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REVIEW ARTICLE

Recent trends in dental research in Saudi Arabia: Mapping review (2010–2020)

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Abstract *Objectives:* To map Saudi-affiliated dental research productivity by institution, managing sector, geographical region, collaboration pattern, study design, dental specialty, time course, publication source, authorship, and funding during 2010–2020.

Methodology: A systematic search strategy was followed to retrieve data from the Web of Science and MEDLINE/PubMed databases. The study included only articles published in English between 2010 and 2020 by authors affiliated with Saudi dental institutions. Data screening and extraction from full-text articles were performed independently by the two authors. The kappa coefficient was > 0.8. Descriptive statistics were calculated, including frequency and percentage. The chi-square test was used to compare categorical variables. Statistical significance was set at a p-value of 0.05.

Results: A total of 1,899 articles were included. The greatest research activity was in the Riyadh region (47%). The most productive corresponding institution was King Saud University (29%). National collaborations between sectors represented 24% of publications, and multiple collaborations accounted for 33%. Endodontics showed the highest levels of collaboration between sectors (33%). The most frequent study designs were cross-sectional (51%) and laboratory experimental (19%), while case-control, cohort, and qualitative studies were among the least common. The most productive years were 2018 and 2019, and the average annual growth rate of research productivity was 21%. Implant dentistry showed the fastest growth rate. Total publications and local collaborations increased remarkably during the second half of the decade. Restorative dentistry was the most funded specialty (18%). There were statistically significant associations between study design, dental specialty, and funding (p < 0.05).

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Conclusion: This bibliometric analysis provides insight into the trends of Saudi-affiliated dental research. Based on our findings, more effective local collaboration between authors, institutions, and sectors; better funding planning for high-quality research; and more research conducted in less well-investigated dental specialties are recommended.

Contents

1. Introduction

Dental research has shown exponential growth during the past few decades, in accordance with tremendous advances in materials and technology leading to major updates in dental knowledge. As a result of the rapid and thorough change in knowledge, dental practice and dental education have been transformed; consequently, oral healthcare services and quality of life have improved. High-quality published research creates a strong body of scientific literature that supports evidence-based dental practice. There has recently been significant progress in dental research worldwide. However, analysis of scientific research outputs can be complex given that no clear and accurate method has been identified for determining the quantity and quality of dental literature (Venkatakrishnan, 2013).

One way to evaluate research output is by bibliometric studies that assess scholarly publications to measure the scientific productivity of authors, institutions, regions, or countries by analyzing various parameters (Ul Haq et al., 2020). Such studies provide useful and objective information about research performance in any scientific field (Ul Haq et al., 2020; Asiri et al., 2021; Assari and Ahmadyar, 2009; Durieux and Gevenois, 2010).

Many studies around the world have analyzed dental research productivity based on certain criteria such as cited articles in a country, specialty or a journal (Asiri et al., 2021; Bueno-Aguilera et al., 2016; Fakheran and Shahravan, 2017; Liu et al., 2022; Lorusso et al., 2020; Moraes et al., 2020; Natto et al., 2019; Venkatakrishnan, 2013). Other recent studies have been conducted based on subject area, such as implant dentistry (Huang et al., 2021), or on recently significant emerging topics, such as COVID-19 (Jacimovic et al., 2021).

In alignment with the Saudi Ambitious Vision of 2030, Saudi dental institutions have increased their contributions to dental research to meet the international standards of higher education and to follow the global trend of becoming an essential part of the modern era of dentistry (Ul Haq et al., 2019; Ul Haq et al., 2020). According to a study that compared research output in Arabic countries, Saudi Arabia was the most productive in dental research among those countries (Ul Haq et al., 2019). However, only few bibliometric studies have been published during the past few years that evaluated the body of Saudi dental literature. Some of these studies analyzed research in a specific discipline (Patil et al., 2020) or analyzed the data produced by authors at a particular institution (Ul Haq and Al Fouzan, 2018), while other studies appraised general research in the health sciences in Saudi Arabia. The aim of the study was to provide a comprehensive descriptive analysis of the Saudi dental literature from 2010 to 2020.

2. Materials and methods

2.1. Search strategy and eligibility criteria

The study was conducted between September and December 2021 at Umm Al-Qura University. Data were retrieved from the Web of Science and MEDLINE/PubMed databases. A systematic search strategy was performed. Filters were used to include the indexed articles published in English during the

period of January 2010 to December 2020 and to narrow the search to "Saudi Arabia" affiliation and the "Dentistry, Oral Surgery, and Medicine" category.

