



# Brazilian Articles in Top-Tier Dental Journals and Influence of International Collaboration on Citation Rates

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This study investigated the presence of co-authorship from Brazil in articles published in top-tier dental journals and analyzed the influence of international collaboration, article type (original research or review), and funding on citation rates. Articles published between 2015 and 2017 in 38 selected journals from 14 dental subareas were screened in Scopus. Bibliographic information, citation counts, and funding details were recorded for all articles (N=15619). Collaboration with other top-10 publishing countries in dentistry was registered. Annual citations averages (ACA) were calculated. A linear regression model assessed differences in ACA between subareas. Multilevel linear regression models evaluated the influence of article type, funding, and presence of international collaboration in ACA. Brazil was a frequent co-author of articles published in the period (top 3: USA=25.5%; Brazil=13.8%; Germany=9.2%) and the country with most publications in two subareas. The subjects with the biggest share of Brazil are Operative Dentistry/Cariology, Dental Materials, and Endodontics. Brazil was second in total citations, but fifth in citation averages per article. From the total of 2155 articles co-authored by Brazil, 74.8% had no co-authorship from other top-10 publishing countries. USA (17.8%), Italy (4.2%), and UK (3.2%) were the main co-author countries, but the main collaboration country varied between subjects. Implantology and Dental Materials were the subjects with most international co-authorship. Review articles and articles with international collaboration were associated with increased citation rates, whereas the presence of study funding did not influence the citations.

## Introduction

In a country basis, Brazil is second with most international articles published in Dentistry since 2006, according to SCImago Journal and Country Rank (1). In 1996, the first year accounted in SCImago ranking, Brazil co-authored 56 dental publications and occupied position #17. In 2017, 1951 dental documents were co-authored by Brazil. USA was the country with most publications in 2017 (2677), whereas India (1326), United Kingdom (1227), and Japan (1052) followed Brazil in the list. By comparison, the number of dental articles published by the USA increased 68% between 1996 and 2017, meanwhile Brazil showed a remarkable 3400% increase in the period. Brazil also occupied the second place in total number of citations in 2017. However, if one considers other metrics, Brazil appeared in position #8 in H-index and #58 in citations per document. These findings suggest that recent efforts to make the Brazilian research to go international were successful, but also that there is room for improving quality and impact.

Strategies to evaluate scientific knowledge are becoming more prevalent. Tools are used to map scientific fields, define the distribution of financial resources and support the design and implementation of policies by

stakeholders (2). Dentistry is a vast area within the health sciences, with a large number of subareas, i.e. subjects or specialties. Each subject has its own characteristics, such as number of researchers in the research network, quantity of journals and articles published yearly, and main topics investigated. These differences may lead to varied behaviors regarding publications, citation patterns, and collaborations established between domestic and international researchers (3-5). Bibliometric studies have shown that differences are present between dental subjects. For instance, the list of the most cited articles from Periodontology was reported to include narrative reviews more often than reproducible systematic reviews (6). In Pediatric Dentistry, the presence of a great number of case reports was noticed (7), whereas observational studies were reported as more prevalent in Oral and Maxillofacial Surgery (8).

Science, technology, and innovation are key in the economic performance and social well-being of a nation. It is increasingly global the recognition of the role that creating and using knowledge appropriately might have on international competitiveness (9). Bibliometric studies allow assessing the capability of a country and its researchers in publishing articles in the top-tier journals of a given area. Identification of citation patterns of those articles

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and associated variables is also helpful. Studies suggest that international co-authorship may result in publications with higher citation rates and greater visibility than purely domestic articles (10,11). This topic, however, has not received much attention in dentistry. Such analysis would allow drawing a current picture of the dental research internationally and the role of Brazil, an emerging powerhouse in dental science.

The purpose of this study was to investigate the presence of co-authorship from Brazil in articles published in top-tier dental journals, categorized according to their main subject, and analyze the influence of international collaboration, article type, and funding on citation rates. The hypothesis was that international co-authorship would be associated with increased citations.

## Material and Methods

This is the report of a cross-sectional study of articles published between 2015 and 2017 in selected international dental journals. A 3-year basis was used to provide a recent picture of the dental research internationally. Dentistry was divided into 14 subareas (subjects): Dental Education, Dental Materials, Endodontics, Implantology, Multidisciplinary, Operative Dentistry/Cariology, Oral and Maxillofacial Surgery, Oral Pathology/Stomatology, Oral Radiology, Orthodontics, Pediatric Dentistry, Periodontology, Prosthodontics, and Public Health/Epidemiology. The separation by subjects had the goal to assess and compare the presence and impact of the Brazilian dental research in the different subareas of dentistry. The subjects were defined based on a classification used by the Brazilian public foundation CAPES (Coordination for the Improvement of Higher Education Personnel), Ministry of Education, for evaluating Brazilian Graduate Programs in Dentistry.

