



ORIGINAL ARTICLE

Impact of international collaboration on dentistry related papers published in Kingdom of Saudi Arabia



Faisal Alonaizan ^{a,*}, Soban Q Khan ^b, Muhammad Ajmal Khan ^c, Nadeem Siddique ^d,
Hend Alshammary ^e, Marwah Alamoudi ^e, Mohammed M. Gad ^f, Jehan AlHumaid ^g

^a Department of Restorative Dental Sciences, College of Dentistry, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

^b Department of Dental Education, College of Dentistry, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

^c Directorate of Library Affairs, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

^d Gad & Birgit Rausing Library, Lahore University of Management Sciences, Lahore, Pakistan

^e Dental Intern, College of Dentistry, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

^f Department of Substitutive Dental Sciences, College of Dentistry, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

^g Department of Preventive Dental Sciences, College of Dentistry, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

Received 17 January 2023; revised 1 May 2023; accepted 2 May 2023

Available online 8 May 2023

KEYWORDS

Bibliometric analysis;
International collaboration;
Citation rate;
Journal impact factor;
Saudi Arabia;
Dentistry

Abstract *Objective:* This bibliographic analysis was designed to review all dental publications in the Kingdom of Saudi Arabia (KSA) and evaluate the effect of international collaboration on the impact of published articles.

Methods: The Web of Science (WOS) database was used to extract all related published articles in the KSA from 1982 to 2021. The keywords were connected using Boolean Operators to download related articles. Downloaded articles were screened according to the following inclusion criteria: collaboration journal category, journal discipline, number of citations, number of authors, and impact factor. After applying the inclusion criteria and excluding single-author articles, 5,689 documents were included in the final analysis. The chi-square test and two-independent samples *t*-test were used to determine the statistical significance between the variables.

* Corresponding author at: Department of Restorative Dental Sciences, College of Dentistry, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia.

E-mail addresses: falonaizan@iau.edu.sa (F. Alonaizan), sqkhan@iau.edu.sa (S.Q Khan), makhan@iau.edu.sa (M. Ajmal Khan), nadeem.siddique@lums.edu.pk (N. Siddique), 2170006148@iau.edu.sa (H. Alshammary), 2170000181@iau.edu.sa (M. Alamoudi), mmjad@iau.edu.sa (M.M. Gad), jaalhumaid@iau.edu.sa (J. AlHumaid).

Peer review under responsibility of King Saud University. Production and hosting by Elsevier.



Production and hosting by Elsevier

<https://doi.org/10.1016/j.sdentj.2023.05.002>

1013-9052 © 2023 The Authors. Production and hosting by Elsevier B.V. on behalf of King Saud University.

This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Results: A significantly higher proportion of articles with international collaboration (51.4%) were published in dental journals than those published nationally (43.3%) or within the institutional level (41.8%) ($P < 0.0001$). In addition, the average number of citations (9.28 ± 23.8) ranged from 0 to 749, received by an article and the impact factor of the journal in which the article was published, significantly higher in the case of internationally collaborative work compared with national or within institutional collaboration ($P < 0.0001$).

Conclusion: International collaboration positively affected the impact factor, number of citations, and quartile rank of published articles. Moreover, the number of co-authors in different countries contributes to the international collaboration effect.

© 2023 The Authors. Production and hosting by Elsevier B.V. on behalf of King Saud University. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

Owing to globalization and the ongoing development of scientific communication, the present era of research is heavily based on international collaboration (Low et al., 2014). Advancements in scientific communication have led to an increase in the international coauthorship of scientific publications and communications. Researchers have reviewed the pattern of international collaboration in publications and found that it has doubled since 1990 (Prathap, 2013a).

Numerous studies have been conducted in various parts of Asia on the impact of international collaboration on the quality of scientific publications. These studies were published in China, Taiwan, India, and Malaysia (Basu and Kumar, 2000; Liu et al., 2012; Low et al., 2014; Wang et al., 2013). According to Adams, the present era of research can be called the “fourth age or era,” which is driven by international collaboration (Adams, 2013). Therefore, institutions that do not emphasize international collaboration may be at risk of a progressive decline in the quality and impact of research (Low et al., 2014).

