

*Original Research*

## **Dimensions of the Scientific Collaborations of the Researchers Affiliated with Shiraz University of Medical Sciences**

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### **Abstract**

Researchers at medical universities are highly active in scientific collaborations at the national, regional, and international levels. Iranian Medical researchers pay diligent attention to scientific collaborations at all levels. The present study aimed to investigate various dimensions of scientific collaborations of the researchers at Shiraz University of Medical Sciences (SUMS). The dimensions include the patterns and levels of national and international collaborations, interdisciplinary interactions, the relationship between geographical distance and scientific collaboration, and the interdisciplinarity pattern of international collaborations. The study adopted a descriptive-analytical method. The data were collected using scientometric measures. The research population consisted of 4499 journal articles in Web of Science (WoS) authored by SUMS researchers during 2014-2018. The VOSviewer was applied to analyze the data and visualize the networks. The results revealed that national collaboration was the dominant pattern. The results showed a desirable ratio of scientific collaborations to all publications (52%). The authors mostly tended to collaborate with American researchers. The majority of interdisciplinary collaborations were observed in the microbiology field. The results suggested that geographical distance did not affect scientific collaborations at the national and international levels ( $P > 0.05$ ). At the international level, SUMS researchers had the highest collaboration with the University of Manitoba and Tehran University at the national level. The results suggested that research policymakers at SUMS should prioritize research policies toward scientific collaborations at all levels and fields to share and synergize knowledge.

**Keywords:** Scientific collaboration, Geographical Proximity, Shiraz University of Medical Sciences, Scientific Visualization, Iran.

### Introduction

Scientific collaboration has gained new and global dimensions in the contemporary world (Sharafoddin, Zarifian Yegane & Kiuju, 2012). International Research Collaboration (IRC) has been increasingly important as an emerging science, technology, and innovation study (Chen, Zhang & Fu, 2019). Technological developments have accelerated the flow of scientific findings to different countries, leading to the data boom and new global dynamics. In this regard, scientific collaboration boosts shareholders' research capacity (Low, Tong & Gunasegaran, 2014). Thus, geographical boundaries in the general sense no longer matter among scientific communities. This has paved the way for deeper globalization (Sharafoddin, Zarifian Yegane & Kiuju, 2012). Cross-border collaborations are undertaken in different interest subjects to solve everyday human problems (He, 2009). These attempts allow developing countries to use scientific capacities and information technologies in developed countries. Such collaboration can result in better visibility (Palacios-Callender & Roberts, 2018).

Collaboration in scientific research is one of the principles of research. In this social behavior, researchers benefit from exchanging ideas, sharing skills, and time-saving efficiency (Wang, Wu, Pan, Ma & Rousseau, 2005) to carry out practical problem-oriented research. The positive effects of scientific collaboration crop up in scientific productivity (Lee & Bozeman, 2005). Understanding the researchers' scientific collaboration practice and patterns at various levels (Petersen, 2015; Kong, Jiang, Yang, Xu, Xia & Tolba, 2016) helps clarify scientific collaboration in different fields in different regions, hence better planning on how to advance scientific collaboration. Studying domestic collaboration patterns in different fields helps understand the diversity of collaboration practices, increases knowledge fusion (Xie, Li, Li, Duan & Ouyang, 2018), and showcases the relations among different fields.

Convergence in different fields of science expands the knowledge boundaries and provides solutions for real-world challenges. Interdisciplinary collaboration reinforces scientific communication and enriches knowledge. In this regard, the expansion of interdisciplinary fields has added to the dynamicity and development of science in the last decades. According to De Lang and Glänzel (1997), collaboration patterns in research vary from field to field. Still, there is evidence of the development of international scientific collaborations among medical researchers. Karlovčec and Mladenčić (2015) argued that interdisciplinary research is most frequent in medical sciences due to collaboration with natural and technical sciences. Thus, interdisciplinary research accelerates science development and commercialization, while translational research bridges basic and applied medical research (Valentin, Norn & Alkaersig, 2016). One should note that, in terms of impact, joint research attracts more citations.

All countries pay attention to international scientific collaborations. Iran has shown interest in international scientific collaborations through the institutions affiliated with the Ministry of Science, Research and Technology and the Ministry of Health and Medical Education (MOHME) (Nikkar & Barahmand, 2014). Researchers in domestic and international institutions contribute to scientific publications in Iran. Studying scientific collaborations has gained considerable importance over the past years because the results may help understand scientific collaborations among different institutions (Shiri & Fadaie, 2011) and inform policymaking in science, technology, and innovation. Leahey, Barringer and Ring-Ramirez (2019) study of interdisciplinary research in institutions suggests that institutional research policies play a significant role in interdisciplinary research development.

