

Trends, Collaborative Networks, and Impact of Infrared Thermography and Thermal Therapies in Dentistry: A Bibliometric Study

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ABSTRACT

Aim: To analyze the scientific literature on infrared thermography and thermal therapies in dentistry published between January 2019 and August 2024 and to identify trends, collaborations, and the impact of research in this field.

Materials and methods: A descriptive, bibliometric study was conducted. The search was performed in Scopus using different MeSH terms, thesauri and other Emtree terms. Data were subsequently exported to SciVal and Bibliometrix for comprehensive analysis. The study evaluated publication trends, institutional and international collaborations, co-authorship networks, keywords, and citation patterns. Key metrics assessed included scholarly output, views per publication, citations per publication, CiteScore 2023, SNIP 2023, collaboration maps by country, Lotka's Law, Bradford's Law, and the corresponding author's country.

Results: The bibliometric analysis identified 41 documents from 23 sources, exhibiting a negative annual growth rate of -4.3%. The average age of the papers was 2.4 years, with each paper receiving an average of 5.2 citations. A total of 153 specific keywords were identified, and 206 authors contributed to the publications, with no single-authored papers. Besides, Universidade Estadual da Paraíba in Brazil led with 4 publications and an average of 7 citations per publication. The journal of thermal analysis and calorimetry stood out with 12 publications with a cite score of 8.5 and 5.3 citations per publication.

Conclusions: Brazil, China, and Indonesia have distinguished themselves through their substantial academic output and notable impact, as evidenced by the high number of citations per publication.

Clinical significance: This bibliometric analysis underscores the most impactful and collaborative research areas on infrared thermography and thermal therapies in dentistry. Beyond collaborative research, the study highlights the diverse techniques employed, the advancements in these techniques, and the geographical regions contributing significantly to this field. The findings provide valuable insights that can guide future research directions, enhance clinical practices, and foster international collaborations in infrared thermography and thermal therapies in dentistry.

Keywords: Dentistry, Infrared Thermography, Thermal therapy.

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INTRODUCTION

Recent advances in infrared technology are opening new opportunities in surgical settings, particularly in flap surgery.¹ Studies have demonstrated that infrared thermography is an effective technique for measuring the energy emitted by an object, providing a radiometric thermal image that visualizes surface temperature distribution. This technique can detect temperature variations in both soft and hard tissues, making it highly valuable in medical applications.^{2,3} Integrating infrared thermography with a wireless module not only reduces costs and time but also ensures greater accuracy in monitoring flap blood flow, especially in less developed regions.⁴

Temperature measurement devices, such as non-contact infrared thermometers and infrared thermography, provide reliable and accurate readings under specific conditions.⁵ As a noninvasive method, infrared thermography offers valuable insights into body thermal changes due to various conditions, including physical activity.⁶ For instance, using infrared thermography to diagnose scoliosis by assessing thermal activity in the back muscles has proven effective in identifying temperature asymmetry.⁷ Additionally, studies on photodynamic therapy have yet to estimate

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heat-mediated effects, presenting an innovative area in thermal medicine.⁸

The fundamental principle of thermal therapy involves applying heat or cold to tissues, which can be applied to soft, cutaneous, and

intra-articular tissues, causing a temperature change in the tissue core.⁹ The integration of nanomaterials into thermal therapies is due to their small size, unique shape, optoelectronic properties, and ability to generate heat through excitation by external sources.¹⁰ Techniques such as laser ablation have been shown to increase the permeability of the blood-brain barrier, facilitating more effective combination therapy options.¹¹ Crucially, thermal therapy creates a therapeutic window for the administration of adjuvant therapies after a few days of treatment.¹²

Given the rapid advancements and increasing volume of research in the fields of infrared thermography and thermal therapies in dentistry, a bibliometric study is essential to systematically analyze and quantify the impact of these developments. Such a study provides valuable insights into publication trends, collaborative networks, and the overall influence of research outputs. This comprehensive analysis is crucial for identifying key areas of progress, potential gaps in the literature, and future research directions. Thus, the aim of this bibliometric study was to evaluate the trends, collaborative networks, and impact of infrared thermography and thermal therapies in dentistry.