Over the past 20 years, the Kingdom of Saudi Arabia (KSA) has been investing in improving health and education by increasing the number of universities and colleges, leading to increased scientific publications (Ul Haq et al., 2019). In dentistry, the KSA produced over one-third (37.83%) of the dental publications among 22 Arab countries (Ul Haq et al., 2019). Although the KSA is producing a high number of dental-related publications in the Arab world, 2,427 out of 6,416, the impact of international collaboration has not been sufficiently investigated (Ul Haq et al., 2019). Some reviews on dental publications have been conducted in the KSA (Rajeh and Khayat, 2021; Ul Haq et al., 2019). However, they did not intend to study the relationship between international collaboration and the impact of articles regarding the total number of citations received and the impact factor of the journal. Hence, this bibliographic study was designed to review all dental publications from the Kingdom of KSA to evaluate the effect of international collaboration on the impact of published articles. This study hypothesizes that international collaboration has a positive effect on the impact of publication.

2. Research methodology

This study used bibliometric methods to analyze research published by the KSA on the impact of international and national collaboration on dentistry. This study analyzed data retrieved

from the Web of Science (WOS), one of the most reliable data sources. The researchers meticulously identified all possible relevant keywords to retrieve relevant publications.

2.1. Keywords and data retrieval

To build the query, the finalized keywords were connected using Boolean Operators. On April 22, 2022, the following query was executed in the main search field of the WOS database: (WC=(dentistry*) OR TI=(dental OR dentistry OR orthodontic* OR prosthodontic* OR periodontic* OR pedodontic* OR “Oral surgery” OR “maxillofacial Surgery” OR restorative OR endodontic* OR “oral hygiene” OR “oral health”) OR AK=(dental OR dentistry OR orthodontic* OR prosthodontic* OR periodontic* OR pedodontic* OR “Oral surgery” OR “maxillofacial Surgery” OR restorative OR endodontic* OR “oral hygiene” OR “oral health”) OR Ab=(dental OR dentistry OR orthodontic* OR prosthodontic* OR periodontic* OR pedodontic* OR “Oral surgery” OR “maxillofacial Surgery” OR restorative OR endodontic* OR “oral hygiene” OR “oral health”)) AND CU=(Saudi Arabia).

Initially, all document types were searched, and the query resulted in 6,983 documents from the WOS Core Collection from 1982 to 2021.

2.2. Inclusion and exclusion criteria

After applying the search filter, the document types, including meeting abstracts (332), letters (112), editorials (50), corrections (26), notes (14), and book chapters (1) were excluded. Thus, the query resulted in 6,448 documents published from Saudi Arabia in any journals worldwide. The results were then downloaded in CSV, RIS, and BIB formats. The RIS file was imported into the citation management software EndNote for duplication checks of the author, title, and publication year. Only one document was found to be a duplicate. After removing duplicate records, 6447 documents were retained for further analysis. A total of 717 documents had a single authorship, and 36 publications were identified in 2022. Therefore, a single author and 2022 documents were eliminated. Finally, 5689 documents were included in the final analysis.

The variables collected from the articles included in the analysis were as follows: (1) collaboration (international, national, and within an institution), (2) journal category (open or not open access), (3) discipline of the journal (dentistry only, multidisciplinary dentistry, or other than dentistry), (4)

number of citations, (5) number of authors, and (6) impact factor of the journal. International collaboration is defined as an article with at least one author that belongs to a non-Saudi institution, whereas national collaboration is defined as authors belonging to more than one Saudi institution. Similarly, within the institution is defined as authors belonging to only one Saudi institution.

2.3. Data analysis

Online visualization platforms (<https://flourish.studio/>), including Biblioshiny, MS Excel, Power BI, MS Access, and BiblioAnalytics software, were used for data analysis. The Statistical Package for Social Sciences version 23 was used for further data analysis. The chi-square test was used to examine the relationship between two categorical variables. One-way analysis of variance was used to study the relationship between categorical and scale variables, followed by Tukey's post-hoc test. A P -value < 0.05 was considered statistically significant.

