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Original article

Scientific Collaboration among Medical Ethics Researchers: A Scientometric Study

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Abstract

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Introduction: Scientific collaboration at the national and international levels influences papers' quality and quantity improvement. Accordingly, this research was designed to analyze the model of scientific collaboration among researchers in medical ethics.

Methods: The research was scientometric and conducted using scientific analysis and drawing indicators. The study population included 14333 documents indexed in the Web of Science (WoS) from 1975 to 2020. Therefore, BibExcel, SPSS, and VOSviewer software were used to analyze and draw the data. In addition, Pearson's correlation coefficient statistical test was utilized to answer the research hypotheses.

Results: The coefficient of collaboration (CC), degree of collaboration (DC), and collaboration index (CI) were obtained to be 0.40, 0.59, and 2.32, respectively. In the last decade, authors have indicated more inclination toward the multiple authorship model; however, most of this type of collaboration is domestic (national), and only 17.8% is international. The highest co-authorship and international collaboration rates belong to the United States (US) among the 152 countries. Furthermore, Pearson's correlation test between the number of papers and international collaboration at the significance level of (0.000) suggests a positive direct relationship ($p\text{-value} < 0.05$).

Conclusion: The dominant authorship pattern has been single authorship during the studied period. The tendency of researchers concerning co-authorship occurs within an average and growing level and is not in a favorable situation in terms of international collaboration.

Introduction

Ethics is the value dimension of human decisions and behaviors, including good or bad, right or wrong, and fair or unfair actions (1). Adhering to ethics is one of the most critical issues of human social life in human history. The issue of ethics has

undergone a broader and more complicated form with the growth of social life and scientific and technological advances (2).

Medical science is one of the sciences strongly influenced by moral crises. Undeniably, ethics has



been considered an integral part of medical science since its formation (3). The first effect of medical ethics may be traced back to the Hippocratic Oath (500 B.C.E.) in ancient times. Islamic medicine was at the forefront in the Middle Ages and the early modern period, and the book "Adab-al-Tabib" (Behavior of a Physician) by Ishāq bin Ali al-Rohawi was a step forward in developing the concept of medical ethics. The pharmaceutical community's attention was drawn to this new concept in the 18th and 19th centuries. Thomas Percival's "Medical Ethics" book is crucial (4, 5). Medical innovations such as gene therapy, cloning, cell, tissue, organ transplantation, and the like have led to many ethical issues that did not exist in conventional medical methods. Therefore, it has made the scientific and ethical communities review traditional issues (5).

Understanding professional values and ethical behavior seems essential for developing a good physician since a physician benefiting from more admirable moral qualifications can attract more trust. Accordingly, medical ethics has become a global component in clinical education courses in recent years (3, 6, 7), and several scientific studies have been conducted in this area.

Research is usually utilized to discover novel knowledge or achieve information regarding a specific subject (8). The publication of scientific findings will be influential in recognizing authors, professional respect, promotion, and advancement and will also affect the funding for future research works (9). Participation and collaboration are known as the mechanisms of researchers' scientific development (10). Performing scientific research at the international level is the broadest type of scientific collaboration, which improves the generation of scientific knowledge besides enhancing the scientific power of developing countries. On the other hand, it creates a proper atmosphere for developing communications and sharing abilities and skills (11, 12). Co-authorship is an obvious and documented form of scientific collaboration (13). Evaluating the co-authorship situation as a method to assess the amount of scientific collaboration among different authors is recognized as one of the

significant and most common quantitative methods in scientometric studies, in which the collaboration index (CI), degree of collaboration (DC), and coefficient of collaboration (CC) are used (14).

The CI and DC indicate the mean number of authors of the article and the ratio of the papers of several authors first introduced by Lawani (15) and Subramanyam (16), respectively. Ajiferuke believes that both scales are incomplete and demonstrates that the collaboration coefficient (CC) is a single scale with the advantages of both scales (17). The coefficient of collaboration is a measure of collaboration in research, representing the mean number of authors in each paper and articles with multiple authors (18).

Multiple studies have examined the collaboration of authors in different subject areas (19, 20). The resulting findings suggest that the tendency of authors to collaborate in groups has enhanced over time. A direct linear relationship is found between the growth of scientific production and scientific collaboration. The analysis of co-authorship patterns and networks in scientific publications reveals that the ratio of domestic and international collaboration is on the rise, positively affecting the quality and observability of scientific productions. The researchers think several factors, such as political, cultural and linguistic, individual, motivational, skill-based, organizational, and communicative variables, are involved in the growth of scientific collaborations (8, 9, 14, 17, 18, 21-24).