### Sample Selection and Eligibility Criteria

The top three dental journals in each subject were selected according to the following bibliometric indicators: Journal of Citation Reports Impact Factor 2017 (JCR-IF, Web of Science), CiteScore 2017 (Scopus), and H-Index (SCImago powered by Scopus). The most recent list of these bibliometric indicators was consulted. When there was a divergence between them in the top-3 list, the highest H-index was decisive for inclusion of a journal. A limited number of journals was used to restrict the sample to top-tier journals in each subject. In this study, top-tier journals were considered those, which attract great attention from dental researchers internationally and publish articles in the frontiers of dental knowledge, having bibliometric indicators supporting those assumptions. When three journals were not considered representative of a given dental subject, only two journals were included. This was the

case for Endodontics and Dental Materials, for instance, in which the third journal identified had a regional character and could induce selection bias. In addition, journals that publish articles by invitation only (e.g. Periodontology 2000) were excluded. A total of 38 journals were selected, as listed in Table 1. A document search for articles published in those journals was carried out in Scopus in April 2018. For each subject, the journals were searched as source titles and the publication data range (inclusive) was set between 2015 and 2017, including all documents (initially) and all access types. In the next screen, the years and source titles were confirmed when necessary to match the eligibility criteria. In addition, in this second screen the document types were restricted to articles and reviews. Editorials, articles in press, notes, errata, conference papers, letters, and other document types were excluded.

### Data Collection

A census was carried out with all articles that met the eligibility criteria. Information about the articles were exported from the database to a comma separated value file, including the following variables:

*Citation information:* authors; document title; year; source title; volume/issue/pages; citation counts in the years 2015, 2016, and 2017; document type; and digital object identifier number;

*Bibliographic information:* authors' affiliations;

*Funding details:* number; acronym; sponsor; and funding text.

Details about the countries co-authoring the publications were obtained from the affiliations. The countries identified were restricted to the top-10 countries with most articles published in dentistry (all subject categories) according to SCImago Journal & Country Rank 2016. Thus, "international co-authorship" in this study refers exclusively to co-authorship from one or more of the following countries: USA, Germany, China, United Kingdom, Japan, Italy, South Korea, Turkey, or India. Other countries were not considered in the analysis. The position of the country in the list of co-authors (i.e., first or corresponding author, for instance) was not registered. Funding was categorized as present or absent. From the total number of citations, annual citation averages (ACA) were calculated, i.e. the average number of citations received by an article each year since it was published up to 2017. The citation counts can be considered early citation rates since all studies in the sample are recent.

### Data Analysis

Data were submitted to descriptive statistics. In addition, Poisson regression models were used to verify differences of Brazilian participation in subareas considering all articles

included, and differences of international co-authorship in papers, which had at least one Brazilian author. A linear regression model was used to assess differences in ACA between the dental subjects in papers co-authored by Brazil. Multilevel linear regression models evaluated the influence of article type, funding, and presence/absence of international collaboration in the ACA separately for

all articles and for Brazilian articles only. Articles (first level) were considered nested to dental subject (second level). In the first stage, an unconditional model ('null' model) estimated the basic partition of data variability between two levels before articles characteristics were taken into account; the second model (crude analysis) added each article independent variable at the individual

Table 1. Journals selected in each dental subject and their bibliometric indicators in two international databases\*

Subject	Journal title (abbreviated)	Publication frequency (issues/year)	Scopus 2017		Web of Science 2017
			CiteScore	H-index	Impact Factor
Operative Dentistry/Cariology	Caries Res	6	2.20	83	2.18
	J Esthet Restor Dent	6	1.30	49	1.53
	Oper Dent	6	2.29	71	2.13
Dental Materials	Dent Mater	12	4.53	123	4.03
	J Adhes Dent	6	1.63	60	1.69
Endodontics	Int Endod J	12	3.08	101	3.01
	J Endod	12	3.72	123	2.88
Pediatric Dentistry	Eur Arch Paediatr Dent	6	1.09	28	-
	Int J Paediatr Dent	6	1.47	52	1.38
	Pediatr Dent	6	1.20	58	-
Multidisciplinary	Clin Oral Investig	7	2.25	64	2.38
	J Dent	12	4.13	95	3.77
	J Dent Res	13	5.05	153	5.38
Orthodontics	Am J Orthod Dentofacial Orthoped	12	1.20	100	1.84
	Angle Orthod	6	1.53	72	1.59
	Orthod Craniofac Res	4	2.20	48	2.07
Periodontology	J Clin Periodontol	12	4.14	126	4.04
	J Periodontal Res	6	2.70	73	2.87
	J Periodontol	12	2.85	138	3.39
Oral Radiology	Dentomaxillofac Radiol	8	1.88	61	1.84
	Oral Radiol	3	0.49	13	0.46
Prosthodontics	Int J Prosthodont	6	1.34	84	1.34
	J Oral Rehabil	12	2.28	81	2.05
	J Prosthet Dent	12	2.11	106	2.34
Implantology	Clin Implant Dent Relat Res	6	2.94	70	3.09
	Clin Oral Implants Res	12	3.81	140	4.30
	Eur J Oral Implantol	4	3.20	34	2.80
Oral Pathology/ Stomatology	J Oral Pathol Med	10	2.13	73	2.23
	Oral Dis	8	2.11	74	2.31
	Oral Oncol	12	3.68	96	4.63
Public Health/ Epidemiology	Community Dent Health	4	0.95	45	0.95
	Community Dent Oral Epidemiol	6	2.21	87	1.99
	J Public Health Dent	4	1.45	54	1.43
Oral and Maxillofacial Surgery	Int J Oral Maxillofac Surg	12	2.47	85	2.16
	J Craniomaxillofac Surg	12	2.03	64	1.96
	J Oral Maxillofac Surg	12	1.63	106	1.77
Dental Education	J Dent Educ	12	0.91	57	1.08
	Eur J Dent Educ	4	0.92	34	1.34