MATERIALS AND METHODS

Study Design

A descriptive, bibliometric study was conducted to analyze the scientific literature on infrared thermography and thermal therapies in dentistry published between January 2019 and August 2024. The objective was to identify trends, collaborations, and the impact of research in this field. The reporting and measurement of items for bibliometric or scientometric studies in health sciences (RAMIBS) guidelines were used to report the results.¹³

Selection Criteria

All dental-related papers published between 2019 and 2024 that mentioned terms related to infrared thermography and thermal therapies in their titles, abstracts, or keywords were included in the analysis. Additionally, only papers available in Scopus were considered. Papers that did not specifically address infrared thermography or thermal therapies in the context of dentistry, publications outside the 2019–2024 range, unavailable papers, or those with incomplete metadata were excluded.

Information Search

The search was conducted on August 31, 2024, using the Scopus database. The following search formula was applied to identify relevant documents: TITLE-ABS ("infrared thermography" OR "thermography healing" OR "infrared therapy" OR "thermal therapy" OR "infrared thermal treatment" OR "infrared-based treatment" OR "thermotherapy" OR "infrared heat therapy" OR "thermal infrared therapy" OR "infrared therapeutic application" OR "infrared-induced therapy" OR "medical infrared treatment" OR "infrared heat treatment" OR "thermal treatment with infrared") AND SUBJAREA (dent) AND PUBYEAR > 2018 AND PUBYEAR < 2025.

Bibliometric Procedure

The data obtained from Scopus was exported to the SciVal and Bibliometrix platforms for comprehensive analysis. In SciVal, various impact metrics were evaluated, including the number of citations per document and the index of international collaboration. Publication trends over time were also analyzed to identify years with the highest and lowest scientific output. In addition,

Table 1: Scientific production characteristics of infrared thermography and thermal therapies for dentistry

Description	Results
Timespan	2019:2024
Sources	23
Documents	41
Annual growth %	-4.3
Document average age	2.4
Average citations per doc	5.2
Author's keywords	153
Authors	206
Single-authored docs	0
Co-authors per doc	5.2
International co-authorships %	24.3
Article	36
Book chapter	1
Review	4

collaborations between institutions and countries were examined, providing a clear picture of global research networks. In R Studio, comprehensive analyzes of co-authorship networks, keywords, and citations were conducted. Visualization techniques, including heat maps and network plots, were employed to uncover patterns and relationships within the data. Co-authorship analyzes pinpointed the most prolific authors and their collaborations, while keyword analyzes identified the most frequent and emerging research topics. Citation analysis aimed to highlight the most influential papers and authors in the field, as well as the connections between various studies.

Data Analysis

For the bibliometric analysis, several key metrics were used, including scholarly output, views per publication, citations per publication, cite score 2023, SNIP 2023, collaboration map by country, Lotka's Law, Bradford's Law, and corresponding author's country. All analyses were performed using SciVal and R Studio 4.3.2.

RESULTS

A bibliometric analysis of the literature on infrared thermography and thermal therapies in dentistry, covering the period from 2019 to 2024, revealed several key findings. A total of 41 papers from 23 sources were identified, with a negative annual growth rate of -4.36%. The average document age was 2.44 years, with each document receiving an average of 5,244 citations. The authors used 153 specific keywords, and 206 authors participated in total, with no single-authored papers. The average number of coauthors per paper was 5.27, with 24.39% of international coauthor ships. The distribution of document types included 36 articles, 1 book chapter, and 4 reviews (Table 1).

The analysis revealed that 20 papers were placed in the first quartile (Q1), with an annual distribution as follows: 2 in 2019, 1 in 2020, 2 in 2021, 6 in 2022, 6 in 2023, and 3 in 2024. In the second quartile (Q2), 11 papers were identified: 2 in 2019, 3 in 2020, 2 in 2021, 2 in 2022, 1 in 2023, and 1 in 2024. The third quartile (Q3) included 4 papers, with 1 in 2020 and 3 in 2021. Finally, the fourth quartile (Q4) comprised 3 papers, with 2 in 2022 and 1 in 2023 (Table 2).