3. Results

The initial search yielded 6,983 documents from various publications (see Fig. 1). However, only 6,447 articles remained after the first search filter was applied. Subsequently, single-author articles were removed, leaving 5,689 articles in the study for analysis. According to descriptive data analysis, the average number of authors per article was 5.27 (± 3.41), with authors ranging from 2 to 131. The average number of citations received by an article was 9.28 (± 23.8), ranging from 0 to 749. Similarly, the average impact factor of a journal was found to be 3.13 (± 2.1), with values ranging from 0 to 53.44.

International collaboration was found in 63.4% of dentistry-related published articles from the KSA, whereas national collaboration was found in 16.4% (Table 1). Further-

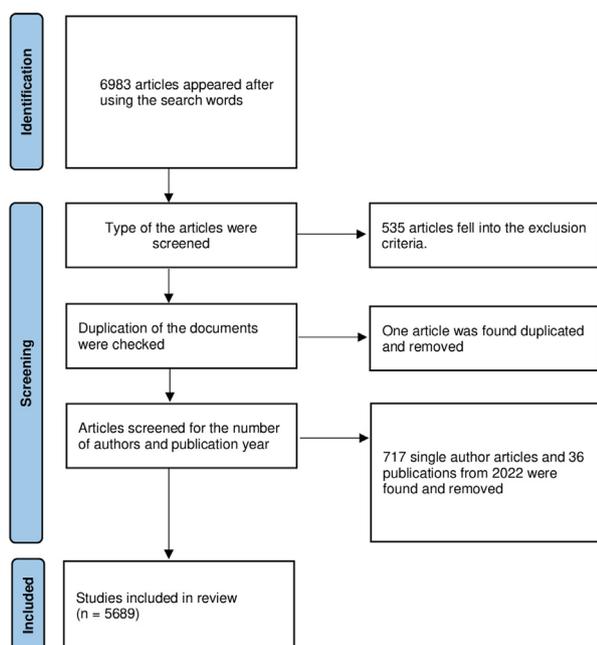


Fig. 1 Identification of studies via the WOS database.

Table 1 Collaboration and category of the Journals.

Collaboration	Frequency	Percentage
International	3608	63.4
National	935	16.4
Within institution	1146	20.1
Journal Category		
Open Access	2545	44.74
Not Open Access	3144	55.26
Discipline of the Journal		
Only Dentistry	2738	48.13
Multidiscipline with Dentistry	555	9.76
Other than Dentistry	2396	42.12

more, a higher proportion of journals (55.26%) were not open-access than that of open-access journals (44.74%). Furthermore, regarding the journal discipline, a high proportion of articles (48.13%) were published in journals devoted solely to dentistry (Table 1).

Fig. 2 shows the top 20 universities and institutions with the highest number of publications in Saudi Arabia. The figure shows the number of studies conducted with international, national, and within the institutional level collaboration with the number of citations. Therefore, it was observed from the figure that King Saud University had the highest number of publications with international, national, and within the institutional level collaborations, along with the number of citations received by each type of collaboration, followed by King Abdulaziz University and Imam Abdulrahman bin Faisal University.

Comparisons were made to assess the impact of collaboration on articles by journal discipline and category. Regarding the scope of the journal, there was a significant difference ($P < 0.0001$) between the number of internationally collaborated studies (51.4%), nationally collaborated studies (43.3%), and studies within the institutional level (41.8%) that were published in dental category journals. Similarly, the proportion of articles (57.5%) with international collaborations published in non-open access journals was significantly higher ($P < 0.0001$) than that of the proportion of articles with national (48.3%) or within institution level collaboration (53.8%) (see Table 2).

Table 3 shows how collaboration affects the average number of citations received by an article. It was discovered that the average citations received by an article, average number of authors, and average impact factor of the journal varied significantly due to the variation in the nature of collaboration ($P < 0.0001$). Therefore, the post-hoc test was used for the pairwise comparison, and it was found that international collaboration had a significantly higher average number of citation ($P < 0.0001$) than that of national (11.58 vs. 4.74) and within the institution collaboration (11.58 vs. 5.74). Similarly, regarding the average impact factor of the journal, the international collaboration had significantly higher average citations ($P < 0.0001$) than that of national (3.32 vs. 2.67) and within the institution collaboration (3.32 vs. 2.53). The average number of authors in the international collaborative study was higher than that of within the institution (5.55 vs. 4.26) and national collaborative study versus within the institution (5.39 vs. 4.26), with a P -value < 0.0001 .