\*Data retrieved August, 2018.

level considering its nesting with the second level but not adjusted by other article characteristics; the "full" final model (adjusted analysis) included all articles characteristics at the same time and second level variability. All variables were retained in the final models; only those with p-value  $\leq 0.05$  were considered statistically significant in the final models.

## Results and Discussion

Table 1 lists the 38 journals included in the sample and their bibliometric indicators. Most journals are published monthly (42.1%) or bimonthly (31.6%). CiteScore varied between 0.49 and 5.05 (mean=2.29; median=2.17) and Impact Factor varied between 0.46 and 5.38 (mean=2.4; median=2.15). Two journals from Pediatric Dentistry had no Impact Factor reported. Oral Radiology was the subject with the lowest average Impact Factor and Dental Education had the lowest average CiteScore. H-index varied between

13 and 153 (median=73). The Multidisciplinary subject had the highest CiteScore and Impact Factor averages. This is likely explained by the fact that articles from all subareas may have the opportunity to quote references from Multidisciplinary journals, which may attract a broader audience compared with journals that publish on more specific subjects. As a consequence, more specific subareas such as Oral Radiology and Dental Education may have a lesser chance of being cited in other subareas. This is an interesting observation that may help to draw a current picture of the dental science published in top-tier journals.

### Articles Published by Subject and Participation of the Top-10 Publishing Countries

The present study shows that Brazil is a frequent co-author of articles published in top-tier dental journals (Table 2). A total of 15619 articles were published in the selected journals between 2015 and 2017. The dental subject with

Table 2. Number of articles published between 2015 and 2017 in the selected journals of each dental subject and participation of the top-10 publishing countries (N=15619)

Subject*	Articles	Co-authorship of the top-10 publishing countries**, n (%)									
		Brazil	USA	Germany	China	UK	Japan	Italy	S Korea	Turkey	India
Oper Dent/ Cariology	640	230 (35.9)	199 (31.1)	53 (8.3)	22 (3.4)	27 (4.2)	23 (3.6)	20 (3.1)	20 (3.1)	36 (5.6)	7 (1.1)
Dental Materials	713	190 (26.6)	207 (29.0)	128 (18.0)	58 (8.1)	85 (11.9)	52 (7.3)	40 (5.6)	18 (2.5)	11 (1.5)	4 (0.6)
Endodontics	1339	323 (24.1)	288 (21.5)	53 (4.0)	134 (10.0)	68 (5.1)	41 (3.1)	57 (4.3)	77 (5.8)	120 (9.0)	47 (3.5)
Pediatric Dentistry	668	115 (17.2)	128 (19.2)	18 (2.7)	2 (0.3)	58 (8.7)	8 (1.2)	7 (1.0)	7 (1.0)	15 (2.2)	46 (6.9)
Multidisciplinary	1902	277 (14.6)	488 (25.7)	365 (19.2)	171 (9.0)	204 (10.7)	147 (7.7)	62 (3.3)	71 (3.7)	53 (2.8)	19 (1.0)
Orthodontics	1128	162 (14.4)	380 (33.7)	25 (2.2)	80 (7.1)	56 (5.0)	71 (6.3)	66 (5.9)	91 (8.1)	85 (7.5)	25 (2.2)
Periodontology	1190	151 (12.7)	328 (27.6)	117 (9.8)	120 (10.1)	81 (6.8)	97 (8.2)	63 (5.3)	60 (5.0)	85 (7.1)	33 (2.8)
Oral Radiology	330	41 (12.4)	37 (11.2)	18 (5.5)	25 (7.6)	18 (5.5)	59 (17.9)	10 (3.0)	13 (3.9)	33 (10.0)	9 (2.7)
Prosthodontics	1326	160 (12.1)	329 (24.8)	101 (7.6)	85 (6.4)	45 (3.4)	124 (9.4)	70 (5.3)	96 (7.2)	55 (4.1)	36 (2.7)
Implantology	1220	132 (10.8)	215 (17.6)	163 (13.4)	97 (8.0)	58 (4.8)	53 (4.3)	235 (19.3)	47 (3.9)	15 (1.2)	11 (0.9)
Oral Pathol/ Stomatol	1357	121 (8.9)	366 (27.0)	48 (3.5)	204 (15.0)	128 (9.4)	93 (6.9)	69 (5.1)	62 (4.6)	16 (1.2)	82 (6.0)
Pub Health/ Epidemiol	472	36 (7.6)	167 (35.4)	13 (2.8)	5 (1.1)	102 (21.6)	11 (2.3)	2 (0.4)	13 (2.8)	3 (0.6)	9 (1.9)
Oral Maxillofac Surg	2762	206 (7.5)	586 (21.2)	318 (11.5)	322 (11.7)	101 (3.7)	175 (6.3)	136 (4.9)	129 (4.7)	110 (4.0)	81 (2.9)
Dental Education	572	11 (1.9)	268 (46.9)	20 (3.5)	8 (1.4)	50 (8.7)	11 (1.9)	3 (0.5)	3 (0.5)	4 (0.7)	6 (1.0)
Total	15619	2155 (13.8)	3986 (25.5)	1440 (9.2)	1333 (8.5)	1081 (6.9)	965 (6.2)	840 (5.4)	707 (4.5)	641 (4.1)	415 (2.7)

