 1991 to 2004. *Int. J. Environ. Pollut.*, 2008, **34**, 1–13.
34. Iran ministry of health and medical education. Deputy of research and technology.The result of evaluation of medical universities of medical sciences in Iran 2006. hbi.ir/research/evaluation/university/.../report85.pdf.ccessed20 August 2015.
35. Guan, J. and Gao, X., Comparison and evaluation of Chinese research performance in the field of bioinformatics. *Scientometrics*, 2008, **75**, 357–379.
36. Cronin, B. and Meho, L., Using the h-index to rank influential information scientists. *J. Assoc. Inf. Sci. Technol.*, 2006, **57**, 1275–1278.

ACKNOWLEDGEMENTS. This article had been extracted from the M. D. thesis (2015) by the first author (Maryam Mohseny) and supervized by one of the co-authors (Maryam Shekofteh).

Received 23 September 2015; revised accepted 7 December 2015

doi: 10.18520/cs/v110/i9/1823-1828

Natural frequency of cancer cells as a starting point in cancer treatment

Saravana Kumar Jaganathan[1,*], Aruna Priyadarshni Subramanian[1], Muthu Vignesh Vellayappan[1], Arunpandian Balaji[1], Agnes Aruna John[1], Ashok Kumar Jaganathan[2] and Eko Supriyanto[1]

[1]IJN-UTM Cardiovascular Engineering Centre, Faculty of Biosciences and Medical Engineering, Universiti Teknologi Malaysia, Johor Bahru 81310, Malaysia
[2]Research and Development Wing, AVTEC Ltd, CK Birla Group, Hosur 635 114, India

Breast cancer and prostate cancer are the most common gender-specific types of cancer among women and men respectively, around the world. The most preferred treatment embraced by the patients is chemotherapy. The anticancer drugs developed and used so far cannot completely cure cancer at all stages and also exhibit some side effects in the patients who undergo chemotherapy. Besides this, some cancer cells eventually acquire resistance to many drugs and evade the treatment procedures. All these factors play a vital role in persuading the researches to find alternative modes of treatment for cancer. This communication proposes an unconventional mode of cancer treatment by determining the natural frequencies of normal and cancer cells. By utilizing these frequencies, it is possible to kill the cancer cells specifically, sparing the healthy cells. The normal and cancer cells in case of breast (MCF-10A, MCF-7) as well as prostate cancer (BPH, LNCap) are modelled as a sphere in ANSYS. The modal analysis is done in order to obtain their natural frequencies along with their mode shapes at different frequencies. The results show that the natural frequency of the normal cells is much higher than that of the cancer cells at each corresponding mode. The natural frequency is proportional to the mechanical properties of the cells and is insignificant with respect to the change in diameter of the cells. Thus, utilizing the natural frequency, cancer cells may be specifically targeted while the burdens of chemotherapy and drug resistance.

Keywords: Breast cancer, modal analysis, natural frequency, prostate cancer.

CANCER cells divide uncontrollably and grow rapidly, forming malignant tumours as well as invading nearby organs of the body. Cancer can also spread to more distant parts of the body through the lymphatic system or bloodstream. According to the American Cancer Society (ACS), a total of 1,658,370 new cancer cases and 589,430 cancer deaths were projected to occur in the United States

*For correspondence. (e-mail: saravana@utm.my)