Country Publications and First Authorship

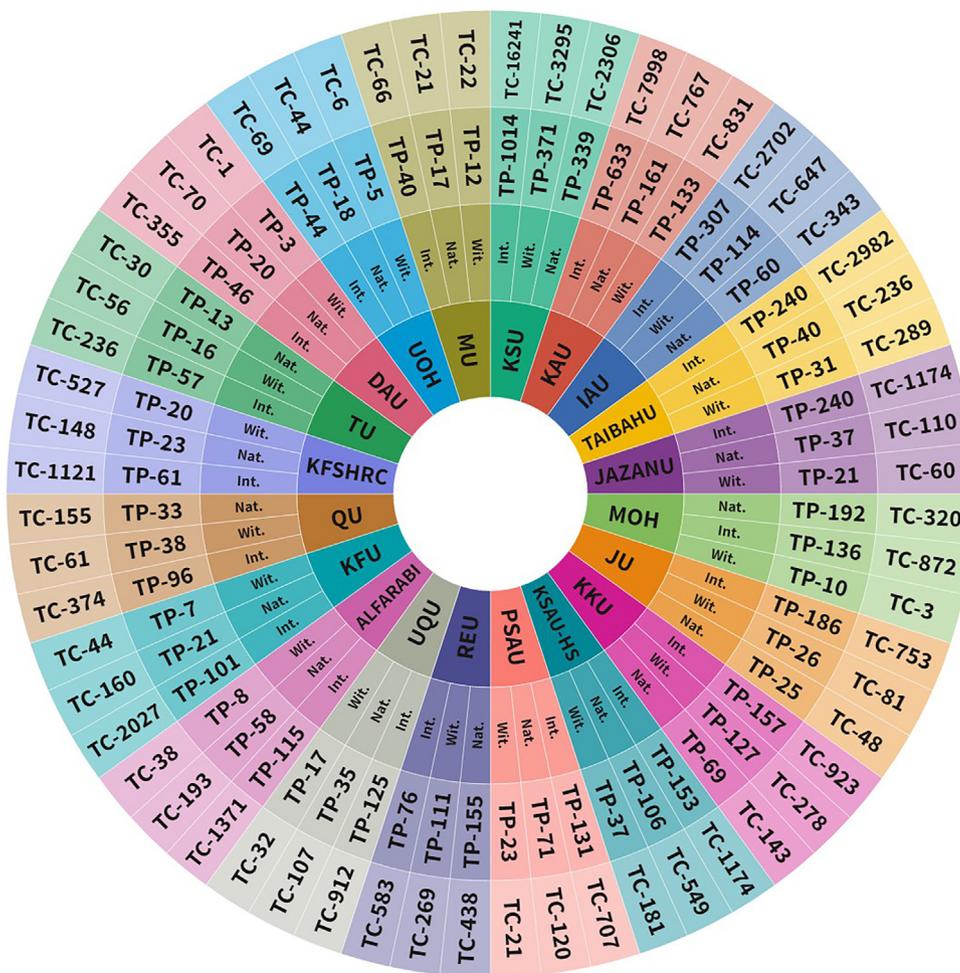


Fig. 2 Pattern and impact of collaboration in the top 20 universities in Saudi Arabia.

Table 2 Discipline and category of a journal in relation to collaboration.

Discipline of the Journal	CollaborationN (%)			P-value
	International	National	Within institution	
Only Dentistry	1854(51.4)	405(43.3)	479(41.8)	0.000*
Multicategory with Dentistry	424(11.8)	45(4.8)	86(7.5)	
Other Categories	1330(36.9)	485(51.9)	581(50.7)	
Journal Category				
Open Access	1533(42.5)	483(51.7)	529(46.2)	0.000*
Not Open Access	2075(57.5)	452(48.3)	617(53.8)	

*Statistically significant at 0.05 level of significance.