Literature review shows that many scientometrics studies have dealt with the area of medical ethics (25-29); however, until now, the scientific participation of researchers in the field of medical ethics has yet to be investigated. This research aims to identify the authorship and collaboration pattern and draw a collaboration network between the countries that produce science in this field. Assumedly, the co-authorship count and national and international collaborations have increased over time. To test the hypotheses, they are following objectives:

- Analysis of annual growth of articles
- Analysis of co-authorship pattern
- Analysis of collaboration indicators
- Drawing of collaboration network.

Methods

This study is scientometric research based on the indicators of co-authorship analysis and drawing the collaboration network. The data of this study was collected from the WoS database with the "WC=medical ethics" strategy. The initial search found 30,324 documents from 1975 to 2020. Based on the type of document (article or review), 16321 articles were recorded in the final study and downloaded as Plain text files on August 6, 2023. One thousand nine hundred eighty-eight papers were omitted due to the need for complete information, and 14333 papers remained. The study period was divided into five intervals to analyze the data: The first period (1975-2000), the second period (2001-2005), the third period (2006-2010), the fourth period (2011-2015), and the fifth period (2016-2020). Approximately 85% of the omitted articles belonged to the first period (1975-2000). The data were analyzed using Bibexcel and SPSS software, while the collaboration network was drawn with VOSviewer software. Moreover, Pearson's correlation coefficient statistical test was also utilized to answer the research hypotheses.

The following equations were used in this research:

Average Annual Growth Rate (AAGR):

The growth rate for each individual period in the series must be computed to compute the average. It can be done by using the basic formula below:

$$\text{Growth Rate Percentage} = ((EV / BV) - 1) \times 100\%$$

EV = The ending value

BV = The beginning value

$$\text{AAGR} = \frac{\text{GR}_y + \text{GR}_{y+1} + \dots + \text{GR}_{y+n}}{N}$$

GR_y = Growth rate in year 1

GR_{y+1} = Growth rate in the next year

GR_{y+n} = Growth rate in the year "n"

N = Total number of periods

The AAGR measures the average annual growth rate over a specified period.

Collaboration Index (CI):

$$\text{CI} = \frac{\sum_{j=1}^k j f_j}{N}$$

j = Number of authors of the paper (i.e., 1, 2, 3...)

f_j = Number of authored papers j

N = Total number of published papers

k = Total number of authors of each paper

The CI indicates the average number of authors of each paper and determines the difference between the levels of authors. It gives a non-zero weight to the authorships with no collaboration. One of the disadvantages of this index is that it does not have an upper limit, so it cannot be interpreted.

Degree of Collaboration (DC):

$$\text{DC} = 1 - \frac{f_1}{N}$$

f_1 = Number of single-author papers

N = Total number of published papers

This index indicates the number of multiple-author papers compared to the total articles of a period, which ranges between 0 and 1. As this number tends to be 1, it will show evidence of fewer single-author papers. A zero weight is given to the single-author papers in computing this index. However, it fails to show any difference between the different levels of multiple authorship.

Collaboration Coefficient (CC):

$$\text{CC} = 1 - \frac{\sum_{j=1}^k (1/j) f_j}{N}$$

j = Number of authors of the paper (i.e., 1, 2, 3...)

f_j = Number of authored articles j

N = Total number of published articles

k = Total number of authors in each article

The CC takes a number between zero and one, and as it further tends to one, it suggests more collaboration between the authors (17).

Results

The scientific production in medical ethics began with 82 papers in 1975 and ended with 1179 articles in 2020. As seen in Figure 1, the growth of authoring articles in this field has been upward. However, it

does not follow a stable trend and has fallen into a decreasing trend in some years compared to years before. The highest growth rate percentage was seen in 1977, and the mean growth rate was 7.8%.