The two authors (MR and WK) each independently screened the titles, abstracts, bibliographies, and publication dates. All duplicates were excluded. Only published articles from authors who were all affiliated with Saudi dental institutions were considered in this study; studies that showed non-Saudi affiliations were excluded. The study also excluded letters to editors, editorials, comments, discussions, book chapters, reliability and validity studies, and abstracts for conferences and lectures (Fig. 1).

2.2. Data extraction and reliability

Full-text articles were retrieved, and data extraction was performed independently by the two authors. Any discrepancy was resolved by discussion until a consensus was reached.

The following data were extracted from each article: name of the study; study design; main dental specialty; name of the journal; year of publication; number of authors; gender, affiliation, and academic level of the corresponding author; presence and pattern of national collaborations; and funding. Reviewers were trained to identify the main methodology or specialty in cases where more than one study design or specialty was reported. The main specialty was identified based on the main outcome of the study. In regard to study design and dental specialty, Kappa coefficient was used to determine inter-rater agreement, which was > 0.8.

2.3. Statistical analysis

All data were organized in a spreadsheet using Microsoft Office Excel 2021 (Microsoft Corporation, Redmond, Washington, USA). Statistical analysis was conducted using Stata 23 (Stata Corp., LLC, College Station, TX, USA). Descriptive
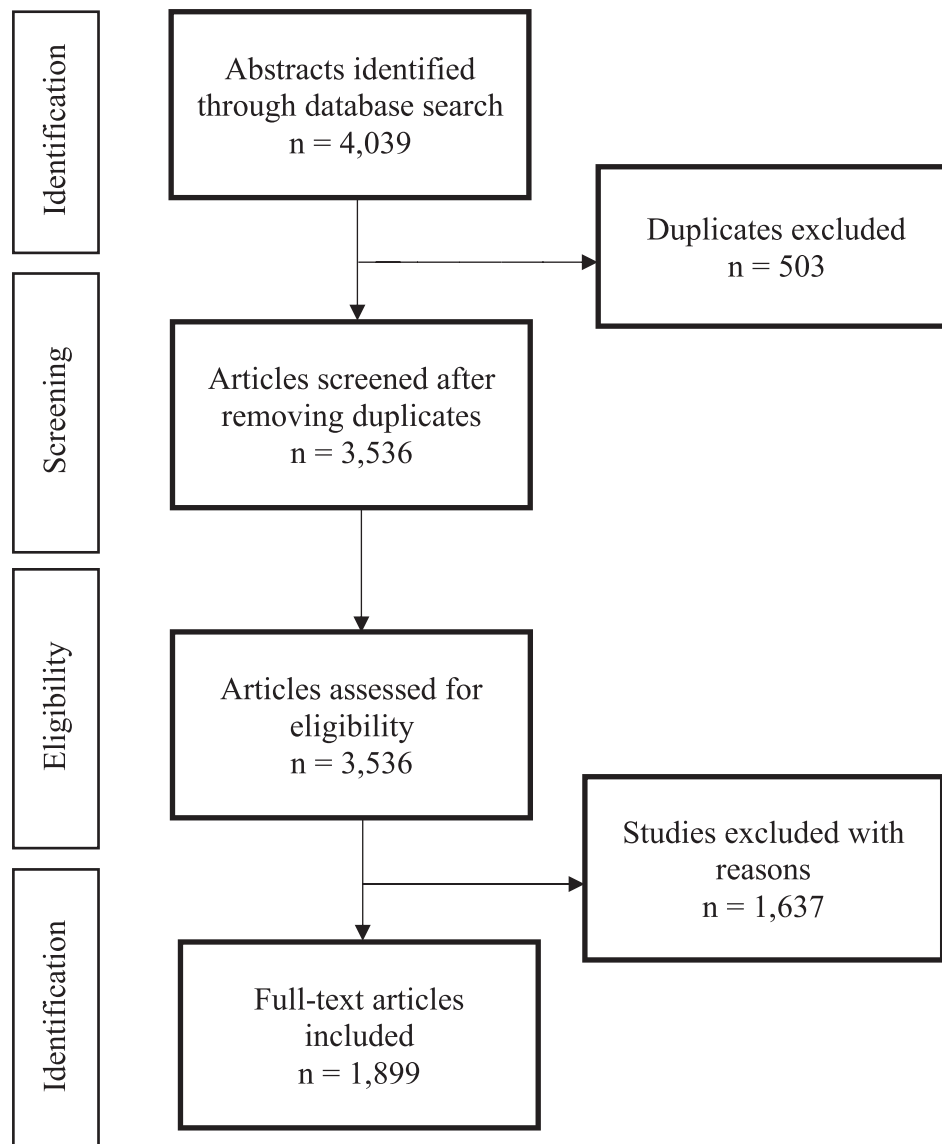

Fig. 1 Systematic review process with an explanation from PRISMA flow diagram.

statistics were calculated, including frequency and percentage. The chi-square test was used to compare categorical variables. A p-value of 0.05 was used as the statistical significance level.