Table 3 Type of collaboration in relation to average citations, authors and impact factor of the journal.

Variables	Collaboration			P-value
	International	National	Within institution	
Average Citations	11.58(28.5)	4.74(9.83)a	5.74(11.2)a	0.000*
Average Number of Coauthors	5.55(3.9)a	5.39(2.5)a	4.26(2.0)	0.000*
Average Journal Impact Factor	3.32(2.27)	2.67(1.37)a	2.53(1.37)a	0.000*

*Statistically significant at 0.05 level of significance.

The same small alphabets in each row showed the insignificant difference between the pairs.

4. Discussion

A bibliometric analysis was performed by Ul et al. (Ul Haq et al., 2019), who described an increase in dental-related scientific publications by researchers affiliated with Saudi Arabia from 1998 to 2017. Another study measured the effect of international collaboration on the level of evidence for dental research published in the last 20 years (2000–2020) (Rajeh and Khayat, 2021). However, no study has evaluated the effect of international collaboration on the impact and ranking of published dental articles in the KSA.

The number of included studies (5689) increased compared with a previous study (1557), which included only clinical studies (Rajeh and Khayat, 2021). A previous study screened data from 1998 to 2017 and compared research productivity among 22 Arab countries and found that the KSA ranked 12th with 2,427 in dental research output (Ul Haq et al., 2019). The increased number of preset studies may be attributed to the inclusion criteria of previous studies and the extended research (1982 and 2021). This is in agreement with Rajeh and Khayat (Rajeh and Khayat, 2021), who stated that the number of Saudi dental research had increased seven-fold during the past 10 years compared with the preceding decade. They attributed this increase to the increasing number of dentists, institutions, and postgraduate programs directed toward scientific research.

The average number of authors in international collaborative studies was higher than that of within the institution (5.55 vs. 4.26) and national collaborative studies versus within the institution (5.39 vs. 4.26). In previous studies, (Frenken et al., 2005; Glänzel, 2002; Leimu and Koricheva, 2005; Persson et al., 2004; Wuchty et al., 2007) scientific collaboration improved the quality of scientific research and had a positive effect on the number of citations.

Based on the findings of the present study, internationally collaborating articles represented 63.4% of the dentistry-related published articles in the KSA compared with national studies. This is in agreement with previous studies on the same research point and location, (Rajeh and Khayat, 2021; Ul Haq et al., 2019) as well as other articles with multiple disciplines (rather than dentistry) and different countries (Leydesdorff and Wagner, 2008; Low et al., 2014; Persson et al., 2004). Jin and Rousseau found exceptional growth in Chinese publications with increased international collaboration publications (Jin and Rousseau, 2005).

Journal access (subscription-based or OA) was another factor considered in the bibliometric analysis. Furthermore, a higher proportion of journals were subscription-based than open-access journals. This can be justified because most authors seek to publish in high-impact factor journals that attract more citations, which are often subscription-based (Crossley et al., 2023). However, a recent study found inconsistent results, in which most collaborative studies were published in open-access journals (Cary and Rockwell, 2020).

Most researchers are interested in publishing articles in related journals; therefore, dental journals are targeted. The results showed that approximately half of the articles were published in journals devoted solely to dentistry, with a high proportion (48.13%) compared with multicategory dentistry and other categories published articles. Based on the journal category (dental and others), the percentage of internationally

collaborating articles published in the dental category journals was significantly higher than that of national studies or those at the institutional level.

The number of citations indicates the strength of the article and the proper way to measure the impact of the journal (Rajeh and Khayat, 2021). International collaboration had a significantly higher average number of citations than that of national (11.58 vs. 4.74) and within the institution (11.58 vs. 5.74). This finding is in agreement with previous studies (Chinchilla-Rodríguez et al., 2009; Lancho-Barrantes et al., 2013; Leimu and Koricheva, 2005; Levitt and Thelwall, 2009), which found that the number of citations is frequently higher in articles with international collaborations than those without international collaborations. Nguyen et al. found that internationally co-authored papers received double the citation average of national papers (Nguyen et al., 2017). Additionally, papers with corresponding authors abroad had a higher citation rate than those with a national corresponding author (Nguyen et al., 2017).

