

Original Article

Network Clustering and Bibliometrics of Pharmacology and Pharmacy Research Outputs Published by Iranian Authors

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ABSTRACT

Objective: Evidence-based practice in medical sciences needs to publish confidential evidence that strongly depends on the research publications. This bibliometrics and network analytic study aims to evaluate the research publications of Iranian authors in pharmacology and pharmacy. **Methods:** Through the pharmacology and pharmacy category of Web of Science (WOS), all published articles affiliated with an Iranian researcher as an author were retrieved. Full records of retrieved articles in the WOS, including author name and affiliation, journal name, citation number, cited references, and keywords, were exported to a plain text file. Network analysis through VOSviewer was used for mapping the characteristics of the retrieved articles. All statistical analyses were done using the Microsoft Excel and SPSS version 25. **Findings:** The total number of Iran's publications (citations) rose from 1557 articles (10,085 citations) in 2000–2009 years to 6271 articles (77791 citations) in 2010–2018 years. Tehran University of Medical Sciences was the most productive university. The total number of RCTs rose from 82 publications in 2000–2009 to 278 publications in 2010–2018. The same numbers for systematic reviews and meta-analyses were four publications in 2000–2009 and 169 publications in 2010–2018. The five major topics of researches in pharmacology and pharmacy were drug delivery, basic pharmacology, oxidative stress, animal study, and molecular aspect of pharmacy. **Conclusion:** This study showed a marked increasing rate of publications and received citations by Iranians in pharmacology and pharmacy. After 2010, the rate of articles in the high-impact journals had growth. Furthermore, research articles in the highest level of evidence were more published by Iranians.

KEYWORDS: *Bibliometrics, Iran, network analysis, pharmacology, pharmacy, scientometrics*

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INTRODUCTION

The term evidence is a word that scientific communities are frequently using especially in medical sciences.^[1] Evidence-based practice in several fields of the medical sciences, such as pharmacology and pharmacy, needs to published and valid evidence that strongly depends on the scientific outputs.^[2] Furthermore, scientific outputs, i.e., published articles, are considered as one of the indicators of productivity in microlevels, for example, a researcher. Simultaneously, it might help the policymakers to evaluate the productivity

in macrolevels, such as a university, research center, or country. Bibliometrics is a tool that through mathematical–statistical analysis of the characteristics of the publications and citations retrieved from the indexing databases, for example, Clarivate analytics, provides a platform to evaluate the scientific outputs.^[3]

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During the last decades, medical research in Iran had experienced an exponential growth rate.^[4,5] Pharmacology and pharmacy, as a major field of medicine, is the most productive research field for Iranian scientists. About 11% of Iran's research publications in medical and health sciences is attributable to the pharmacology and pharmacy.^[5] The landscape of the research in pharmacology and pharmacy is essential for policymakers, institutes, universities, and researchers. Although there are few numbers of bibliometrics study of Iran's researches in pharmacology and pharmacy,^[6,7] there is not a report about the highest level of evidence, most-cited articles and topics, and progression of published articles in pharmacology and pharmacy.

This study aims to evaluate research publications affiliated with Iranian researchers in pharmacology and pharmacy through bibliometrics tools and network analysis. We will provide trends of published articles, received citations, publication of the highest level of evidence, networks of international collaboration, and clustering major topics in Iran's researches in pharmacology and pharmacy.

METHODS

Through the pharmacology and pharmacy category of Web of Science (WOS) in the Clarivate analytics (formerly ISI), all published articles affiliated with at least an Iranian researcher as an author were retrieved. To ensure retrieving articles in the context of pharmacology and pharmacy, we limited our search strategy to the journals indexed in the Journal Citation Report (JCR) under the category of pharmacology and pharmacy.^[8] At first, the ISSN of the journals indexed in the pharmacology and pharmacy category of the WOS was extracted through the JCR 2017. Then, the search algorithm was applied in the search line as follows: IS = ("ISSN of journal 1" OR "ISSN of journal 2" OR ... OR "ISSN of journal 261") AND (AD = [Iran]). Besides, a systematized search in the PubMed on December 2018, through the same but modified search strategy used in the WOS, was conducted for extraction of the study types of the articles in pharmacology and pharmacy. Due to some misspecifications of the PubMed filters for determination of the study type, we used a comprehensive, sensitive, and combined search strategy to identify the clinical trials (CT), randomized CTs (RCTs), and systematic reviews and meta-analyses (SRMAs). The search strategy could be found in the Supplementary.