3. Results

3.1. Trends in affiliated institutions and local collaboration

The search revealed 1,899 articles that met the inclusion criteria and were written exclusively by Saudi-affiliated dental authors from a total of 64 affiliated institutions. The top five most productive institutions in a descending order were King Saud University, King Abdulaziz University, Imam Abdulrahman Bin Faisal University, King Khalid University and Riyadh Elm University. The greatest number of published papers between 2010 and 2020 (according to the corresponding author's affiliation), with a total of 555 (29%), originated from King Saud University.

The affiliated institutions were categorized based on the institution's type of managing sector into educational (Ministry of Education), military (Ministry of Defense and National Guard), healthcare (Ministry of Health), or private educational or healthcare sectors. According to the contributions of the sectors, the governmental educational sector contributed to 1,633 (85%) of the publications, 277 (14%) publications showed contributions from the private educational sector, 178 articles (9%) had affiliations from the military sector, 138 (7%) from the Ministry of Health sector, and 67 (3%) were from private healthcare and other sectors.

Regarding local collaboration, only 472 (24%) studies showed collaboration between national institutions. The percentage of collaborations between two affiliations was 67%, while the percentage of collaboration between multiple affiliations was 33%. Collaboration among governmental academic institutions was 45%. Collaboration between governmental academic institutions and another governmental sector (e.g., the MOH or military) was 17%, and collaboration between governmental academic institutions and private academic institutions was 11%. The corresponding author of most articles is affiliated with an educational institution (72%). The presence of collaboration has increased about four times, from 17% during the first half of the past decade to 80% during the second half. Based on dental specialties, endodontics showed the highest percentage of collaboration between sectors (33%), while dental education showed the least local collaboration. The distribution of the corresponding affiliations by geographic regions of the country are presented in Fig. 2. The highest number of publications was 893 (47%) from the Riyadh region (from 23 institutions), followed by 372 (19%) publications from the Makkah region (from 14 institutions) and 177 (9%) publications from the eastern region (from 8 institutions). Two of the top five most productive institutions found in our study are located in the Riyadh region. No corresponding dental affiliation was from the Tabuk region, and <10 publications were found from the Northern Border region or the Al-Baha region.

The total number of academic journals in which the included articles were published was 389. Eleven of them were Saudi journals (2%). The percentage of articles that were pub-
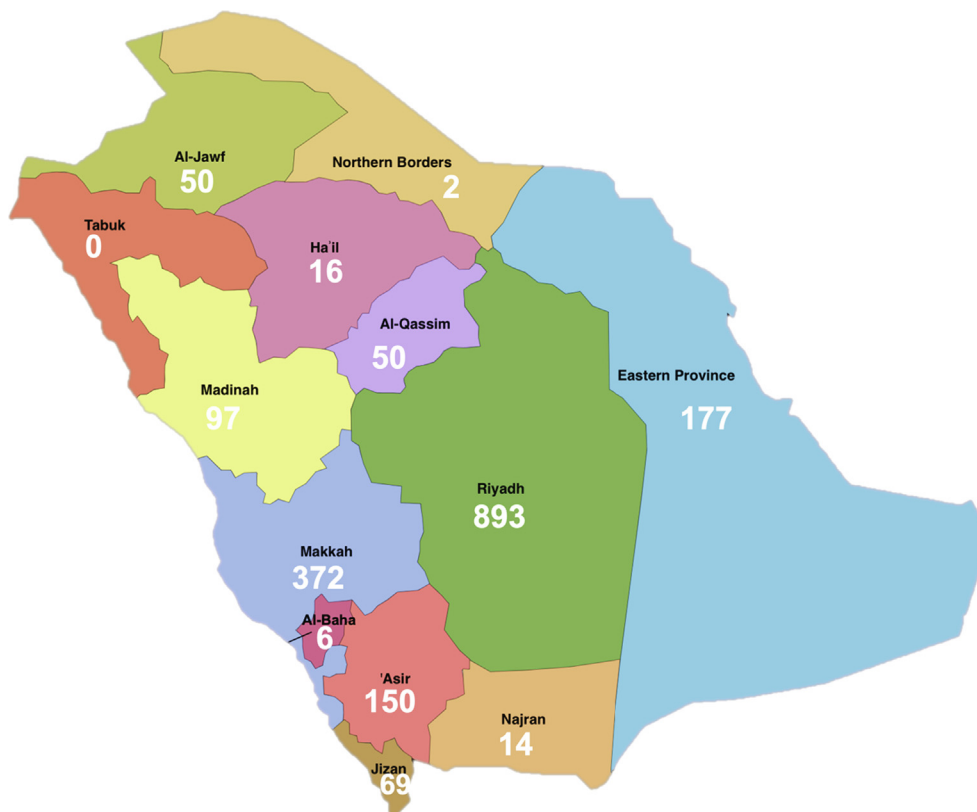