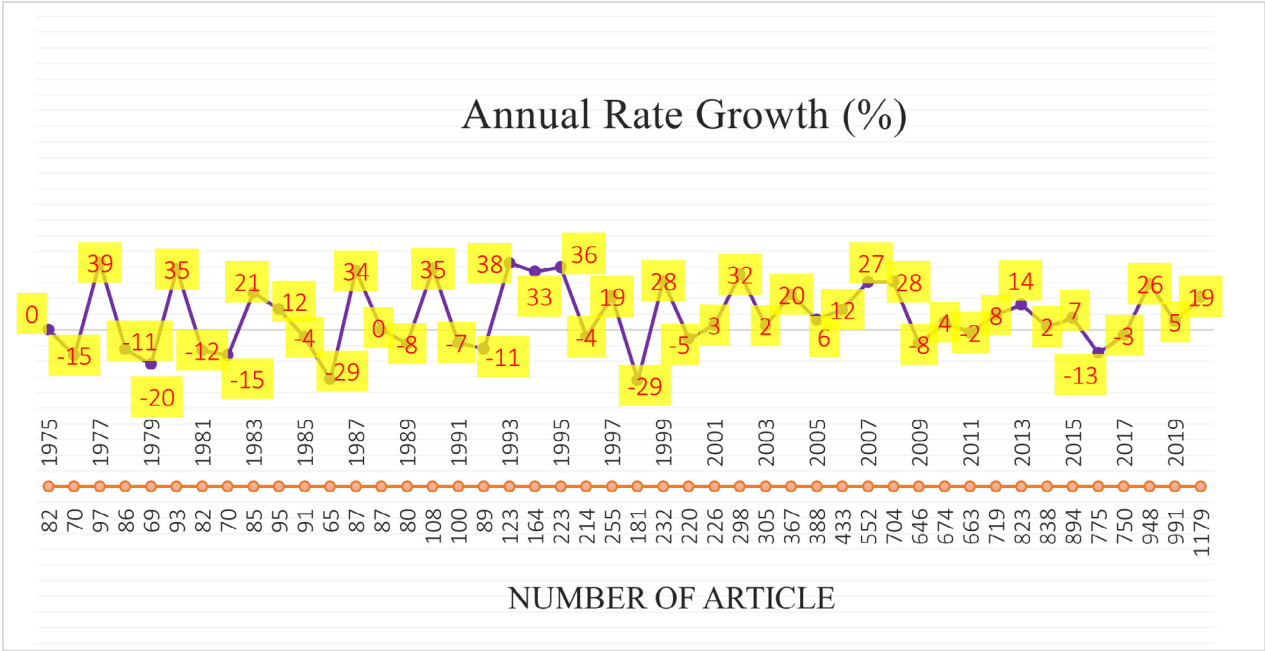


Figure 1. The number and growth trend of papers in medical ethics during 1975-2020.

Table 1 represents a view of the behavior of authors in co-authoring. Accordingly, 5,886 (41%) papers in medical ethics have been generated individually. The bi-authorship has been the dominant model of multiple authorship during these years. This trend is observed in all the studied periods. According to the

calculations, among 8447 papers with a co-authorship model, 82.2% have considered national collaboration, and 17.8% of the co-authorship has been performed in the form of international collaboration. Additionally, approximately 76% of the international collaboration has been made with two countries' participation.

Table 1. Co-authorship model in the articles in the field of medical ethics from 1975 to 2020

		First period (1975-2000)	Second period (2001-2005)	Third period (2006-2010)	Fourth period (2011-2015)	Fifth period (2016-2020)	Total
Total articles		1610	1498	2910	3917	4398	14333
Number of authors	1	817	641	1259	1491	1678	5886
	2	285	262	589	810	949	2895
	3	199	167	333	493	658	1850
	4	109	167	214	375	385	1250
	5	74	117	177	247	256	871
	>5	126	144	338	501	472	1581
Number of collaborating countries	1	1610	1498	2702	3324	3556	12690
	2	0	0	170	457	623	1250
	3	0	0	18	84	141	243
	4	0	0	4	27	45	76
	5	0	0	7	9	11	27
	>5	0	0	9	16	22	47

The CI formula was used to compute the average number of authors. The results suggested that the average number of authors per article is growing over time, so the fifth period (2016-2020) has the highest rank with 2.32 authors per article. The mean CI in the whole period is 2.47 authors per article.

The findings also indicated that the fifth period (2016-2020) obtained the highest DC, and the mean value of this index in the entire period was equal to 0.59, which justifies the closeness of the number of single-author articles to the multiple-author papers. In general, the DC of the authors is moderate and on the rise.