Interdisciplinary research attempts are significant in medical sciences (Karlovčec &

Mladeníć, 2015; Ferligoj, Kronegger, Mali, Snijders & Doreian, 2015). Thus, medical schools of advanced technologies have been established in Iran to move toward the boundaries of knowledge and technology. According to the statistics released by the MOHME Center for Development and Coordination of Information and Scientific Publications, Shiraz University of Medical Sciences (SUMS) is one of the leading Iranian poles of medical, scientific productions ranking fifth in the country (Nikkar & Barahmand, 2014). SUMS has 901 active and 133 retired faculty members (MOHME, 2020). Moreover, the National Hospital Statistics and Information System reported that SUMS covers 4,156,214 people and 62 hospitals, including 13 training hospitals (National Hospital Statistics and Information System, 2020). In addition to training students in medical sciences, SUMS is responsible for providing medical and health services to people in Fars province. It also plays a vital role in the information production cycle and has considerable potential to accelerate scientific production. Therefore, it is necessary to study SUMS scientific collaborations at the institutional, domestic, and international levels.

Also, Navarro and Martín (2004), in their research, studied scientific publications and collaboration in epidemiology and public health at the national and international levels 1997-2002. Their research results showed a direct relationship between scientific publications and collaboration at the national level; in other words, countries with more scientific publications have more collaboration at the level of national institutions. International scientific participation is different from national scientific participation. This means that countries with high scientific publications have less collaboration at the international level. European countries also have high scientific participation. In line with previous research, Nouri, Danesh, Karimian & Papi (2010) reviewed Isfahan University of Medical Sciences's faculty members' scientific publications and the factors affecting scientific publications in the WOS 2000-2005. Two hundred three affiliate degrees of Isfahan University of Medical Sciences were indexed in WOS from 2000 to 2005. The highest number of publications at the faculty level was related to medical faculty. The highest number of publications at the department level was related to the Department of Pharmacognosy. The essential scientific publications' factors were fluency in English, familiarity with research methods, and familiarity with WOS search methods. Valinejad, Vakili Mofrad, Amiri, Mohammadhasanzadeh and Bouraghi (2012) examined the scientific publications of researchers at Hamadan University of Medical Sciences in WoS and Scopus. Their research showed that Tehran University of Medical Sciences had the most collaboration (23 documents in WOS and 51 documents in Scopus) with Hamadan University of Medical Sciences in scientific publications. Basu and Aggarwal (2001) also examined international scientific participation in science in India and studied the impact of international scientific participation on Institutional Performance. The results showed that the institutions that received the most international scientific collaboration were private hospitals. The results also showed that each institution's productivity and impact factor was helpful in its scientific collaboration. Bordons, Gomez, Fernandez, Zulueta and Mendez (1996) also examined local, domestic, and international scientific collaboration in biomedical research with bibliometric metrics. In their research, eight hospitals, fourteen universities, and three research institutes were studied. Hospitals and then universities had the most scientific and productive publications. The university and Research Council had lower relative activity than the other institutions studied

The present study investigated the patterns and levels of SUMS scientific collaborations in

WoS during 2014-2018. Moreover, the study addressed interdisciplinary collaborations by the researchers at SUMS. The scientific collaborations of SUMS researchers were also examined in terms of the geographical locations of the collaborators. The following research questions were formulated to meet the above objectives:

**RQ1.** What are SUMS patterns and levels of scientific collaboration at the national and international levels?

**RQ2.** What is the status of SUMS researchers in terms of international interdisciplinary collaborations?

**RQ3.** What is the relationship between geographical distance and scientific collaboration in SUMS?

**RQ4.** Are there any significant differences among different fields in terms of international collaboration?

**RQ5.** How is the national and international scientific collaboration network of SUMS?

### Methodology

The present study adopted a descriptive-analytical method. The data were collected and analyzed using scientometric measures. The research population consisted of all SUMS publications indexed in WoS during 2014-2018. The search query OG = (Shiraz Univ Med SCI) was inserted into WoS Advanced Search to retrieve the relevant data over the five years. The document type was limited to articles only. Accordingly, 4,499 articles were retrieved from WoS. The results of the Kolmogorov–Smirnov test showed that the data were not normally distributed. Therefore, non-parametric tests, including the Spearman correlation coefficient and Chi-Square test, were run to analyze the data. The search query was administered in WoS and the year's selection and document type to collect interdisciplinary collaboration data. Then the results were refined for the collaborating countries. Due to the multitude of collaborating countries, the results were limited to the top 100 countries with the most significant collaborations. To this end, the journals publishing the largest number of articles by SUMS researchers could be identified. The journals were subsequently searched in Journal Citation Reports (JCR) and Browse by Journal console to identify the Journal subject categories. The VOSviewer version 1.6.14 and Excel 2016 were applied to analyze the data and visualize the collaboration networks.