\*Listed in descending order of co-authorship (%) from Brazil. \*\*Countries with most articles published in dentistry (all subject categories) according to SCImago Journal & Country Rank 2016.

most articles published overall was Oral and Maxillofacial Surgery (n=2762, 17.7%) whereas Oral Radiology was the subject with least articles (n=330, 2.1%). The country with most articles in the sample was USA (n=3986, 25.5%), followed by Brazil (n=2155, 13.8%), Germany (n=1140, 9.2%), China (n=1333, 8.5%), and UK (n=1081, 6.9%). Dental Education was the subject with least presence of Brazil as co-author (1.9%). The subject with most Brazilian participation was Operative Dentistry/Cariology (35.9% of all papers). Brazil was the country with most publications also in Endodontics (24.1%). USA was the country with most publications in almost all other subjects except Oral Radiology (Japan is first, 17.9%) and Implantology (Italy is first, 19.3%).

According to SCImago, Brazil is the second most publishing country in dental science since 2006, which means the second highest number of papers published in peer-reviewed articles. The present study indicates that when the dental subjects were analyzed separately, Brazil figured in the top-2 or top-3 countries by number of articles in almost all subjects. This finding shows that authors from Brazil are able to occupy spaces in the most rigorous dental journals, which theoretically adds quality to the high number of publications since only top-tier dental journals were included here. The role of research supporting funding agencies on improving the quality of dental research in the last decades has to be acknowledged. Figure 1 shows a comparison between the total number of articles co-authored by the top-10 publishing countries,

number of citations gathered by those articles, and citation averages for each country. Brazil is the second country with most articles and citations, but fifth in citation averages. During the last decade, which had a booming of international dental articles co-authored by Brazil, the need for the Brazilian science to have stronger quality indicators has been a topic of much discussion. When analyzing the data presented in Figure 1, one can observe that the citation average of Brazilian papers is still lower than USA, Germany, UK, and Italy, but higher than China, Japan, South Korea, Turkey, and India. These findings suggest that there is still room for improving the quality of Brazilian dental science and, to some degree, to exchange a bit of quantity over quality. However, authors from other countries often cite Brazilian dental research articles. A recent study (12) analyzing five different scientific fields reported that country over-citation rates, i.e. the practice whereby researchers from a given country tend to over-cite articles from their own country are tending to become less pronounced, probably due to improved communication means and diffusion of knowledge internationally in recent years.

#### Collaboration Between Brazil and Other Top-10 Publishing Countries

From the total 2155 articles co-authored by Brazil, 74.8% had no co-authorship from other top-10 publishing countries (Table 3). This finding indicates that the Brazilian dental science is not dependent on international collaboration to reach the main journals. Cooperation