Fig. 2 The distribution of Saudi dental publications by regions of the country (2011–2020).

lished in dental journals was 64%, while 31% were published in medical/healthcare sciences journals. The top five most frequent academic journals for Saudi dental publications are presented in Table 1.

3.2. Trends in study design and dental specialty

In terms of the designs used in the studies reported by the articles, 977 (51%) were designed as cross-sectional studies, followed by 367 (19%) as laboratory experimental designs and 137 (7%) as literature reviews. Cohort, case-control, and qualitative study designs were the least used designs in Saudi dental literature, with < 20 studies found in our study for each of these designs.

Dental public health was the most studied dental discipline during the past decade, presenting a count of 371 (19%) of the total published studies, followed by restorative and esthetic dentistry with 258 (13%) published articles, and stomatology (such as oral medicine, oral radiology, oral biology and oral pathology) with total published studies of 235 (12%). Dental education was among the least investigated specialty in Saudi literature (4%). Fig. 3 shows the three most frequent specialties identified in the articles analyzed per year during the period 2010–2020. The subject area of dental public health received more attention than other specialties in the top five most productive Saudi dental institutions, except for King Saud University, where the restorative and dental esthetics specialty had the most frequently published topics.

We further categorized the articles within each specialty according to the study design. The results revealed that all dental specialties published a high number of cross-sectional studies, except for the restorative and endodontic specialties, where experimental lab work was presented in 66 % and 54% of the publications, respectively. The overall p-value was < 0.05, which indicates that the selection of the study design is associated with the dental specialty (Table 2).

3.3. Trends of annual research productivity

During this period, the curve of Saudi published articles per year showed an ascending trend, indicating an annual increase of publications with an average annual growth rate of 21%.

Table 1 Top five indexed journals publishing articles by Saudi-affiliated dental authors.

| Name of journal	ISI-indexed	Impact factor	Region	Type of journal	N	Percentage
Saudi Dental Journal	Yes	N/A	Saudi Arabia	Dental	171	9%
Saudi Medical Journal	Yes	1.484	Saudi Arabia	Medical	91	4 %
Journal of International Society of Preventive and Community Dentistry	Yes	N/A	India	Dental	73	3%
International Journal of Dentistry	Yes	N/A	USA	Dental	44	2%
Open Dentistry Journal	Yes	N/A	Netherland	Dental	41	2%
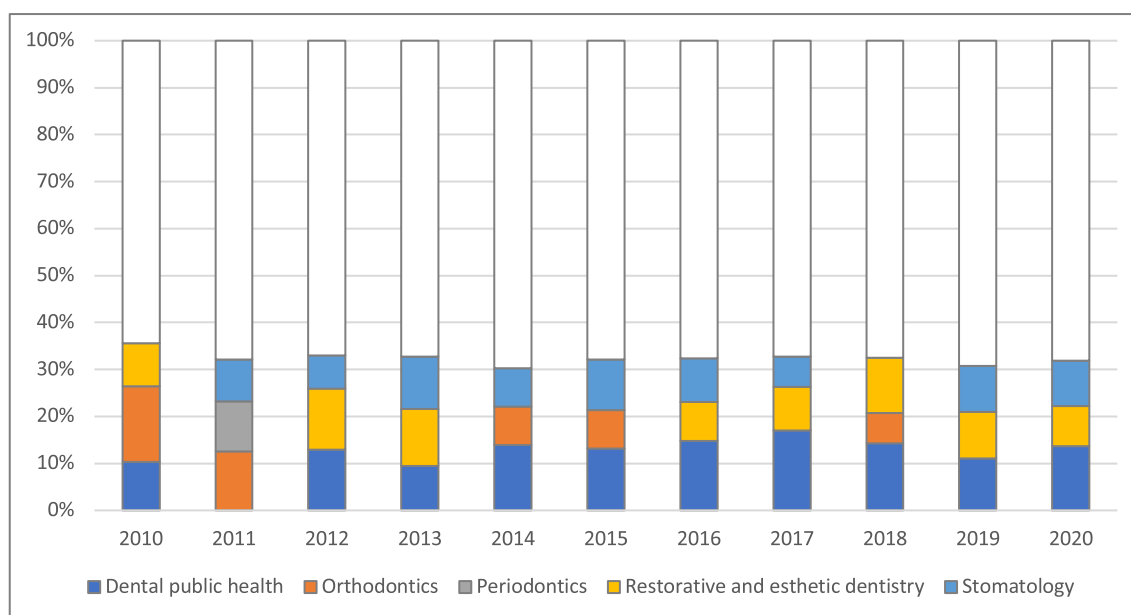
Fig. 3 Distribution of the most frequent specialties for Saudi dental publications per year.