Full records of retrieved articles in the WOS, including author name and affiliation, journal name, citation number, cited references, and keywords, were exported to a plain text file. Furthermore, the rate of international collaboration was calculated. An article with affiliated

authors in different countries is considered as an output of international collaboration. After data cleaning, the file was used for network analysis using the VOSviewer version 1.6.9.^[9] In the network maps, the size of the bubbles indicates some documents. The bubbles close to each other with the same colors are in the same homogeneous clusters regarding co-occurrence in the documents. The strength of the relationship is indicated by the lines connecting the bubbles.

All statistical analyses were done using the Microsoft Excel 2016 and Statistical Package for Social Sciences (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). Mean \pm standard deviation and frequency (percent) were used for the description of quantitative and qualitative variables, respectively.

RESULTS

Worldwide, a total of 715,919 articles were published in the 261 pharmacology and pharmacy journals indexed in the WOS. Figure 1 shows the growth trend of publications and citations published by Iranian researchers. Iranian researchers were contributed in 7971 (1.11%) articles, with total citation of 88,412 and average citations per article of 11.08. Eighty-three articles of Iranians had received at least 83 to maximum 358 citations (H-index = 83). The total number of publications (citations) rose from 1557 articles (10085 citations) in 2000–2009 years to 6271 articles (77,791 citations) in 2010–2018 years.

Table 1 shows the top 10 most productive authors and universities in pharmacology and pharmacy. Tehran University of Medical Sciences was the most productive (2351 articles) and the most cited (28538 citations) university of Iran in pharmacology and pharmacy. Among the Iranian researchers, Zarrindast MR (219 articles), Dehpour AR (207 articles), and Abdollahi M (121 articles) were the authors with the highest number of publications.

Journals

Two hundred and sixty-one journals, with impact factor (IF) ranged from 0 to 50.16, were indexed under the category of pharmacology and pharmacy in the WOS. Half of them had IF greater than 2.48. Just 14 journals were not indexed in the PubMed. Iranian journals indexed in the WOS were *DARU Journal of Pharmaceutical Sciences* (IF = 2.66), *Iranian Journal of Basic Medical Sciences* (IF = 1.51), and *Iranian Journal of Pharmaceutical Research* (IF = 1.37). All of the three journals were indexed in the PubMed. About 25% (2010 out of 7971) of the articles with an Iranian researcher was published in *Iran J Pharm Res* and *Iran J Basic Med Sci*. Table 1 shows the top 10 journals with a large number of articles published by Iranian researchers.