### Results

Concerning scientific collaboration at the national level, the results revealed that SUMS had the highest collaboration with Tehran University of Medical Sciences (n=863), followed by Shiraz University (n=317) and Shahid Beheshti University (n=282). Iran University of Medical Sciences and Fasa University of Medical Sciences ranked fourth and fifth, respectively, regarding the magnitude of collaboration. Overall, the number of SUMS collaborations with 50 universities, mostly medical universities, ranged between 19 and 863. The results illustrated in Table 1 indicate that SUMS had the largest number of collaborative research articles in 2017 (n=1481). International collaborations at SUMS amounted to 391 articles in 2014. The international scientific collaboration was on the rise in SUMS over the studied period. SUMS had the highest international collaboration in 2018 with 1234 articles and the lowest amounts in 2015 and 2016 (Table 1).

Table 1

*The ratio of SUMS national scientific collaborations to all scientific productions*

Year	No.of collaborations	No.of international collaborations
2014	391	205
2015	741	204
2016	882	234
2017	1481	447
2018	1224	1234
Total	4719	2324

Total scientific collaborations by SUMS amounted to 2324 articles from 2014 to 2018. Researchers at SUMS had the highest international collaborations with USA (n=235) followed by Canada (n=103) and Australia (n=81), which constituted 5.22%, 2.29%, and 1.8% of total collaborations (Table 2). Researchers at SUMS had the highest collaborations with European and the lowest with Australian researchers in a wider geographical domain. The SUMS collaboration magnitude with 50 foreign universities ranged between 15 and 235 articles.

Table 2

*The ratio of SUMS international collaborations (top five)*

Rank	Country	Frequency	% of 4499
1	USA	235	5.22
2	Canada	103	2.29
3	Australia	81	1.8
4	Italy	74	1.65
5	Germany	66	1.47

The results showed that researchers at SUMS had the highest interdisciplinary, international collaborations in microbiology and public health, environment, occupational health, genetics and heredity, general and internal medicine, biochemistry, and molecular medicine. The findings also revealed that intra-institutional interdisciplinary collaborations mainly occurred among the Faculty of Medicine, Faculty of Advanced Medical Sciences and Technologies, and Faculty of Health.

Concerning the effect of geographical distance on scientific collaborations at the national level, the furthest distance that SUMS researchers collaborated was 927 Km (Table 3). In other words, the majority of SUMS scientific partners resided in Tehran during 2014-2018, which included Tehran University of Medical Sciences, Shahid Beheshti University of Medical Sciences, Iran University of Medical Sciences, Baqiyatallah University of Medical Sciences, Tarbiat Modares University, Tehran University, Alborz University of Medical Sciences, Academic Center for Education, Culture, and Research, Pasteur Institute of Iran, University of Social Welfare and Rehabilitation Sciences, and MOHME. The closest scientific collaborators of SUMS included Shiraz University and the Shiraz University of Technology, followed by Fasa University of Medical Sciences at 152 km and Yasouj University at 175 km from SUMS. The furthest domestic collaborators of SUMS resided in Urmia, Qazvin, and Tabriz at 1512, 1392, and 1369 km, respectively. Payame Noor University and Islamic Azad University were excluded from the analysis as they were outlined as comprehensive universities with aggregated

statistics.