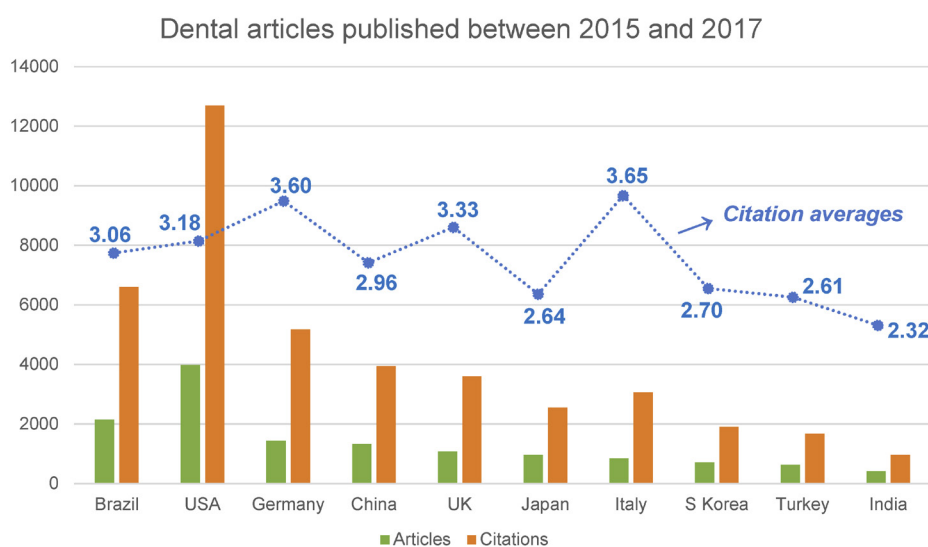


Figure 1. Total number of articles co-authored by the top-10 publishing countries between 2015 and 2017 (green bars), number of citations gathered by those articles up to 2017 (orange bars), and citation averages for each country (blue circles). Brazil is the second country with most articles and citations, but fifth in citation averages.

with other top-publishing countries in the past decades was important for the Brazilian dental science to achieve maturity, but it is positive to observe that no dependency on international collaboration is in place. Implantology (43.9%) and Dental Materials (42.6%) were the subjects with most co-authorship from other countries, whereas Dental Education (0%) and Pediatric Dentistry (9.6%) were the subjects with least international collaboration. The country most often present as co-author in Brazilian papers was USA (17.8%),

followed by Italy (4.2%) and UK (3.2%), although the co-author country most often present varied among subjects. In Dental Materials, for instance, Germany was a more frequent co-author than Italy; Japan and UK were the second main contributors in Pediatric Dentistry; Italy was the country with most collaboration in Implantology, and UK in Public Health/Epidemiology. The differences regarding the countries that most often collaborate with Brazil may be explained by the stage of development of each subject in those countries leading to a greater production of research articles.

**Citation Rates**

Table 4 shows the citation rates for articles co-authored by Brazil with or without other top-10 publishing countries. The 2155 articles published by Brazil between 2015 and 2017, with and without co-authorship from the other

countries, gathered 6596 citations in the period. Dental Education was the subject accounting for fewer citations (0.1%), whereas Endodontics was the subject with the greatest absolute number of citations (17.3%). However, Implantology was the subject with highest ACA. For papers authored by Brazil alone, the ACA varied between 0.18 (Dental Education) and 2.41 (Implantology). The ACA in different subjects varied largely for papers co-authored by other countries. Overall, compared to Brazil alone, Brazilian articles co-authored by some of the top-10 countries showed increased ACA: papers with the UK had 44.4% average increase and 44.6% median increase; papers co-authored by the USA had 36.1% average and 27.3% median increase; papers co-authored by Germany had 49.5% average and 9% median increase; papers co-authored by Italy had 21.7% average and 3.6% median increase. In contrast, papers co-authored by China (median=-17.2%)

Table 3. Collaboration between Brazil and other top-10 publishing countries in dental articles published between 2015 and 2017 (N=2155)

Subject	Brazil alone, n (%)	Co-authorship of the other top-10 publishing countries in dentistry, n (%)*								
		USA	Italy	UK	Germany	China	Japan	Turkey	India	S Korea
Oper Dent/ Cariology	167 (72.6)	48 (20.9)	3 (1.3)	5 (2.2)	8 (3.5)	0	1 (0.4)	0	0	0
Dental Materials	109 (57.4)	72 (37.9)	9 (4.7)	12 (6.3)	10 (5.3)	5 (2.6)	5 (2.6)	0	0	0
Endodontics	262 (81.1)	44 (13.6)	9 (2.8)	5 (1.5)	0	2 (0.6)	2 (0.6)	3 (0.9)	1 (0.3)	0
Pediatric Dentistry	104 (90.4)	9 (7.8)	0	4 (3.5)	2 (1.7)	0	4 (3.5)	0	0	0
Multidisciplinary	195 (70.4)	58 (20.9)	6 (2.2)	12 (4.3)	9 (3.2)	6 (2.2)	2 (0.7)	0	0	0
Orthodontics	129 (79.6)	32 (19.8)	6 (3.7)	0	1 (0.6)	0	0	0	0	0
Periodontology	106 (70.2)	36 (23.8)	1 (0.7)	4 (2.6)	4 (2.6)	1 (0.7)	1 (0.7)	2 (1.4)	0	0
Oral Radiology	32 (78.0)	6 (14.6)	0	1 (2.4)	1 (2.4)	1 (2.4)	0	1 (2.4)	0	0
Prosthodontics	134 (83.8)	16 (10.0)	9 (5.6)	2 (1.3)	2 (1.3)	0	0	0	0	0
Implantology	74 (56.1)	15 (11.4)	37 (28.0)	3 (2.3)	4 (3.0)	8 (6.1)	2 (1.5)	0	0	0
Oral Pathol/ Stomatol	90 (74.4)	17 (14.0)	6 (5.0)	12 (9.9)	1 (0.8)	1 (0.8)	0	0	1 (0.8)	0
Pub Health/ Epidemiol	23 (63.9)	5 (13.9)	0	8 (22.2)	1 (2.8)	0	0	0	0	0
Oral Maxillofac Surg	175 (85.0)	25 (12.1)	4 (1.9)	1 (0.5)	1 (0.5)	2 (1.0)	2 (1.0)	1 (0.5)	0	0
Dental Education	11 (100)	0	0	0	0	0	0	0	0	0
Total	1611 (74.8)	383 (17.8)	90 (4.2)	69 (3.2)	44 (2.0)	26 (1.2)	19 (0.9)	7 (0.3)	2 (0.1)	0

\*Percentage of participation in the total number of articles co-authored by Brazil.