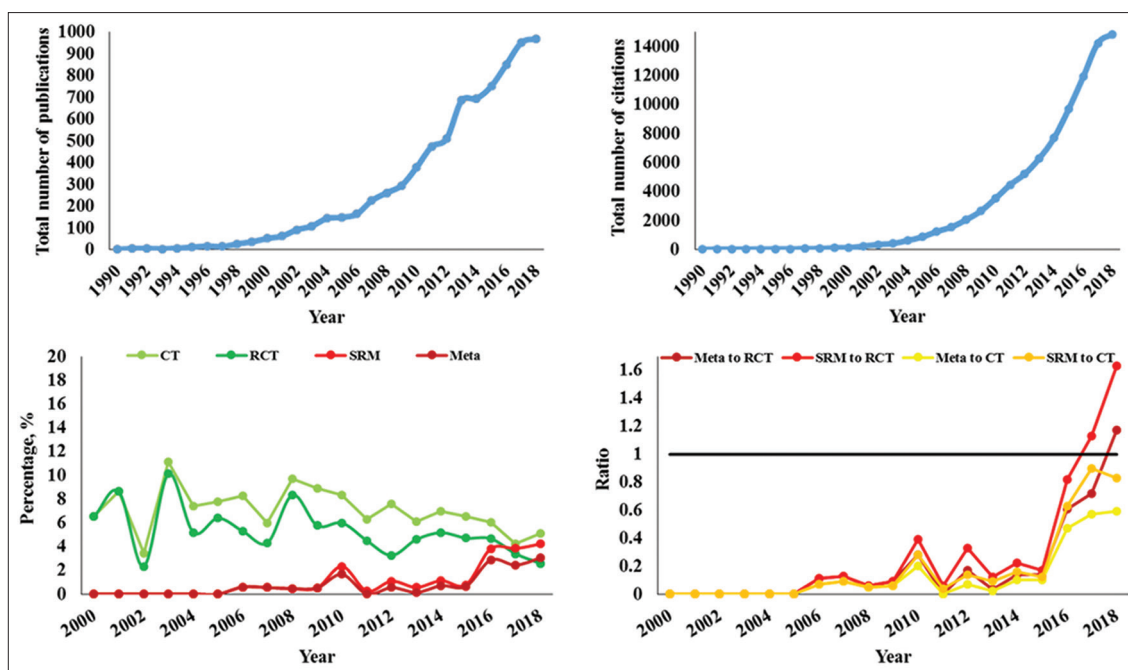


Figure 1: (Top, left) Total number of publications per year in pharmacology and pharmacy. (Top, right) Total number of citations per year. (Bottom, left) Percentage of the highest level of evidence published by Iranian authors. (Bottom, right) Ratio of SRM and Meta to CT and RCT. CT: All types of clinical trial, RCT: Randomized clinical trial, Meta: A meta-analysis, SRM: Systematic review and meta-analysis

Table 1: Top 10 most productive authors, universities, and journals in pharmacology and pharmacy; and also, countries with the highest rate of collaboration with Iranian authors

Rank	Author	TA	TC	H	Journal	TA	TC	H	University	TA	TC	H	Countries	TA	TC	H
1	Zarrindast MR	219	3687	32	Iran J Pharm Res	1096	5771	25	TUMS	2351	28538	58	USA	243	3585	33
2	Dehpour AR	207	2810	29	Iran J Basic Med Sci	914	4345	22	SBUMS	1164	11019	42	England	212	4385	38
3	Abdollahi M	121	1972	26	Eur J Pharmacol	292	4391	32	IAU	1031	8159	37	Canada	150	2909	26
4	Shafiee A	103	1723	26	Biomed Pharmacother	204	986	15	MUMS	926	11728	49	Australia	107	1534	24
5	Hosseinzadeh H	99	3041	33	Int J Pharm	185	5103	40	TBZMED	739	9862	43	Italy	90	1035	19
6	Nokhodchi A	89	2206	26	Pharm Biol	170	1783	21	UT	524	7547	42	Germany	89	1119	16
7	Dinarvand R	87	1848	25	Daru	164	1135	17	TMU	439	4741	34	Netherlands	72	1037	14
8	Kobarfard F	87	590	13	Phytother Res	153	3663	33	SUMS	421	3629	28	Malaysia	66	1263	18
9	Atyabi F	85	1875	26	J Pharm Biomed Anal	138	2964	32	MUI	417	5754	38	Japan	58	990	20
10	Ramezani M	83	1420	24	J Ethnopharmacol	134	4428	40	IUMS	335	2676	25	Switzerland	50	664	14

TA=Total number of articles, TC=Total number of citations, H=H-index, SBUMS=Shahid Beheshti University of Medical Sciences, TUMS=Tehran University of Medical Sciences, IAU=Islamic Azad University, MUMS=Mashhad University of Medical Sciences, TBZMED=Tabriz University of Medical Sciences

The number of articles in the top 10 journals in pharmacology and pharmacy rose from 18 articles until 2009 to 86 articles after 2010 [Table 2]. However, 86.54% of the published articles in the top journals had an Iranian researcher as the first author; about 77% of them were published in *J Control Release* (the Netherlands, IF = 7.87) and *Aliment Pharm Ther* (England, IF = 7.35).

Most-cited articles

Table 3 shows the top 10 most-cited articles in pharmacology and pharmacy by Iranian authors. Eight articles had published with Iranians as the first authors. The most-cited article was about the phenoxy radicals of dietary flavonoids and other polyphenolics published in

the toxicology (IF = 3.26) in 2002.^[10] It had an Iranian, Sabzevari *et al.*, as the second author and received 358 citations. The most recent article in the list of top 10 most-cited article was entitled “Antioxidant activity, phenol and flavonoid contents of 13 citrus species peels and tissues” by Ghasemi *et al.* published in the *Pak J Pharm Sci* in 2009 that received 193 citations.^[11]