Universidade Estadual da Paraíba in Brazil led with 4 publications, an average of 18.8 views per publication, and 7 citations per publication, accumulating a total of 28 citations. Universitas Syiah Kuala in Indonesia also had 4 publications, with 16.8 views per publication and 1.5 citations per publication, totaling 6 citations in all. In the Russian Federation, Northern Arctic Federal University and Northern State Medical Academy had 2 publications each, with the former getting 22.5 views per publication and 0.5 citations per publication, while the latter had 15.5 views per publication and no citations. In Brazil, Universidade de São Paulo and Universidade Federal de Minas Gerais had 2 publications each, with the latter standing out with 10 citations per publication and a total of 20 citations. Universidade Federal de Pernambuco, also in Brazil, had 2 publications with 10 views per publication and 2.5 citations per publication, accumulating 5 citations. In Turkey, Çankiri Karatekin University had 1 publication with 40 views and 4

citations. Ajman University in the United Arab Emirates and Amrita Vishwa Vidyapeetham in India had 1 publication each, with the latter obtaining 14 views and 6 citations (Table 3).

The journal of thermal analysis and calorimetry led with 12 publications, a cite score of 8.5 in 2023, 5.3 citations per publication, and a SNIP of 0.99. The journal of international dental and medical research had 3 publications, a cite score of 1.1, 0.3 citations per publication and a SNIP of 0.37. The journal of oral rehabilitation also had 3 publications, a cite score of 6.1, 2 citations per publication and a SNIP of 1.4. The journal of clinical and experimental dentistry and the journal of lasers in medical sciences had 2 publications each, with cite scores of 2.7 and 3, respectively, and 3 and 2 citations per publication, respectively. The oral surgery, oral medicine, oral pathology and oral radiology also had 2 publications, with a cite score of 3.8 and 11 citations per publication. Other sources included clinical oral investigations with 1 publication and a cite score of 6.3, cranio-journal of craniomandibular practice with 1 publication and a cite score of 4.5, dental and medical problems with 1 publication and a cite score of 4, and dentomaxillofacial radiology with 1 publication and a cite score of 5.6 (Table 4).

The bibliometric analysis of collaborations among countries in research on infrared thermography and thermal therapies in dentistry revealed several international partnerships. Brazil collaborated with Canada, the Netherlands, and Switzerland once each and with the United States twice. China has collaborated with Australia, Canada, Singapore, and the United Kingdom on each occasion. Egypt and Saudi Arabia collaborated once, as did Ireland

Table 2: Impact of publications on infrared thermography and thermal therapies in dentistry

<i>CiteScore quartile</i>	<i>Overall</i>	<i>2019</i>	<i>2020</i>	<i>2021</i>	<i>2022</i>	<i>2023</i>	<i>2024</i>
Q1	20	2	1	2	6	6	3
Q2	11	2	3	2	2	1	1
Q3	4	0	1	3	0	0	0
Q4	3	0	0	0	2	1	0
Total	38	4	5	7	10	8	4

Table 3: Institutions with the highest scientific production of infrared thermography and thermal therapies in dentistry

<i>Institution</i>	<i>Country</i>	<i>Scholarly output</i>	<i>Views per publication</i>	<i>Citations per publication</i>	<i>Citation count</i>
Universidade Estadual da Paraíba	Brazil	4	18.8	7	28
Universitas Syiah Kuala	Indonesia	4	16.8	1.5	6
Northern Arctic Federal University	Russian Federation	2	22.5	0.5	1
Northern State Medical Academy	Russian Federation	2	15.5	0	0
Universidade de São Paulo	Brazil	2	13	0.5	1
Universidade Federal de Minas Gerais	Brazil	2	22	10	20
Universidade Federal de Pernambuco	Brazil	2	10	2.5	5
Çankiri Karatekin University	Turkey	1	40	4	4
Ajman University	United Arab Emirates	1	1	0	0
Amrita Vishwa Vidyapeetham	India	1	14	6	6

Table 4: Scientific Journals with the highest infrared thermography and thermal therapies in dentistry

<i>Source</i>	<i>Scholarly output</i>	<i>CiteScore 2023</i>	<i>Citations per publication</i>	<i>SNIP 2023</i>
Journal of thermal analysis and calorimetry	12	8.5	5.3	0.99
Journal of international dental and medical research	3	1.1	0.3	0.37
Journal of oral rehabilitation	3	6.1	2	1.4
Journal of clinical and experimental dentistry	2	2.7	3	0.81
Journal of lasers in medical sciences	2	3	2	0.8
Oral surgery, oral medicine, oral pathology and oral radiology	2	3.8	11	0.94
Clinical oral investigations	1	6.3	0	1.48
Cranio-journal of craniomandibular practice	1	4.5	1	1.08
Dental and medical problems	1	4	31	0.89
Dentomaxillofacial radiology	1	5.6	6	1.47