According to our findings, regarding the average impact factor of the journal, the international collaboration had significantly higher average citations than that of national (3.32 vs. 2.67) and within the institution (3.32 vs. 2.53). Latif (2015) concluded that 23% of papers were published in none impact factor journals, and 49% were published in journals with less than one impact factor (Latif, 2015). Furthermore, we found that internationally collaborating studies were cited more than twice the citation rate of locally co-authored studies. These findings are consistent with those of a previous study (Nguyen et al., 2017).

None of the peer-reviewed journals were indexed in the WOS. Thus, our analysis did not include articles published in other than ISI-indexed journals. Lastly, citation patterns may differ between the non-dental and dental categories, causing bias in the analysis of citations. This study included all published dentistry articles in Saudi Arabia. However, the study did not evaluate the subject area of the research. The strength of the study is that it included all published articles on dentistry from Saudi Arabia; therefore, the findings of the study can be generalized.

5. Conclusion

This review showed a noticeable growth in internationally collaborated dental studies. International collaboration positively affects the impact factor, number of citations, and quartile rank of published articles. Moreover, the number of co-authors from different countries contributed to the impact of the collaborative study. Based on this review, international collaboration with other countries is highly recommended for the publication of high-quality studies with a higher impact.

Additional information

No additional information is available for this paper.

Ethical statement

An ethical statement is not required for this manuscript.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRedit authorship contribution statement