Table 2. Co-authorship indicators in the field of medical ethics papers from 1975 to 2020

Year	First period (1975-2000)	Second period (2001-2005)	Third period (2006-2010)	Fourth period (2011-2015)	Fifth period (2016-2020)	Total period (1975-2020)
CC	0.33	0.39	0.38	0.42	0.41	0.40
DC	0.49	0.57	0.57	0.62	0.62	0.59
CI	1.90	2.23	2.23	2.47	2.43	2.32

In contrast to the other two indicators, the CC was introduced to better represent the rate of multiple authorship in papers and considers the co-authorship status more favorable in the fourth period (2011-2015). However, the CC is low in all periods. The mean CC in the whole period equals 0.40 (Table 2).

The results of the correlation studies are shown in

Table 3. The results show a positive and significant correlation between the variables coefficient of cooperation, the number of articles, and the level of national and international cooperation (p-value < 0.05). However, a weak positive relationship was observed between the coefficient of cooperation and international cooperation, with a correlation coefficient of 0.343.

Table 3. The correlation coefficient between the number of papers and scientific collaboration variables

	Article	P	National collaboration	P	International collaboration	P
National collaboration	996**	<0.01				
International collaboration	918**	<0.01	879**	<0.01		
Collaboration coefficient	510**	<0.01	536**	<0.01	343*	0.02
** Correlation is significant at the 0.01 level (2-tailed).						
* Correlation is significant at the 0.05 level (2-tailed).						

Scientific collaboration at the national level, primarily at the international level, is recognized as a significant factor affecting the quantity of papers. In the current research, 152 countries have produced articles on medical ethics. However, 137 countries have had international collaboration. By producing more than 40 percent of articles (N=5733), the US obtains the first rank, followed by England (N=2105) and Canada (N=1061) in the following rankings with a significant difference.

Ten leading countries are depicted in Figure 2. On the

other hand, the countries leading in producing articles try to maintain their positions in international collaboration and multiple authorship. However, Switzerland, France, and the Netherlands produced many articles with international collaborations. National collaboration is more common than international collaboration in all countries, and in most countries, the model of multiple authorship appears as the prevalent behavior in the scientific collaboration of authors. About 97% of articles in Turkey follow the multiple-author model; however, international collaboration is negligible.