Table 3

*Geographical distance of SUMS domestic collaborators (top five)*

Rank	University/Institution	Frequency	Km
1	Tehran University of Medical Sciences	863	927
2	Shiraz University	317	1
3	Shahid Beheshti University of Medical Sciences	278	927
4	Iran University of Medical Sciences	206	927
5	Fasa University of Medical Sciences	633	152

The results showed no significant correlation between scientific collaboration and universities' geographical distance at the national level ( $P > 0.05$ ). It is thus assumed that geographical distance may not affect domestic scientific collaboration. About the effect of geographical distance on scientific collaboration at the international level, the closest foreign collaborators of SUMS included the American University of Beirut, Aga Khan University, and Cairo University at 2054, 2114, and 2152 KM, respectively. The furthest SUMS collaborators were Western University, Texas University, and the University of Sydney at 12855, 12571, and 12507 KM. The most frequent collaborators of SUMS included the University of Manitoba (10339 KM), Karolinska Institute (5197 KM), and Sapienza University of Rome (4930 KM) with 30, 28, and 27 joint publications, respectively (Table 4). The international Pasteur institutes were excluded from the analysis due to their geographical dispersion. The results showed no significant correlation between scientific collaboration and foreign universities' geographical distance ( $P > 0.05$ ). Therefore, it follows that geographical distance may not affect international scientific collaborations.

Table 4

*Geographical distance of SUMS international collaborators*

Rank	University/Institution	Country	Frequency	Km
1	University of Manitoba	Canada	30	10339
2	Karolinska Institute	Sweden	28	5197
3	Sapienza University of Rome	Italy	27	4930
4	Thomas Jefferson University	USA	26	10581
5	London University	England	26	6269

About the pattern of international collaboration across different subject fields, the results showed that SUMS scientific collaborations hinged on 20 fields, including general and internal medicine, pharmacology & pharmacy & molecular biology of health, environment and occupational health, applied neurology, and neurology with a frequency of 49, 47, 40, 37, 34, and 34 joint international publications, respectively.

Identical distribution analysis (i.e., observed distribution) examined the significance of scientific collaborations at the international level. As shown in Table 5, the Chi-square value

for the studied groups is 72.566 at 19 degrees of freedom and a 0.001 level of significance. Thus, the H<sub>0</sub> hypothesis is rejected as the significance level corresponding to Chi-square is less than 0.05. Thus, it may be concluded that there is a significant difference in international collaboration patterns across different subject fields.

Table 5  
*Chi-square test*

Studied groups	Value
Chi-square	72.566
Df	19
P	0.001

A hypothesis was put forward in the research that SUMS international scientific collaborations increased along with domestic collaborations during 2014-2018 while there was no significant difference in the patterns of scientific collaborations at the national and international levels. It should be noted that domestic inter-institutional and intra-institutional collaborations were aggregated to examine the national collaboration ratio (Table 6).

Table 6  
*Frequency distribution and percentage of SUMS national and international scientific collaborations*

			Collaboration		Total	
			International	National		
Year	2014	Frequency	205	580	785	
		Percentage	3.2	6.6	0.9	
	2015	Frequency	204	1081	1285	
		Percentage	3.2	3.12	7.14	
	2016	Frequency	234	1284	1518	
		Percentage	7.2	6.14	3.17	
	2017	Frequency	447	1879	2326	
		Percentage	1.5	4.21	5.26	
	2018	Frequency	1234	1620	2854	
		Percentage	1.14	5.18	6.32	
	Total		Frequency	2324	6444	8768
			Percentage	5.26	5.73	0.100

The frequency distribution in the two groups revealed that collaborations were distributed evenly during the five years. That is, there is a significant correlation between national and international collaborations in the studied period. The chi-square test results showed no significant difference in the ratio of collaborations at the national and international levels (Table 7).

Table 7

*Chi-square test*

	X2	df	Sig. 2- sided
Chi-square	644.037	4	0.001

Both national and international scientific collaborations increased in SUMS over the five years; however, national collaborative publications outweighed international ones. That is, researchers at SUMS collaborated more often with national than international researchers (Figure 1).

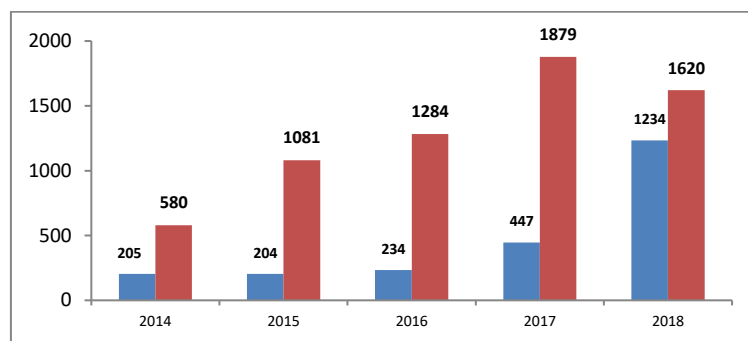


Figure 1. Frequency Distribution of SUMS Domestic and International collaborations

The patterns of international collaboration were investigated from two aspects to examine if they followed similar trends. Firstly, the number of international collaborations was studied by year. Secondly, international collaborations were studied in terms of different subject areas. About the former, the Chi-square test was run to see if there was a significant difference between the observed and expected distributions. The results revealed a significant difference in the number of international collaborations in different years. International collaborations at SUMS did not follow similar trends across the studied years (Table 8).