Table 2 Frequency and percentage of study designs by different dental specialties.

	Animal study N (%)	Case-control N (%)	Case report N (%)	Clinical trial N (%)	Cohort N (%)	Cross-sectional N (%)	Lab work N (%)	Longitudinal study N (%)	Qualitative study N (%)	Quasi-experimental N (%)	Randomized controlled trial N (%)	Review N (%)	Systematic review N (%)	Total number by specialty
Dental education	0	0	2 (2)	1 (1)	3 (3)	50 (65)	0	1 (1)	2 (2)	10 (13)	2 (2)	5 (6)	0	76 (4)
Dental public health	1 (0.2)	1 (0.2)	13 (3)	4 (1)	1 (0.2)	323 (87)	4 (1)	1 (0.2)	2 (0.5)	7 (1)	1 (0.2)	8 (2)	5 (1)	371 (19)
Endodontics	0	0	0	1 (0.8)	0	33 (29)	61 (54)	0	0	0	4 (3)	7 (6)	6 (5)	112 (5)
General dentistry	0	0	0	0	0	60 (89)	2 (2)	0	0	1 (1)	0	3 (4)	1 (1)	67 (3)
Implant dentistry	8 (6)	0	6 (5)	8 (6)	1 (0.8)	36 (30)	23 (19)	5 (4)	0	0	9 (7)	11 (9)	10 (8)	117 (6)
Oral and maxillofacial surgery	9 (6)	1 (0.7)	30 (22)	12 (9)	3 (2)	52 (39)	3 (2)	0	0	0	10 (7)	9 (6)	4 (3)	133 (7)
Orthodontics	4 (2)	1 (0.5)	12 (6)	7 (3)	1 (0.5)	98 (54)	24 (13)	0	0	0	5 (2)	15 (8)	13 (7)	180 (9)
Pedodontics	0	0	12 (8)	3 (2)	0	73 (52)	13 (9)	2 (1)	1 (0.7)	0	21 (15)	11 (7)	4 (2)	140 (7)
Periodontics	3 (2)	2 (1)	14 (12)	5 (4)	1 (0.9)	42 (38)	5 (4)	0	0	1 (0.9)	13 (11)	14 (12)	9 (8)	109 (5)
Prosthodontics	0	0	13 (12)	2 (1)	0	41 (40)	33 (32)	0	0	0	3 (2)	7 (6)	2 (1)	101 (5)
Restorative and esthetic dentistry	0	1 (0.3)	6 (2)	2 (0.7)	0	56 (21)	172 (66)	0	0	1 (0.3)	1 (0.3)	11 (4)	8 (3)	258 (13)
Stomatology	3 (1)	9 (3)	28 (11)	3 (1)	1 (0.4)	113 (48)	27 (11)	0	0	1 (0.4)	4 (1)	36 (15)	10 (4)	235 (12)
Total number by study design	28 (1)	15 (0.7)	136 (7)	48 (2)	11 (0.5)	977 (51)	367 (19)	9 (0.3)	5 (0.2)	21 (1)	73 (3)	137 (7)	72 (3)	1899

The highest numbers of publications per year were in 2018 and 2019, showing totals of 297 and 382 published papers, respectively.