Publication of the highest level of evidence

After 1990, Iranian authors published 526 of all types of CTs and 1081 of all types of review articles (RAs). The total number of RCTs rose from 82 publications in 2000–2009 to 278 publications in 2010–2018. The same numbers for SRMs were four publications in 2000–2009 and 169

Table 2: Total number of articles published in the top 10 journals of pharmacology and pharmacy by Iranian authors

	Country	IF	Before 2010 (18 articles)		After 2010 (86 articles)	
			TAI	TAIF	TAI	TAIF
Nat Rev Drug Discov	England	50.16	0	0	0	0
Pharmacol Rev	USA	18.96	0	0	0	0
Adv Drug Deliver Rev	Netherlands	13.66	1	1	5	3
Annu Rev Pharmacol	USA	13.29	0	0	0	0
Trends Pharmacol Sci	Netherlands	12.10	0	0	5	3
Drug Resist Update	England	11.63	0	0	2	1
Pharmacol Therapeut	England	10.37	0	0	7	2
Med Res Rev	USA	8.29	0	0	4	4
J Control Release	Netherlands	7.87	4	4	49	45
Aliment Pharm Ther	England	7.35	13	13	14	14*

*12 articles are letter to editors and the rest are review articles. IF=Impact factor, TAI=The total number of articles with at least one affiliated Iranian researcher, TAIF=The total number of articles with affiliated Iranian researcher as the first author

Table 3: Top 10 most-cited articles in pharmacology and pharmacy by the Iranian authors

Rank	The first author (number of total authors)	Title	Journal (impact factor)	Year of publication	# of citation
1	Galati, G (4)	Prooxidant activity and cellular effects of the phenoxy radicals of dietary flavonoids and other polyphenolics	Toxicology (3.26)	2002	358
2	Singh, RB (6)	Randomized, double-blind, placebo-controlled trial of fish oil and mustard oil in patients with suspected acute myocardial infarction: The Indian experiment of infarct survival 4	Cardiovascular Drugs and Therapy (2.77)	1997	352
3	Ghasemi, K (3)	Antioxidant activity, phenol, and flavonoid contents of 13 citrus species peels and tissues	Pakistan Journal Of Pharmaceutical Sciences (0.80)	2009	193
4	Eidi, A. (3)	Antidiabetic effect of garlic (<i>Allium sativum</i> L.) in normal and streptozotocin-induced diabetic rats	Phytomedicine (3.61)	2006	178
5	Emami, Jaber (1)	<i>In vitro - in vivo</i> correlation: From theory to applications	Journal of Pharmacy and Pharmaceutical Sciences (2.33)	2006	173
6	Hajhashemi, V (3)	Black cumin seed essential oil, as a potent analgesic and anti-inflammatory drug	Phytotherapy Research (3.35)	2004	156
7	Hosseinzadeh, H (3)	Antinociceptive, anti-inflammatory, and acute toxicity effects of <i>Zataria multiflora</i> Boiss extracts in mice and rats	Journal of Ethnopharmacology (3.11)	2000	154
8	Jouyban-Gharamaleki (2)	Comparison of models for describing multiple peaks in solubility profiles	International Journal of Pharmaceutics (3.86)	1998	152
9	Ghorbani, A (1)	Studies on pharmaceutical ethnobotany in the region of Turkmen Sahra, north of Iran (Part 1): General results	Journal of Ethnopharmacology (3.11)	2005	144
10	Hosseinzadeh, H (2)	Safranal, a constituent of <i>Crocus sativus</i> (saffron), attenuated cerebral ischemia-induced oxidative damage in rat hippocampus	Journal of Pharmacy and Pharmaceutical Sciences (2.33)	2005	142

publications in 2010–2018. The ratio of SRMs to CTs has converged to 1 since 2015. For the first time in 2017 and 2018, the number of SRMs and MAs has surpassed the RCTs. Figure 1 (bottom) shows the percentage of the highest level of evidence and also the ratio of SRMs and MAs to CTs and RCTs published by Iranian authors.