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and Japan (median=-76.2%) had decreased ACA.

Figure 2 shows a comparison of citation averages for all articles published in each subject, articles authored

by Brazil alone, and articles co-authored by Brazil and at least one of the top-10 publishing countries. For most subjects, citation averages were higher when international

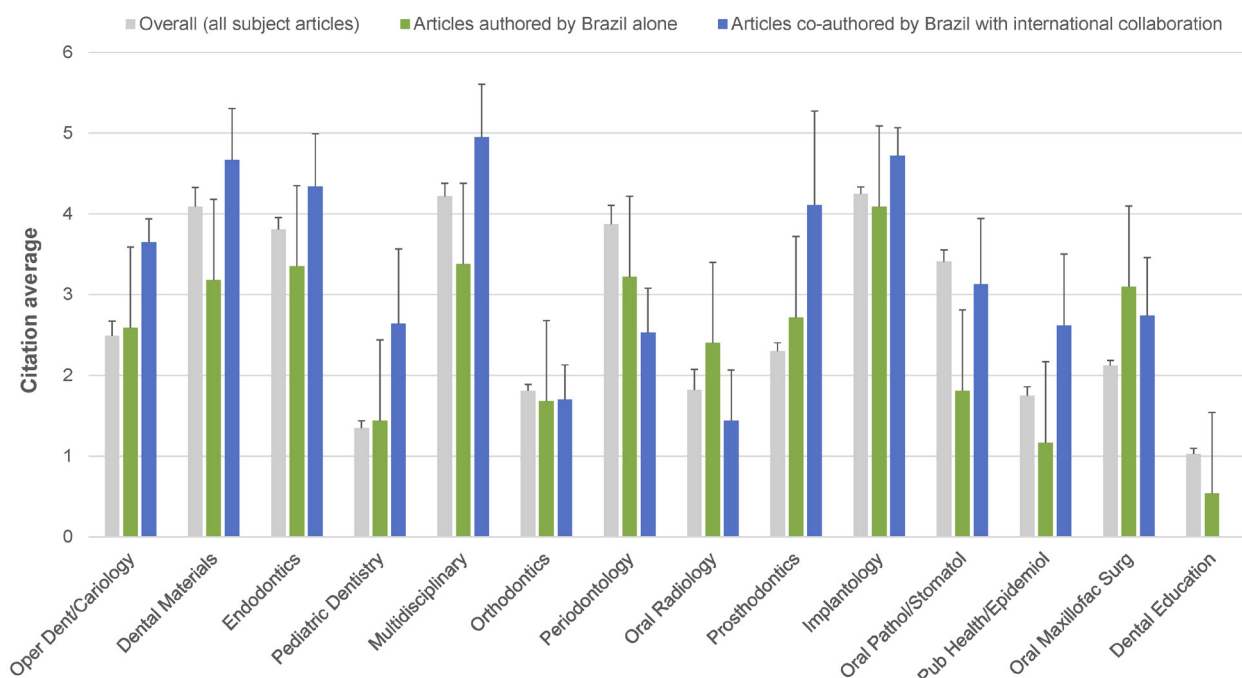


Figure 2. Citation averages for all articles published in each subject (gray bars), articles authored by Brazil alone, i.e. no other top-10 publishing country (green bars), and articles co-authored by Brazil and at least one of the top-10 publishing countries (blue bars). For most subjects, the citation averages are higher when international collaboration is present. Bars are averages + standard errors.

Table 4. Citation rates in Scopus for articles co-authored by Brazil published in the selected journals of each dental subject (N=2155 articles)