Table 8

*Chi-square test*

Studied groups	value
Chi-square	1679.791
df	4
P	0.001

The results showed a significant correlation in the number of SUMS of international scientific collaborations in medical sciences subject fields across different years. As illustrated in Table 9, SUMS international collaborations mainly focused on general and internal medicine in the five years (9.4%), followed by pharmacology and pharmacy (9.0%).

Table 9

*Frequency distribution and percentage of SUMS collaborations by subject field*

			Year					Total
			2014	2015	2016	2017	2018	
Subject field	General and internal medicine	Frequency	9	4	7	10	19	49
		Percentage	7.1	8.0	3.1	9.1	7.3	4.9
	Pharmacology and pharmacy	Frequency	6	7	10	12	12	47
		Percentage	2.1	3.1	9.1	2.3	3.2	0.9
	Molecular biology of health	Frequency	5	6	9	8	12	40
		Percentage	0.1	2.1	7.1	5.1	3.2	7.7
	environment and occupational health	Frequency	8	7	3	9	10	37
		Percentage	5.1	3.1	6.0	7.1	9.1	1.7
	Applied neurology	Frequency	5	4	8	7	10	34
		Percentage	0.1	8.0	5.1	3.1	9.1	5.6

The chi-square test results showed that SUMS international collaborations were not identically distributed across different subject fields in the five years. In other words, the findings showed no significant correlation in the amounts of international collaborations across different subject fields, so that collaboration patterns varied from field to field (Table 10).

Table 10

*Chi-square test*

	Value	df	Sig (two-sided)
Chi-square test	87.905	76	0.1655

The national and international scientific collaboration network of SUMS

The scientific collaboration of SUMS at the national level is shown in Figure 2, which is observed in 4 clusters of different colors (green, blue, red, and yellow). The color of each node indicated the subject areas of that cluster. The color or diameter of the lines also indicated the relationship between the nodes. Each node represented a university, and the lines showed how the nodes communicate. Larger nodes showed a greater collaboration and communication volume with other institutions and universities at the national level in this network (Figure 2). The universities' rank in the Leiden University Ranking System is shown with (l.r.). The network depicts that the most scientific collaboration in the national arena is with Tehran University of Medical Sciences (frequency of collaboration, 863 and rank 302), Islamic Azad University (frequency of collaboration, 331 and rank 590), Shiraz University (frequency of collaboration, 317 and rank 644), respectively. Shahid Beheshti University of Medical Sciences (frequency of collaboration, 278 and rank 568) and Isfahan University of Medical Sciences (frequency of collaboration, 148 and rank 901). The lowest level of collaboration is observed at SUMS with the Isfahan University of Technology, Dezful University of Medical Sciences, and Qazvin University of Medical Sciences.



## Discussion

A study of scientific collaborations at SUMS revealed that the university had more national than international collaborations during 2014-2018. In other words, the SUMS of researchers showed a stronger tendency to collaborate with researchers in domestic institutions. The findings suggested that international collaborative research publications were on the rise in SUMS over the five years; however, the SUMS researchers still showed a greater tendency to collaborate at the national level. This is consistent with the findings of Erfanmanesh (2017), Pourkarimi Daranjani, Galyani-Moghaddam and Jalali Dizaji (2017), Farahani, Eskrootchi, Mohaghegh and Hosseini (2014), and Abramo, Angelo and Di Costa (2019), who asserted that domestic scientific collaboration was the expected trend. This is also partly consistent with Wang, Wu, Pan, Ma and Rousseau (2005), who reported that Chinese researchers prioritized scientific intra-institutional, intra-regional, inter-regional, and international collaborations, respectively. Concerning scientific collaborations, Nikkar and Barahmand (2014) reported that international collaborations had a share of 11.6% of all SUMS scientific productions during 2005-2011. The present findings confirmed the growing trend of international collaborations at SUMS as the share of international collaborations amounted to 51.7% of all scientific productions of the university during 2014-2018. The present findings demonstrated that intra-institutional collaboration had lower growth than national collaboration at SUMS. The decline in intra-institutional collaboration may result from the increasing specialization of sciences, the need for a mix of expertise from various interdisciplinary fields, and specific tools and equipment. It seems that the patterns of scientific collaboration differ from country to country so that it can be affected by various factors. In China, for example, the priority is given to intra-institutional collaboration (Wang, Wu, Pan, Ma & Rousseau, 2005). Adopting new policies on promoting national and international collaborations may have been a contributing factor (Nikkar & Barahmand, 2014).