Faisal Alonaizan: Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing. **Soban Q Khan:** Investigation, Data curation, Visualization, Writing – original draft, Writing – review & editing, Conceptualization, Methodology, Investigation. **Muhammad Ajmal Khan:** Resources, Formal analysis, Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing. **Nadeem Siddique:** Resources, Formal analysis, Writing – original draft, Writing – review & editing. **Hend Alshammary:** Investigation, Data curation, Visualization, Writing – original draft, Writing – review & editing. **Marwah Alamoudi:** Investigation, Data curation, Visualization, Writing – original draft, Writing – review & editing. **Mohammed M. Gad:** Investigation, Data curation, Visualization, Writing – original draft, Writing – review & editing. **Jehan Al-Humaid:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- Adams, J., 2013. The fourth age of research. *Nature* 2013 497:7451–7457. [10.1038/497557a](https://doi.org/10.1038/497557a).
- Basu, A., Kumar, B.S.V., 2000. International Collaboration in Indian Scientific Papers. *Scientometrics* 48, 381–402. <https://doi.org/10.1023/A:1005692505687>.
- Cary, M., Rockwell, T., 2020. International Collaboration in Open Access Publications: How Income Shapes International Collaboration. *Publications* 2020, Vol. 8, Page 13 8, 13. [10.3390/PUBLICATIONS8010013](https://doi.org/10.3390/PUBLICATIONS8010013).
- Chinchilla-Rodríguez, Z., Vargas-Quesada, B., Hassan-Montero, Y., González-Molina, A., Moya-Anegón, F., 2009. New Approach to the Visualization of International Scientific Collaboration. <http://dx.doi.org/10.1057/ivs.2009.31> 9, 277–287. [10.1057/ivs.2009.31](https://doi.org/10.1057/ivs.2009.31).
- Crossley, J.R., Almasri, M., Samaha, N., Deklotz, T.R., Harley, E.H., Davidson, B.J., Malekzadeh, S., Kim, H.J., 2023. Citations and Author Characteristics in Open-Access and Subscription-Based Otolaryngology Journals. *Laryngoscope* 133, 79–82. <https://doi.org/10.1002/LARY.30167>.
- Frenken, K., Hölzl, W., de Vor, F., 2005. The citation impact of research collaborations: the case of European biotechnology and applied microbiology (1988–2002). *Journal of Engineering and Technology Management* 22, 9–30. <https://doi.org/10.1016/J.JENGTECMAN.2004.11.002>.
- Glänzel, W., 2002. Coauthorship patterns and trends in the sciences (1980–1998): A bibliometric study with implications for database indexing and search strategies.
- Jin, B., Rousseau, R., 2005. China's Quantitative Expansion Phase: Exponential Growth but Low Impact. *Proceedings of ISSI*, 362–370.
- Lancho-Barrantes, B.S., Guerrero-Bote, V.P., de Moya-Anegón, F., 2013. Citation increments between collaborating countries. *Scientometrics* 94, 817–831. <https://doi.org/10.1007/S11192-012-0797-3/METRICS>.
- Latif, R., 2015. Medical and biomedical research productivity from the Kingdom of Saudi Arabia (2008–2012). *J Family Community Med* 22, 25. <https://doi.org/10.4103/2230-8229.149583>.
- Leimu, R., Koricheva, J., 2005. Does Scientific Collaboration Increase the Impact of Ecological Articles? *Bioscience* 55, 438–443. [https://doi.org/10.1641/0006-3568\(2005\)055\[0438:DSCITI\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2005)055[0438:DSCITI]2.0.CO;2).
- Levitt, J.M., Thelwall, M., 2009. Citation levels and collaboration within library and information science. *Journal of the American Society for Information Science and Technology* 60, 434–442. <https://doi.org/10.1002/ASI.21000>.
- Leydesdorff, L., Wagner, C.S., 2008. International collaboration in science and the formation of a core group. *J Informetr* 2, 317–325. <https://doi.org/10.1016/J.JOI.2008.07.003>.
- Liu, H.I., Chang, B.C., Chen, K.C., 2012. Collaboration patterns of Taiwanese scientific publications in various research areas. *Scientometrics* 92, 145–155. <https://doi.org/10.1007/S11192-012-0719-4>.
- Low, W.Y., Ng, K.H., Kabir, M.A., Koh, A.P., Sinnasamy, J., 2014. Trend and impact of international collaboration in clinical medicine papers published in Malaysia. *Scientometrics* 98, 1521–1533. <https://doi.org/10.1007/S11192-013-1121-6/FIGURES/3>.
- Nguyen, T. v., Ho-Le, T.P., Le, U. v., 2017. International collaboration in scientific research in Vietnam: an analysis of patterns and impact. *Scientometrics* 110, 1035–1051. [10.1007/S11192-016-2201-1/METRICS](https://doi.org/10.1007/S11192-016-2201-1/METRICS).
- Persson, O., Glänzel, W., Danell, R., 2004. Inflationary bibliometric values: The role of scientific collaboration and the need for relative indicators in evaluative studies. *Scientometrics* 60, 421–432. https://doi.org/10.1023/B:SCIE.0000034384_35498_7D.
- Prathap, G., 2013a. Second order indicators for evaluating international scientific collaboration. *Scientometrics* 95, 563–570. <https://doi.org/10.1007/S11192-012-0804-8/METRICS>.
- Rajeh, M., Khayat, W., 2021. Level of Evidence of Dental Research in Saudi Arabia (2000–2020). *Int J Dent* 2021. <https://doi.org/10.1155/2021/3463434>.
- Ul Haq, I., Khalid Al Fouzan, S., Khalid Al Fouzan, R., Nadeem, M., Latif, A., Ul, I., Fouzan, A., Khalid, S., Khalid, R., Appraisal, B., 2019. Bibliometric Appraisal on Dental Research at Kingdom of Saudi Arabia from 1998–2017. *Library Philosophy and Practice (e-journal)*. 2518.
- Wang, X., Xu, S., Wang, Z., Peng, L., Wang, C., 2013. International scientific collaboration of China: Collaborating countries, institutions and individuals. *Scientometrics* 95, 885–894. <https://doi.org/10.1007/S11192-012-0877-4/METRICS>.
- Wuchty, S., Jones, B.F., Uzzi, B., 2007. The increasing dominance of teams in production of knowledge. *Science* 1979 (316), 1036–1039. https://doi.org/10.1126/SCIENCE.1136099/SUPPL_FILE/WUCHTY.SOM.PDF.