Subject	Total citations	Annual citation average (SD)*	Annual citation average of articles co-authored by Brazil with other countries**						
			Brazil alone	USA	Italy	UK	Germany	China	Japan
Oper Dent/Cariology	663	1.35 (3.14) <sup>cdef</sup>	1.31	1.57	0.87	0.33	3.02	0	14.67
Dental Materials	725	1.52 (1.85) <sup>bcd</sup>	1.27	1.92	2.98	2.06	1.90	3.93	1.37
Endodontics	1142	1.72 (2.19) <sup>b</sup>	1.65	2.10	2.39	1.47	0	0	0.83
Pediatric Dentistry	179	0.81 (1.26) <sup>g</sup>	0.70	1.60	0	1.75	0.50	0	0.37
Multidisciplinary	1065	1.68 (2.20) <sup>bc</sup>	1.51	2.09	1.33	2.57	1.65	1.36	2.5
Orthodontics	273	0.73 (0.96) <sup>g</sup>	0.71	0.85	1.08	0	0	0	0
Periodontology	455	1.41 (1.63) <sup>bcdef</sup>	1.41	1.38	7	4.50	4.00	0	0
Oral Radiology	90	0.85 (1.28) <sup>defg</sup>	0.92	0.72	0	0	1.00	0	0
Prosthodontics	472	1.36 (2.34) <sup>bcdef</sup>	1.26	1.51	2.04	4.50	7.00	0	0
Implantology	577	2.46 (1.74) <sup>a</sup>	2.41	2.07	2.87	3.06	1.58	2.08	3.33
Oral Pathol/Stomatol	260	1.00 (1.41) <sup>efg</sup>	0.85	1.56	1.56	1.58	2.00	0	0
Pub Health/Epidemiol	61	0.73 (0.84) <sup>eg</sup>	0.51	0.93	0	1.23	0	0	0
Oral Maxillofac Surg	628	1.46 (2.64) <sup>bcde</sup>	1.41	1.93	0.79	1.33	4.00	9.5	0.67
Dental Education	6	0.18 (0.34) <sup>fg</sup>	0.18	0	0	0	0	0	0

\*Average number of citations per year (standard deviation) considering all articles in the subject. P-value from linear regression <0.001. Same letters represent no statistical difference. \*\*Total number of citations divided by the number of articles in each dental subject.

collaboration was present. Articles authored by Brazil alone had lower citation average than overall articles in 64.3% of the subjects. At the same time, in 69.2% of the subjects, articles co-authored by Brazil with co-authorship from any of the other top-10 publishing countries had higher citations averages than overall articles. The association between international collaboration and citation rates was further investigated and the results are shown in Table 5, which presents the results for unadjusted and adjusted multilevel assessment of ACA. Considering all articles in the sample, the presence of co-authorship from Brazil was not associated with ACA after adjustment. However, the article type was associated with citation rates, with review articles presenting higher ACA than original research articles. In the analysis that considered only articles co-authored by Brazil, the presence of international co-authorship, i.e. at least one of the other top-10 publishing countries, and

article type were both associated with increased ACA after adjustment. The intercepts present in Table 5 should be used for understanding the comparisons. For instance, considering articles co-authored by Brazil alone, an original article with no funding and no international co-authorship had a mean ACA of 0.41 (95% CI 0.25-0.66) in the adjusted model. The presence of international co-authorship adds 0.39 to the ACA (95% CI 0.18-0.60), whereas a review article will have an additional 0.63 increase in the ACA (95% CI 0.32-0.95). It has been shown that diversity of research methods in different countries may lead to variations in the potential impact of the work in the literature (13).

The above findings reinforce the assumption that international collaboration generally tends to increase the citations rates. This is well documented in the literature for other science fields, but this is the first study to show the effect for dental articles. There are many points to be addressed in the explanation for this finding, including higher visibility and audience in the international community, and the possibility of international collaboration aiding in the validation of the articles by the science community. In addition, when the cooperation includes more experienced research groups, it is likely that the evidence generated is stronger and the article more likely would to be in the frontier of knowledge. It has been cited that the phenomenon of self-citation could be stronger for articles in collaboration since there are more authors to cite themselves (14). In corroboration to the present findings, a study analyzing a sample of articles co-authored by Brazil observed that international collaboration and network organization of work played a fundamental role in the resulting impact of the articles as measured by citation counts (15).

In contrast, another study reported that whether a paper was multinational had no significant effect on citation rates (13). According to the authors, previous work showing that multi-country papers are more highly cited reached that conclusion by ignoring the confounding effect of multiple funding sources. Inadequate funding

Table 5. Multilevel assessment of annual citation averages associating variables in the individual level (articles) considering all articles in the sample or only articles co-authored by Brazil (contextual level = dental subject)

Mixed effect	Null model β (95% CI)	Crude analysis β (95% CI)	Adjusted model β (95% CI)
<b>All articles in the sample</b>			
Intercept	1.25 (0.97-1.54)		0.54 (0.37-0.79)
<b>Individual Level (articles)</b>			
<i>Brazilian co-authorship</i>			
Absence		ref.	ref.
Presence		-0.01 (-0.11-0.10)	-0.01 (-0.12-0.09)
<i>Funding</i>			
Absence		ref.	ref.
Presence		0.03 (-0.07-0.13)	0.06 (-0.04-0.16)
<i>Document Type</i>			
Original article		ref.	ref.
Review		0.75 (0.62-0.88)	0.75 (0.62-0.89)
Deviance (-2loglikelihood)	70995.076	-	70868.172
<b>Articles co-authored by Brazil</b>			
Intercept	1.31 (1.05-1.56)		0.41 (0.25-0.66)
<b>Individual Level (articles)</b>			
<i>International co-authorship</i>			
Absence		ref.	ref.
Presence		0.39 (0.18- 0.60)	0.39 (0.18-0.60)
<i>Funding</i>			
Absence		ref.	ref.
Presence		0.02 (-0.20-0.25)	0.01(-0.21-0.24)
<i>Document Type</i>			
Original article		ref.	ref.
Review		0.63 (0.31-0.94)	0.63 (0.32-0.95)
Deviance (-2loglikelihood)	9364.6648	-	9296.2634

CI: confidence interval; ref: reference.