Scientific collaborations reinforce scientific relations among researchers and increase scientific production at the national, regional, and international levels. Since international collaboration is the most widespread type of scientific relations, it can be considered the source of scientific-economic fertility and the expansion of research productions in a country. According to Moed (2005, p. 385), "there has always been controversy over international scientific collaboration among scholars and policymakers so that it has been an important issue in scientometrics and quantitative studies of science and technology". Thus, scientific collaborations at any level, especially at the international level, lead to better scientific impact as low-impact universities find the opportunity to cooperate with strong institutions. The findings showed that the frequency of both national and international collaborations distributed evenly at SUMS over the studied period so that there was a significant correlation between national and international scientific collaborations. However, the findings revealed a statistically significant difference between national and international scientific collaborations. Nguyen, Ho-Le and Le (2017) studied the trend of scientific collaborations in Vietnam and reported that international contributors appeared in 77% of Vietnamese publications.

Moreover, internationally-collaborated publications received twice as many citations as domestic publications. The results also showed an increasing trend of international collaborations in Vietnam, which is not consistent with the present findings. Nikkar and Barahmand (2014) studied international joint publications of the faculty members at SUMS and reported an increasing international collaboration trend. However, the international joint

publications' ratio to all SUMS publications was small, consistent with the present findings. Two approaches were taken to study collaboration patterns: 1) the number of international joint publications by year, and 2) the number of international joint publications by subject field by year. The results showed no significant relationship between international scientific collaborations in various subject fields in different years. However, international collaborations followed a similar trend in the studied years. Nikkar and Barahmand (2014) asserted that scientific collaborations were on the rise in SUMS, consistent with the present findings. González-Pereira, Guerrero-Bote and Moya-Anegón (2010) and Glänzel and Schubert (2001) argued that international scientific collaborations increased in Iran, which is generally consistent with the present findings. However, the growth trend of international collaborations is different, at least in the medical fields.

The results indicated that 69 out of the 100 journals publishing SUMS articles were listed in Journal Citation Reports (JCR). Besides, researchers at SUMS paid greater heed to microbiology and public health, environment, occupational health, genetics and heredity, and general and internal medicine. Medicine is an interdisciplinary field. Therefore, interdisciplinary research is expected to be carried out in medicine. In this regard, Karlovčec and Mladenčić (2015) showed that medical researchers collaborated with researchers in technical and natural sciences. This is consistent with the present findings on the diversity of interdisciplinary collaborations. One should note that universities' research policies could have an essential role in developing interdisciplinary research (Leahey, Barringer & Ring-Ramirez, 2019). Thus, the diversity of interdisciplinary collaborations at SUMS may be rooted in research policies. Such policies encourage interdisciplinary research, an essential factor in commercializing science (Valentin, Norn & Alkærsg, 2016). One can conclude that interdisciplinary collaborations at SUMS have been in line with these policies.

Furthermore, one can argue that research policies have directed interdisciplinary research at SUMS toward microbiology, public health, occupational health, environment, genetics and heredity, and general and internal medicine. This, however, is inconsistent with the findings of Steinberg (1993), who asserted that more collaborations were contributed by basic sciences and less with clinical sciences. It seems that SUMS departments are strongly committed to interdisciplinary research policies. This indicates the importance of interdisciplinary research in these departments (Erfanmanesh, 2017). The present findings revealed that most interdisciplinary collaborations occurred at the Faculty of Medicine, Faculty of Advanced Medical Sciences and Technologies, and Faculty of Health. According to Shahid Beheshti University of Medical Sciences (2019) website, schools of advanced technologies in medicine were primarily established in Iran to advocate specific tasks. In line with the tasks, they support interdisciplinary researchers, unite researchers of medicine and sciences, convert innovative ideas into applicable products, establish relations with foreign universities, and promote research and education. Scientific collaborations at SUMS Faculty of Advanced Medical Sciences and Technologies are consistent with these policies.