Network analysis

Coauthorship map of authors in Figure 2 (bottom, right) revealed 5 clusters of 31 authors with minimum of 50 articles that they collaborate. Each bubble indicates an author, and the links connecting the bubbles indicate collaboration in at least one publication. Figure 2

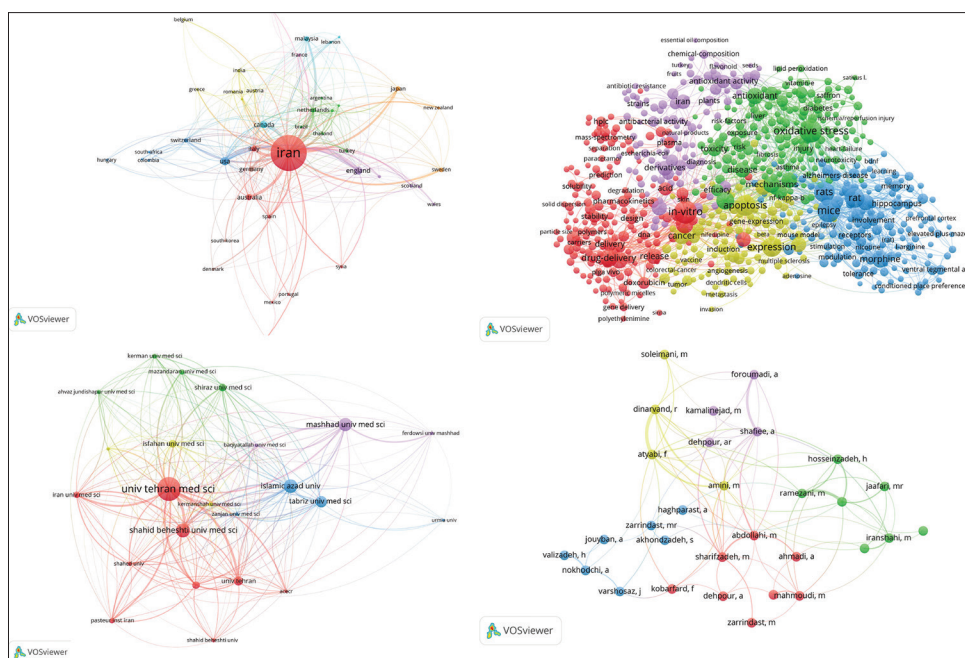


Figure 2: Network analysis of published researches in pharmacology and pharmacy. (Top, left) Co-authorship map of Iranian with the other countries, (Top, right) Co-occurrence map of the most frequent keywords used in articles published by Iranian authors, (Bottom, left) Co-authorship map of the universities with more than 100 published articles in pharmacology and pharmacy, (Bottom, right) Co-authorship map of the authors with minimum 50 published articles

(bottom, left) shows the network map of universities with at least 100 publications in the pharmacology and pharmacy. Tehran University of Medical Sciences (TUMS, 2351 articles) followed by the Shahid Beheshti University of Medical Sciences (1164 articles) and Islamic Azad University (1031 articles) are the most productive universities listed in Table 1. Based on the H-index, TUMS had the highest level of H-index (H = 58), followed by the Mashhad University of Medical Sciences (H = 49) and Tabriz University of Medical Sciences (H = 43).

Iranian authors had the most collaboration with USA (243 articles, 3.05%) followed by England (212 articles, 2.66%) and Canada (150 articles, 1.88%). The network of an international collaboration of Iranian authors is mapped in Figure 2 (top, left); and also, countries with the highest rate of collaboration with Iranian authors are listed in Table 1.

Out of the 30151 unique keywords, the top 5 most frequent keywords in the articles were *in vitro* (648 times), mice (639 times), oxidative stress (630 times), rat (526 times), and apoptosis (516 times). The five clusters of major topics, denoted by the green, blue, red, purple, and yellow colors, based on the most commonly used terms in the researches related to the pharmacy in the pharmacy and pharmacology field were mapped in Figure 2 (top, right). Red-colored cluster represented terms related to the drug delivery topic such as “*in vitro*,” “gene delivery,” or

“design;” purple-colored cluster represented terms related to basic pharmacology (antioxidant activity) such as “anti-bacterial,” “essential oil,” or “chemical composition;” green-colored cluster represented terms related to oxidative stress such as “liver,” “diabetes,” or “lipid peroxidation;” blue-colored cluster represented terms related to animal study such as “rat” or “mice;” and yellow-colored cluster represented terms related to molecular aspect of pharmacy such as “apoptosis,” “expression,” and “cancer.”