A comparison of the total number of publications between the first and second halves of the past decade showed a jump from 524 to 1,375 publications. In addition, our analysis indicated that the total number of articles in the top two most frequently studied dental specialties increased remarkably around three times during the second half of the past decade in comparison with the first half. The implant dentistry and endodontics fields showed the fastest growth rates of about four times during the second half of the decade, while oral and maxillofacial surgery had the lowest rate of increase (1.6 times) (Fig. 4).

3.4. Trends in authorship and funding

The number of authors ranged from 1 to 14. There were 448 (23%) articles written by a single author (the highest number), 313 (16%) articles written by two authors (the second highest number), and 260 (13%) articles written by four authors (the third highest number). We found that 86 articles in total were conducted by more than seven authors. Regarding study design, 19% of dental studies designed as cross-sectional were written by a single author, as were 21% of laboratory experimental, 46% of reviews, 34% of case reports, and 38% of systematic reviews, representing the highest number of authors in each previous study design. Most clinical trials and random-
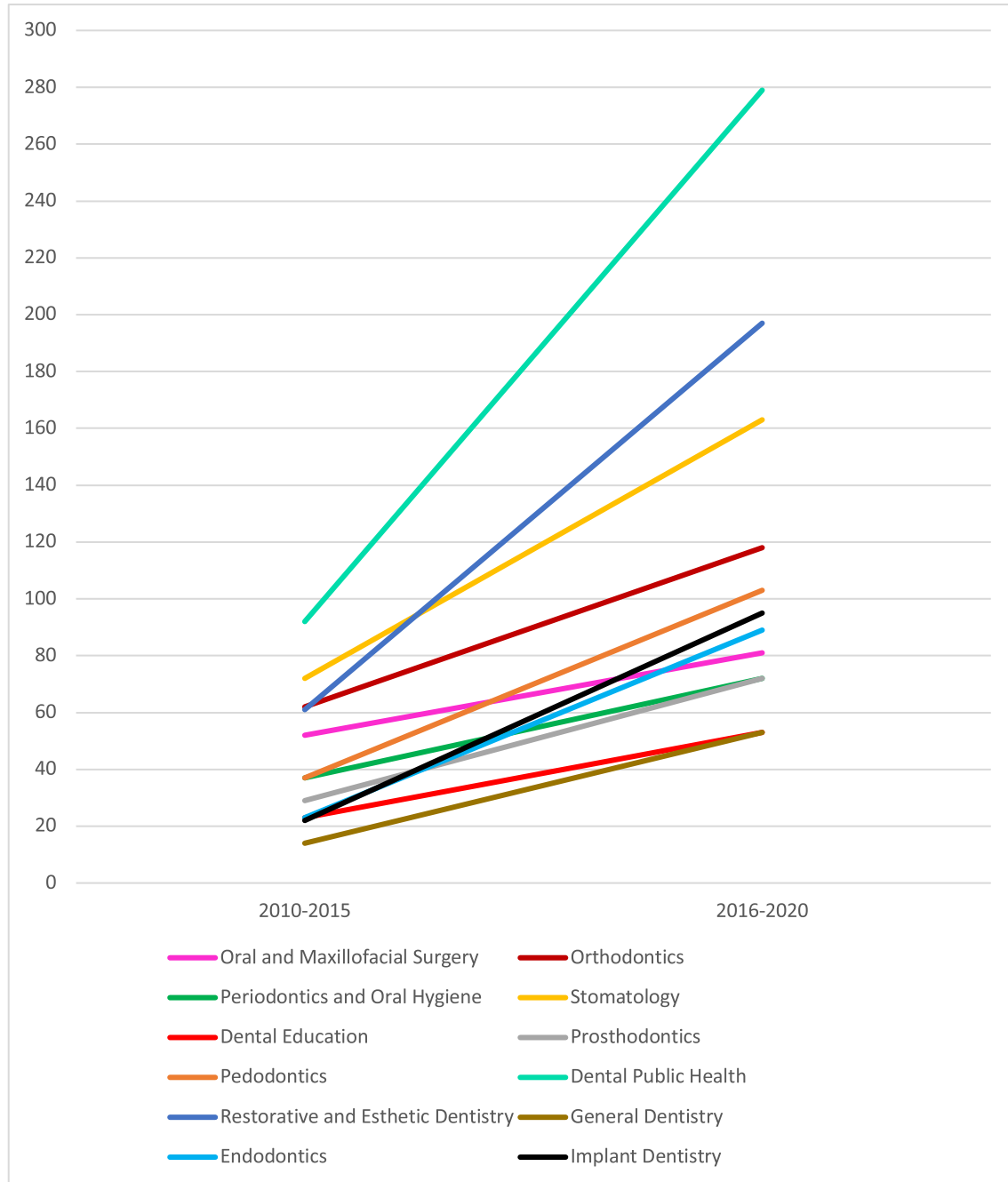

Fig. 4 Comparison of total number of publications for each specialty during the first and second halves of each year, 2010–2020.

ized controlled trials involved two or four authors, while more than half of the case-control studies (60%) and qualitative studies (60%) were written by more than five authors.