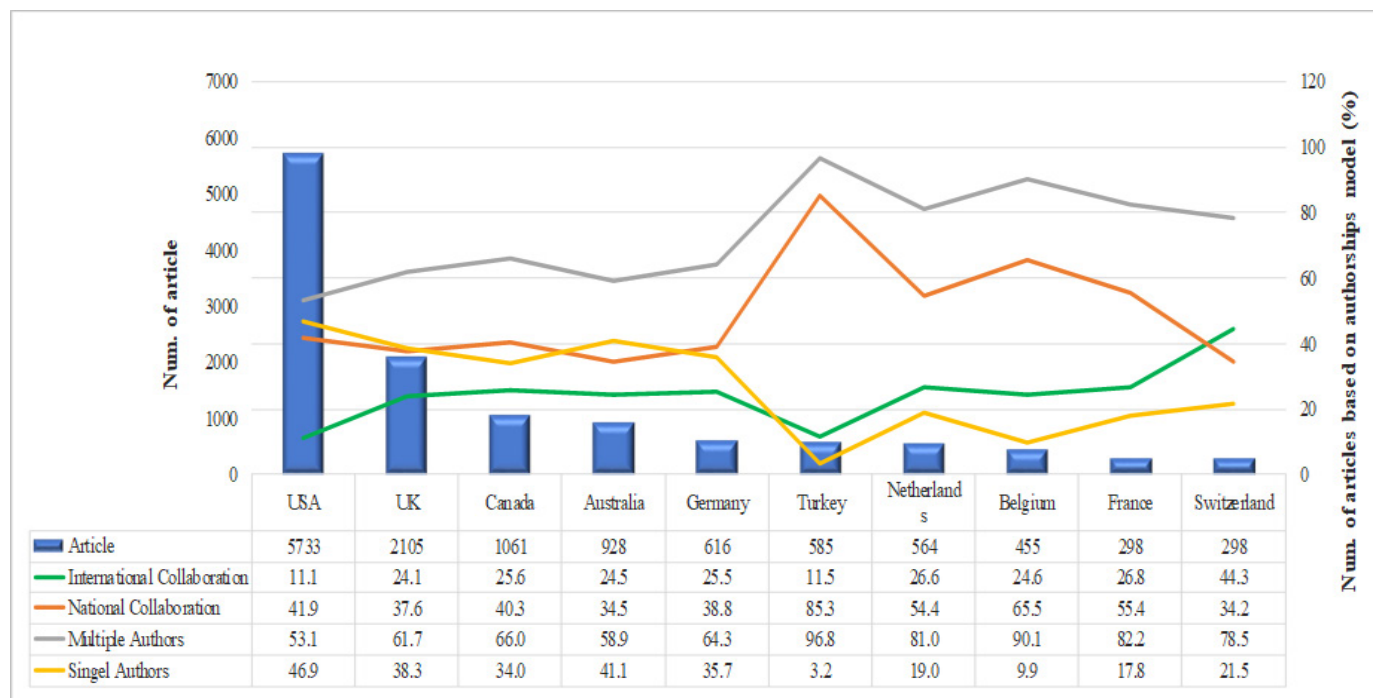


Figure 2. The number of articles and the authorship model of the top 10 countries in the production of articles in the field of medical ethics from 1975 to 2020

The collaboration network of authors was drawn based on the countries producing papers in medical ethics based on the degree of centrality. As indicated in Figure 3, the international collaboration network consists of three components, including 3092 connections and 137 nodes (countries); 15 countries only rely on national cooperation. The size of the nodes is based on the number of connections with other nodes, which means that the larger the number of

collaborating countries, the bigger the node. Therefore, the USA, England, France, Germany, and Canada are the top five countries and have cooperated with more countries. Considering that the thickness of ties shows the number of cooperation between two countries, in this sense, the USA has been more active than other countries and has cooperated more times with other countries. The highest number of collaborations was also observed between the USA and Canada.

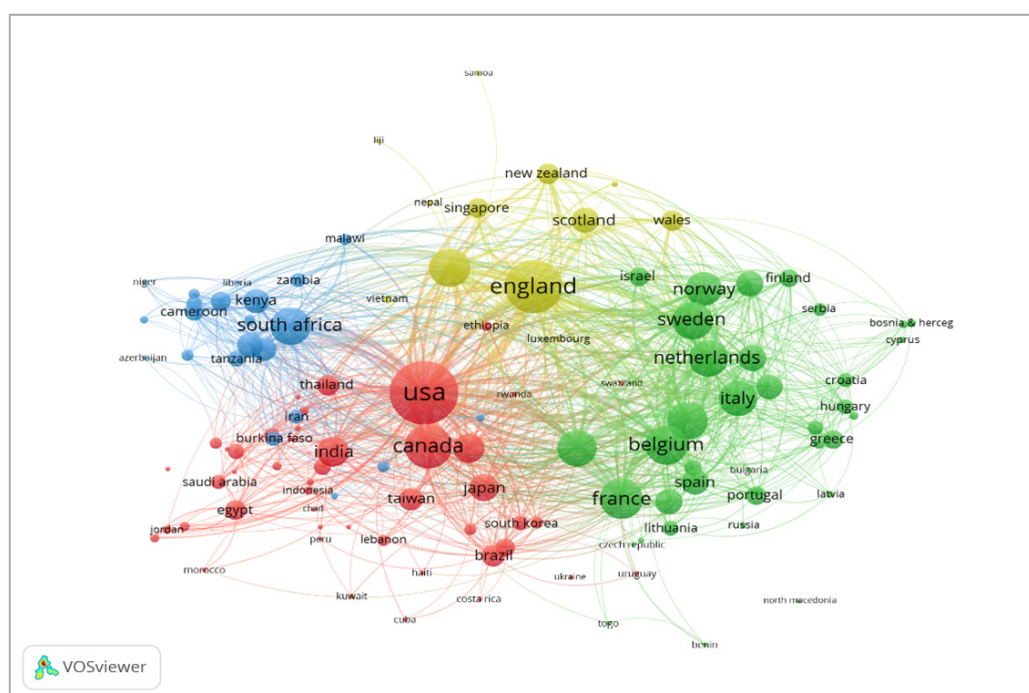


Figure 3. Collaboration network of the countries in the production of articles in the field of medical ethics from 1975 to 2020

Discussion

The present paper was authored to analyze the co-authorship model of researchers and the status of scientific collaboration in medical ethics in the countries, which is associated with the growth of the production of articles similar to other scientific fields. Reviewing the growth of scientific papers in this field based on the documents indexed in the WoS databases during the studied years (1973-2019) reveals that the mean annual growth rate during these 46 years was equal to 7.8%.