DISCUSSION

The present study is a bibliometrics and network analysis of the research articles published by Iranian authors in the field of pharmacology and pharmacy. This study showed a marked increasing rate of publications and received citations by Iranians in pharmacology and pharmacy. Furthermore, after 2010, the rate of articles in the high-impact journals had a growth. Also, during the recent decade, research articles in the highest level of evidence were more published by Iranians.

Quality of researches in pharmacology and pharmacy affiliated with Iranian researchers is improving. The increasing rate of received citations (rose from 10,085 citations in 2000–2009 to 77,791 in 2010–2018) and some articles published in the high-impact journals (rose from 18 articles until 2009 to 86 after 2010) could be considered as indicators of the research quality. This result is in line with the progression of the other fields of medical sciences in Iran.^[4,5]

Zarrindast MR, Dehpour AR, and Abdollahi M were the top 3 authors that produced the highest number of published articles. The top 3 authors based on the H-index were Hosseinzadeh H, Zarrindast MR, and Dehpour AR. Like the previous studies, TUMS was the most productive regarding a total number of published articles (2351 articles), the total number of received citations (28538), and highest H-index ($H = 58$).^[5-7]

Iranian researchers in pharmacology and pharmacy had more collaboration with the USA, England, and Canada. Conducting researches with the international collaborations is needed to keep moving forward in the science and technology.^[12,13]

Evidence is not the same.^[14] RCTs and SRMs of the RCTs are gold standards in the evidence-based medicine. They are on the top level of evidence hierarchy.^[15] The rate of publishing the highest level of evidence, for example, SRM, CTs, and RCTs in pharmacology and pharmacy is growing during the recent decades. Increasing the number of SRMs could be considered as good news for practitioners in pharmacology and pharmacy. However, they are strongly dependent on the CTs and especially RCTs as the inputs. Neglecting production of high-quality original research in the highest level of evidence, for example, RCTs can harm the evidence-based pharmacology and pharmacy over time.^[16] In general, CTs are time-consuming and need more cost and expertise. It seems that researchers tended to do SRMs that request lower cost and time, but with more scientific credits such as citation and improving H-index. Over time, this fast way to produce high-quality evidence with fewer resources makes the pharmacology and pharmacy in Iran to be more dependent, hence vulnerable to the CTs as original data published by other countries.

Network clustering indicates the five distinctive clusters of authors with minimum 50 published articles. In the previous studies, it was mentioned that Iranian authors did not tend to expand their research networks.^[7] Furthermore, this issue exists among high-level researchers. Expanding the research network could improve the visibility of researches and also provide opportunities for learning or teaching experiences.^[6,7]

Most frequent keywords in the articles were *in vitro*, mice, oxidative stress, rat, and apoptosis. The five major topics of researches in pharmacology and pharmacy were drug delivery, basic pharmacology, oxidative stress, animal study, and molecular aspect of pharmacy. The previous researches did not explore the topics in the published articles in pharmacology and pharmacy.

Our study has some limitations and strengths.

A comprehensive search strategy used in the most popular indexing databases, Clarivate analytics, and PubMed, and providing a report about the highest level of evidence published by Iranians are considered as the strengths. It is worth mentioning that there are potential articles published in the journals indexed in the other databases, for example, Scopus, or the journals in different categories of the sciences, for example, chemistry. Furthermore, all of the indexing databases have some weaknesses regarding the limited coverage of all literature in several fields of the science. Therefore, retrieved articles in the present study might underestimate the whole literature in the pharmacology and pharmacy. It might be mentioned as the limitation of the study.

In conclusion, published articles by Iranian authors in pharmacology and pharmacy are growing progressively. Its growth is regarding quantity and quality.

AUTHORS' CONTRIBUTION

Mohammad Salehi-Marzijarani and Payam Peymani provided the idea and study design, Mohammad Salehi-Marzijarani is responsible for statistical analysis, Marziyeh Zare provided the data and technical assistance, and Seyyed-Mohammad-Taghi Ayatollahi and Saeedeh Pourahmad supervised the study. Mohammad Salehi-Marzijarani and Payam Peymani drafted the manuscript, and all authors critically reviewed the manuscript, providing suggestions for revision where necessary. All authors reviewed and approved the final version of the paper.

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Conflicts of interest

There are no conflicts of interest.

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