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is often cited as a reason for methodological shortcomings in health sciences research (16). In the current study, the presence of funding did not influence the citation rates. In corroboration, a study on bibliometric profile of four information science journals observed that citation counts appeared to be associated with journal of publication and authors' nationality, but not with funding (17). However, Reed et al. (18) observed that higher funding was associated with increased study quality, which was measured by means of applying a quality instrument in medical education research articles. One limitation is that we took into consideration articles and citations from 2015 to 2017 to make the analysis as an up-to-date picture of the presence of Brazil as co-author in the main world-class dental journals. This means that the articles had less than 3 years to gather citations and may have not achieved their citation peak yet, which usually occurs between two and six years after publication (19). Perhaps the relationship between funding and citation rates may be present if the window for citation was longer. Another limitation is that the articles were categorized according to their year of publication, thus articles published in the first months of the year had a higher window of opportunity for citations than articles published in the last months. However, the analysis did not consider articles in individual levels but rather clusters of countries co-authoring the articles and dental subareas to which the articles belong to. This means that the effects related to the date of publication affected articles from all countries and subareas in a similar way.

This study analyzed a piece of articles published between 2015 and 2017 in selected international dental journals. In the period, above 400 articles were published monthly, which means almost 15 articles published daily in those 38 journals only. If one considers articles with Brazilian co-authorship, in average two articles were published each and every day in those journals. According to SCImago, the dental science output in the last decade (2017-2008) had a 64.8% increase in citable documents compared to the period 1998-2007, reaching above 15,000 documents published yearly. How can a researcher and further, how can a dentist be well informed and up-to-date with so many articles published? It is increasingly discussed that large bodies of published research may be unreliable and hinder the separation between good and poor-quality science (20). Further, the widespread availability of bibliometric data from multiple sources makes it easy for scientists to obsess about their productivity and impact, and to compare their numbers with those of other scientists (20). However, encouraging the trendiest rather than the best, most important science to people in general may be harmful. Therefore, this report should be used mainly for understanding the current status and fomenting the

progress of potential less developed areas of the Brazilian dental science.

In conclusion, Brazil is a frequent co-author and the second most publishing country of articles in top-tier international dental journals. The subjects with the biggest share of Brazil are Operative Dentistry/Cariology, Dental Materials, and Endodontics. In contrast, Brazil is fifth in citation averages. From articles co-authored by Brazil, 74.8% had no co-authorship from other top-10 publishing countries. The most frequent co-author country was USA, but the main collaboration country varied between subjects. Implantology and Dental Materials were the subjects with most international co-authorship. This study also shows that international collaboration was associated with increased citation rates and that review articles have higher citations than original research articles. The presence of funding was not associated with citation counts.

## Resumo

Este estudo investigou a presença de coautoria do Brasil em artigos publicados nos principais periódicos odontológicos e analisou a influência da colaboração internacional, tipo de artigo (artigo original ou revisão) e financiamento nas taxas de citação. Artigos publicados entre 2015 e 2017 em 38 periódicos selecionados de 14 subáreas foram pesquisados no Scopus. Informações bibliográficas, número de citações e detalhes de financiamento foram registrados para todos os artigos (N=15619). Colaboração com outros países no top-10 de publicações em odontologia foi coletada. Médias anuais de citação (MAC) foram calculadas. Um modelo de regressão linear avaliou as diferenças de MAC entre as subáreas. Modelos multinível de regressão linear avaliaram a influência do tipo de artigo, financiamento e presença de colaboração internacional nas MAC. O Brasil foi coautor frequente de artigos publicados no período (top 3: EUA=25,5%; Brasil=13,8%; Alemanha=9,2%) e o país com mais publicações em duas subáreas. As subáreas com maior participação do Brasil foram Dentística/Cariologia, Materiais Dentários e Endodontia. O Brasil foi o segundo no total de citações, porém quinto em citações médias por artigo. Do total de 2155 artigos de coautoria do Brasil, 74,8% não tiveram coautoria de outros países do top-10 de publicação. EUA (17,8%), Itália (4,2%) e Reino Unido (3,2%) foram os principais países coautores, porém o principal país de colaboração variou entre as subáreas. Implantodontia e Materiais Dentários foram as subáreas com mais coautoria internacional. Artigos de revisão e artigos com colaboração internacional foram associados a maiores taxas de citação, enquanto a presença de financiamento do estudo não influenciou as citações.

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