Scientific collaboration influences knowledge production and development since a researcher always experiences the constraints of time, knowledge, and skills, as well as the high cost of research. Therefore, science collaborations are recognized as a critical element in advancing knowledge (30, 31). Joint authorship is one of the prominent and documented forms of scientific collaboration evaluated with scientometric indicators in this research. According to the results, the dominant authorship model during the studied period has been single authorship followed by the collaboration model of 2-5 authors; however, articles with the participation of more than five authors were found to be rare (in the production of medical ethics articles, 6-28, 32, 38, 43, 50 and 59 authors were observed). Another significant point in this finding is the increase in scientific collaboration over time, such that the single authorship pattern in each period has decreased compared to the total productions of the same period. The fourth and fifth periods have the lowest percentage of single authorship (38% of the total production); nevertheless, the dominant model is still single authorship. Previous studies also obtained this finding (8, 18). At the same time, other studies (9, 24) have achieved contradictory results. Their findings suggest that the number of multiple-authored articles has overtaken single-authored articles by a large percentage over time, and the 2-5 authorship style has become popular among authors.

The calculation of the CI obtained the average number of authors to be 2.32. This number is higher than the findings of Gaud et al. (8), and Verma et al. (18). The average number of authors

in medical studies (14, 24, 32) is higher than four. The DC equal to 0.59 indicates the moderate tendency of authors to multiple authorship, while more than 90% of the scientific productions have been collaborative in pharmaceuticals, cardiology, and the products of Shahid Beheshti University (14, 24, 32). Moreover, the CC equal to 0.40 suggests that co-authoring in medical ethics does not follow a favorable status compared to other fields (8, 14, 18, 24, 33), confirmed by 41% of single-authored articles.

National and international collaboration is another type of scientific collaboration that has experienced rapid growth. National and international scientific collaborations have always been a topic of discussion and have had an advantageous position as an essential and influential indicator in scientific policy-making (34). The present study found that 137 countries have participated in international collaboration. However, the international to national co-authorship ratio is negligible (about 13%). This finding is consistent with Naraghian and Mohammad Esmail's research (33).

The USA has achieved the highest rank with 865 international collaborations, plays a central role in the network at the collaboration map, and has formed approximately 24% of the connections, and if it is removed, the collaboration network will be disconnected. Similar results have been reported in previous studies (23, 24). After the USA, England, Germany, France, and Canada established more common relations with other countries. Notably, a country's high number of international papers does not essentially suggest more international colleagues. As indicated in this research, Canada and Australia, with the third and fourth ranking in international production in terms of the number of collaborating countries, are placed after France and Germany. These countries have stronger connections with fewer partner countries and have collaborated many times.

The evaluation of the relationship between the number of articles, the coefficient of co-authorship, and international collaboration demonstrated a significant positive relationship between the number of papers and international collaboration.

Although international collaboration requires co-authorship, this research found a weak relationship between these two variables. On the other hand, more tendency toward multiple authorship could not justify the growth of articles. This result suggests that many factors may affect the scientific growth of a field, and the variables investigated in this research are only part of those factors. The research results of Riahi et al. and Ahmadi et al. can confirm this claim. (21, 22).

Conclusion

According to the present investigation, the production of science in medical ethics follows an upward trend. Moreover, the authorship pattern tends towards multiple authorship, and national collaboration is preferred over international one. Therefore, some measures should be considered to develop scientific collaboration by identifying the inhibiting factors and eliminating the existing

obstacles.

Declaration

Acknowledgment

Not applicable.

Conflicts of Interests

The authors declare that they have no conflict of interests.

Ethical Statement

The authors have observed all ethical issues in all stages.

Authors' contributions

Yaminfirooz M, Tahmasbei KH, and Ouchi A designed this work. Yaminfirooz M, Tahmasbei KH, and Ouchi A wrote this manuscript. All authors contributed to the article and approved the submitted version.

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