The present study confirmed that SUMS had the highest domestic collaborations with Tehran University of Medical Sciences (TUMS) at a distance of 863 km. In this regard, Shiri and Fadaie (2011) argued that TUMS had considerable potential for scientific collaboration and could play a central role in publishing joint research works. Moreover, Mohammadian and Vaziri (2017) reported that medical universities were strongly inclined to collaborate with Tehran University. Contrary to Shiri and Fadaie (2011), Mohammadian and Vaziri (2017)

believe that TUMS, as with any other university, has a limited research capacity to not respond to many requests for collaboration. Therefore, a portion of collaboration potential remains untapped that can contribute to scientific development. It is not viable, though, to unlock this potential through TUMS. The only solution may be to facilitate collaborations among other medical universities in the country.

Moreover, SUMS had the highest number of international collaborations with the USA. This is consistent with the findings of Osareh and Wilson (2002), Hassanzadeh, Gorji, Shokranehnanekharan and Valinejadi (2009), Shiri and Fadaie (2011), and Nikkar and Barahmand (2014). One can conclude that political issues have little to do with scientific relations among researchers. Canada held second place in terms of the number of collaborations with SUMS. As both are English-speaking countries, SUMS researchers have a greater tendency to collaborate with English-speaking regions. This is consistent with the findings of Shiri and Fadaie (2011). Notably, most SUMS collaborations hinged on American and European countries, so little attention is paid to collaborations with Islamic or neighboring countries. This is not consistent with research policies in Iran. In the International Scientific Collaborations Meeting, Gholami (2019) asserted, “we have to avoid a mere attention to European and American countries and look at the whole world as Asian countries like China are among the most impressive samples.”

The present findings at the national and international levels showed no significant correlation between the number of joint publications and institutions' geographical distance ( $P > 0.05$ ). Thus, geographical distance does not affect scientific collaborations. This is confirmed by Sabouri Ghannad, Valinejadi, Ghonsooly and Mohammadhassanzadeh's (2012) research, which suggested that Iranian researchers were willing to work with Canadian, Swedish, and Australian researchers between 2000 and 2008. It seems that scientific activity among scientists of the world is independent of time. As such, we conclude SUMS researchers paid greater heed to their contributors' expertise. This is inconsistent, though, with the findings of Wang, Wu, Pan, Ma and Rousseau (2005) and Liang and Zhu (2002), who considered geographical distance an essential factor contributing to scientific collaborations. The reason may be the development of technology and the Internet. An important issue is the geographical distance on research impact in citations, which is more limited in humanities and social sciences but more profound in sciences (Abramo, D'Angelo & Di Costa, 2020). These findings, however, are noticeable in terms of the effect of distance on scientific collaborations, as represented in citations.

The study's default results suggested a significant difference in collaboration patterns among different medical sciences fields. Accordingly, the collaboration patterns of researchers vary across different fields. Researchers of general and internal medicine and pharmacy showed a greater tendency for scientific collaboration. The findings were consistent with Ippersiel and Godin's (1996) findings regarding the subject field differences and also in line with Shekofteh, Karimi, Kazerani, Zayer and Rahimi (2017), who found that Iranian researchers' scientific collaboration in Pharmacology and Pharmacy with colleagues is one of their scientific tendencies. Vargas-Quesada, Zacca-González and Chinchilla-Rodríguez (2018) reported that scientific collaborations in medical sciences mainly occurred in surgery cardiology, oncology, and clinical neurology. This is inconsistent with the present findings revealing that SUMS researchers had the highest number of collaborations in general and internal medicine, pharmacy and pharmacology, molecular biology of health, and environment and occupational

health 2014-2018. There are different motivations for scientific collaborations among researchers, universities, domestic areas, and cross-border regions. The motivations are different across different research fields as well.