Regarding the academic level of the corresponding author, 86% of the published articles did not specify the academic degree of the corresponding author. However, assistant professors, associate professors, professors, and lecturers were corresponding authors in 107, 67, 34, and 23 articles, respectively. It was found that 1,329 articles (69%) had corresponding male authors, while 528 articles (27%) had corresponding female authors.

A total of 399 (21%) studies were funded by their institutions. There was an association between study design and funding ($p < 0.001$), and most of the funds were allocated to cross-sectional and lab work studies. In addition, there was an association between the dental specialty and funding ($p < 0.001$), where 18% of the funding was allocated to restorative dentistry and biomaterials specialties, followed by 13% for dental public health and 12% for implant dentistry. Studies done in academic governmental sectors were more likely to receive funds (95%) than those from other governmental healthcare sectors (3%) ($p < 0.001$). In each year, funding status has varied, with an overall ascending pattern throughout the past decade. The years 2018 and 2019, the most productive research years, received the greatest amount of funding. However, this was not statistically significant ($p = 0.19$).

4. Discussion

This study was carried out to analyze the dental literature published by Saudi-affiliated authors during the past decade (2010–2020). According to our study, the Riyadh region was the most productive region in dental research, publishing almost half of the total dental publications in Saudi Arabia. It was found that most of these publications corresponded to King Saud University. The College of Dentistry at King Saud University was the first dental school established in Saudi Arabia in 1975. The age and size of the school, cumulative research experience, availability of facilities and funding, and number of researchers are contributing factors that explain the high level of research productivity at King Saud University. Parallel to our findings, a bibliometric study conducted in 2020 to review Saudi-affiliated health sciences publications indexed in Scopus similarly found that King Saud University was the most productive institution in all health sciences, including dentistry (Ul Haq et al., 2020). While our study reviewed the dental literature indexed in the Web of Science and MED-LINE/PubMed databases, another study investigated Saudi dental research productivity for two decades (1997–2017) of data retrieved from the Scopus database and found that the top three most productive Saudi research institutions were the same as those found in our study (Ul Haq et al., 2019).

The most productive sector in dental research in our study was the educational governmental sector which contributed to about 4/5 of total dental publications in Saudi Arabia. The absence of research productivity in the North Border and Tabuk regions can be related to the absence of academic dental institutions in these areas. According to the study that analyzed health sciences in Saudi Arabia, the similar apparent trend was toward a greater number of publications from teaching institutions but with no statistically significant difference in that study between the teaching and healthcare sectors in the medical and health sciences field (Ul Haq et al., 2020).

The current study found that local collaboration between various national sectors and institutions expanded four times during the second half of the decade. However, this represents only about 1/4 of total studies; about 2/3 of total collaborations were binary (involving collaborations between only two sectors or institutions). The field of endodontics showed the highest percentage of local collaboration. It was also found that endodontics is one of the fastest growing fields in terms of total publications during the first and second halves of the decade in Saudi Arabia. Collaborations between institutions, sectors, and countries enhance the quality of research and should be encouraged (Ul Haq et al., 2019). However, the focus of our study was on national collaborations only to evaluate national-level research activity without the influence of international collaboration. In addition, the pattern of international collaboration with Saudi affiliations was covered by other studies (Ul Haq et al., 2019; Rajeh and Khayat, 2021).

Based on publication source and category, about 2/3 of the articles were published in dental, oral, and maxillofacial journals, while 1/3 were published in medicine, pharmacology, and health sciences journals. The remaining 4% of studies were published in other journal categories, such as biology and social sciences. Some articles in the dental field might be published in categories other than dentistry due to collaborations with other branches of science or saturation in dental journals (Pulgar et al., 2013). Consistent with our study, a bibliometric study in 2019 also found that both the *Journal of International Society of Preventive and Community Dentistry* and the *Saudi Dental Journal* were the most frequently cited journals for Saudi dental publications (Ul Haq and Al Fouzan, 2019). Among the top five cited journals found in our study, only the *Saudi Medical Journal* has an impact factor, although all of them were ISI-indexed journals.