The most vital collaboration link in the national scientific collaboration network was from Tehran's medical universities, with 19.18% collaboration. This university is ranked 302 in the Leiden University Ranking System, while the University of Tehran is ranked 212 with 24 collaboration 46 has been established with SUMS. Then, Islamic Azad University, Shiraz, and Shahid Beheshti University of Medical Sciences had the highest collaboration with SUMS. It has also had the weakest collaboration links with the Isfahan University of Technology. SUMS was associated with 13 universities and institutes ranked in the Leiden University Ranking System at the national level. In examining the status of universities' academic collaboration, each university's rank has, to some extent, affected the communication for collaboration. However, it can not be said with certainty that the university's ranking has played a decisive role in establishing scientific collaboration between universities at the national level. This part of the paper follows Mohammadian and Vaziri (2017) visualized medical universities' scientific collaborations through the co-authored network. In their research, Tehran University of Medical Sciences has collaborated with Shahid Beheshti University of Medical Sciences with 933 co-authors. Also, Tehran University of Medical Sciences, in national-level collaboration with non-medical institutions, had the most scientific collaboration with Islamic Azad University with 739 co-authors. Also, the study of Valinejad et al. (2012) examined the status of scientific publications of Hamadan University of Medical Sciences researchers. It concluded that this university had the most scientific collaboration with Tehran University of Medical Sciences. The results of this article with the research of Bordons et al. (1996) are straightforward. The highest and strongest links of SUMS with other universities and institutions abroad were related to the University of Manitoba (30 collaboration and rank 299) with the highest level of collaboration and the lowest number of scientific collaboration links with the Medical University of California (14 collaboration and Rank 196) was seen. International scientific interactions have been attempted with better-ranked universities in the Leiden ranking system, although this has not been fully achieved. For example, with Harvard University, only nineteen scientific collaborations have taken place.

This part of the article is in line with and comparable with Mohammadian and Vaziri's (2017) research, which has visualized medical universities' scientific collaborations through the peer-reviewed network. In their research, Shahid Beheshti University of Medical Sciences had the most peers with the University of Malaya in Malaysia. Also, with Navarro and Martín (2004), who have met with national and international scientific production and collaboration in the field of epidemiology and public health, Bordons et al. (1996) and Basu and Aggarwal (2001) in International Collaboration. Science in India is compatible.

### Conclusion

Considerable developments in medical sciences and related sciences have led to researchers' strong motivation for joint publications. This motivation can be seen in the increasing trend of scientific collaborations by SUMS researchers. Investigations showed that SUMS researchers mostly opted for national collaborations followed by international and intra-institutional collaborations, respectively. Attempts should be made at SUMS to maintain the phenomenal growth in international scientific collaborations in 2018. SUMS officials should

investigate this growth and pursue adequate policies to reinforce it. SUMS researchers were most active in the following interdisciplinary fields: microbiology and public health, environment and occupational health, genetics and heredity, and general and internal medicine. Besides SUMS, researchers had the highest number of general medicine publications, pharmacy and pharmacology, and health research laboratories.

The findings demonstrated that geographical distance did not affect scientific collaborations. SUMS researchers primarily looked for collaborators with adequate expertise. Tijssen and Jonkers (2008) contend that researchers with a history of international mobility play an essential role in developing scientific collaborations among countries. Therefore, SUMS researchers, who have studied, taught, or taken sabbaticals at top-level foreign universities may take the lead in establishing collaborations with their foreign counterparts. On the other hand, establishing relations with expatriate Iranian researchers can facilitate the transfer of knowledge and experiences. Concerning the outreach of scientific collaborations at the national and international levels, it is inferred that increasing the capabilities of technology and networking may increase both national and international collaborations across more expansive areas and remove the geographical constraints.

This study's results may function as a benchmark for SUMS officials to identify the university's development routes, select adequate collaborating universities consistent with national research policies, determine interdisciplinary fields in the university, and seek collaborations from researchers at domestic and foreign institutions. Bu, Murray, Ding, Huang and Zhao (2018) referred to the new stability indices in scientific collaborations. They believed that stable interdisciplinary collaborations had the highest average of scientific impact so that this index will lead to a new classification in scientific collaborations. It is essential to determine the most widely used fields, devise fair budget plans consistent with scientific productions, link widely used fields together to achieve better scientific outcomes, and identify the interdisciplinary journals publishing the largest share of SUMS works. Based on the results of the research, the following recommendations are made to improve the quality of scientometric studies on SUMS of scientific collaborations:

1. SUMS officials may pave the way for more scientific collaborations at the national and international levels to improve the quality of scientific productions, in the long run, to achieve better rankings in national and international assessments.
2. Higher scores may be assigned to the publications jointly contributed by authorities in each field.
3. Sabbatical opportunities may be provided for researchers to develop international scientific collaborations.
4. SUMS officials need to devise plans to direct and extend scientific collaborations at the national and international levels. This may be done through increasing research budgets, allocating financial resources to costly research, facilitating researcher communications, allocating extra budgets to joint research projects, and organizing domestic and foreign conferences.

#### **Endnote**

1. This article is extracted from the M.A. thesis by Samaneh Kesht-Karan, entitled "Investigation and Analysis of the Scientific Collaboration Pattern of Faculty Members at Shiraz University of Medical Sciences in Web of Science during 2014-2018", undertaken at RICEST.

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