This study also found a statistically significant association between dental specialty and study design. The selection of study design is critical to properly answering research questions related to various dental fields. The distribution of study design by dental specialty revealed that cross-sectional design was the most frequently used for all specialties except restorative dentistry and endodontics. Most of the research questions in these areas were answered using laboratory experimental designs. Generally, both cross-sectional and in vitro studies produce less evidence than clinical trials. More attention, funding, and efforts toward conducting high-quality clinical studies should be considered.

The finding of a high prevalence of cross-sectional study design was not limited to Saudi dental literature, as Iranian publications showed similar findings (Assari and Ahmadyar, 2009; Fakheran and Shahravan, 2017), but these studies were older, and the current literature might be changed. Cross-sectional designs require less effort, facilities, and costs. Furthermore, because the greatest prevalence of dental specialties was dental public health, cross-sectional designs could be the most often used design to answer research questions concerning populations, which would explain the prevalence of that study design. In a comparison of worldwide dental literature, a study published by Natto et al. (2019) showed that case reports and case series were the most prevalent study designs in the dental literature over the past 50 years. However, Natto

et al.'s study considered only clinical studies and excluded any in vitro, animal studies and reviews, which account for a large percentage of the dental literature.

There has been an increasing trend in the number of dental publications during the past decade in Saudi Arabia. The total number of publications expanded about 2.6 times during the second half of the decade compared to the first half, with an average annual growth rate of 21%. The increasing trends could be related to the higher number of available open access journals in medical and dental fields in recent years. The mapping of publication growth rates by specialty indicated that implant dentistry had the largest growth, affirming the increasing interest, advancements, and applications of implant dentistry during recent years in the modern era of dentistry. Digital dentistry is also an emerging technology, and the research productivity of this subject area should be assessed in future studies.

Currently, there are 29 governmental and private dental schools in Saudi Arabia (Ul Haq and Al Fouzan, 2018). Excluding King Saud University and King Abdul-Aziz University, all other Saudi dental schools were established between 2000 and 2013 except two. Because most dental schools were already in place during the studied period (2010–2020), the ascending curve of research production was not associated with the number of academic dental institutions; rather, the increasing research productivity could be related to increases in the enrollment capacity of schools and dental workforces, the number of post-graduate dental programs, and an awareness of the significance of research in the country. In addition, published research became a requirement for acceptance in dental residency programs by the Saudi Commission of Health, which encourages dental students and recently graduated dentists to pursue research. The peak of research productivity was in 2019. The reduction in the number of publications in 2020 may reflect the influence of COVID-19, causing less research activity and delays in publishing articles.

Articles written by a single author were the most prevalent throughout the past decade. In our study, data regarding the academic levels of authors only accounted for the academic degrees of corresponding authors (found only for 12% of the studies) and did not consider other clinical rankings. This has no significant impact because the majority of corresponding authors are from academic institutions.

Our results indicate that the dental specialty, study design, and managing sector were statistically significant contributing factors for research funding in Saudi Arabia. It was also found that the higher the funding, the higher the productivity, although the association was not statistically significant. Governmental financial support needs to be maintained to support research and to cover the higher cost of publication charges to redirect funding toward high-level quality research because a lack of funding may influence the quality and quantity of research, which might be an area of concern.

The current study was limited to data indexed in the Web of Science and MEDLINE/PubMed databases under only the category of Dentistry/Oral Surgery and Medicine. Thus, there is a probability of the exclusion of influential and impactful articles from other databases such as Google Scholar, or categories such as Social Sciences. Our study focused on quantitative analysis and did not provide information about the qualitative analysis, such as citation indexes and level of evidence. However, these aspects, in addition to analyzing data from Scopus, have been covered by other studies (Ul Haq et al., 2019; Rajeh and Khayat, 2021). Future studies should evaluate the quality of dental literature in Saudi Arabia in each dental discipline.

5. Conclusion

This bibliometric analysis gave insight into the trends in Saudi-affiliated dental research and the distribution patterns of publications that were mapped based on various valuable criteria. Based on our findings, more effective local collaboration between authors, institutions, and sectors, better planning for funding high-quality research, and more investigations in some dental specialties are recommended.

Ethical statement

This article does not contain any studies with human participants or animals performed by the author.

CRediT authorship contribution statement

Waad Khayat: Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **Mona Rajeh:** Conceptualization, 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.

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