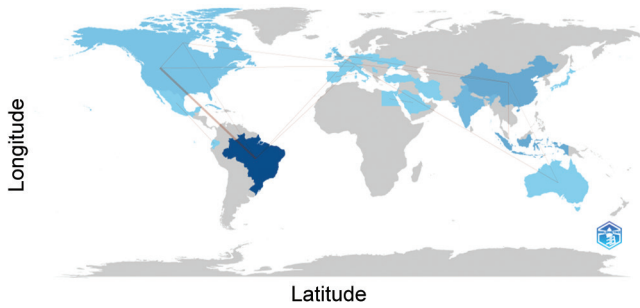


Fig. 1: Country collaboration map

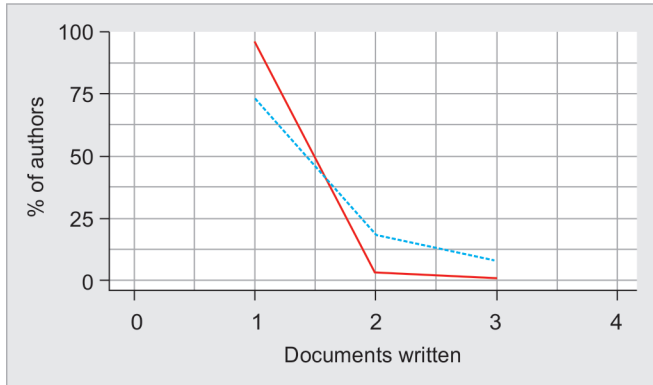


Fig. 2: Author productivity through Lotka's law

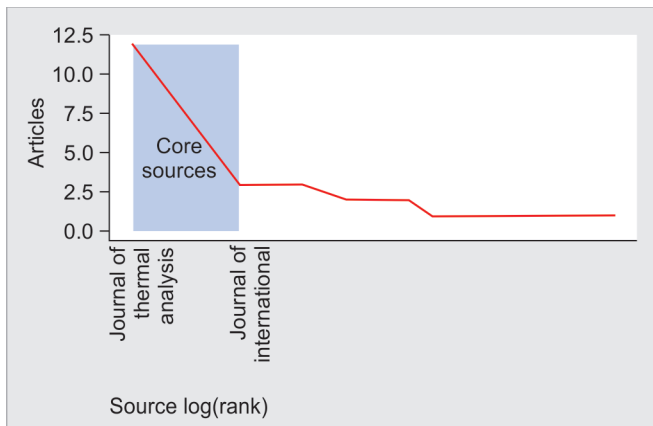


Fig. 3: Core sources by Bradford's law

and Poland, Mexico and Ecuador, and Spain and Italy. The United Kingdom and Australia also collaborated once. The United States collaborated with Canada and Switzerland once (Fig. 1).

Bibliometric analysis based on Lotka's law revealed that most authors contributed a single paper. Specifically, 198 authors (96.1%) wrote a single paper, 6 authors (2.9%) wrote two papers, and 2 authors (1%) wrote three papers (Fig. 2).

The bibliometric analysis based on Bradford's law showed that the journal of thermal analysis and calorimetry had 12 publications in zone 1. In zone 2, several journals were noted, including the journal of oral rehabilitation and the journal of clinical and experimental dentistry. Zone 3 included various journals with only one publication each, such as journal of dentistry and open dentistry journal (Fig. 3).

The bibliometric analysis of the corresponding authors' countries showed that Brazil had 11 articles, representing 26.8% of the total, with 9 single authored (SCP) and 2 multiple collaborative (MCP) articles, representing 18.2% of MCP. China and Indonesia followed with 4 articles each (9.8%), although China had a higher proportion of MCP (75%) than Indonesia (0%). India contributed 3 articles (7.3%), all single-authored. Other countries, such as Egypt, Ireland, Mexico, Spain, and the United States, had a high proportion of CCM (100%) despite having only one article each (Fig. 4).

DISCUSSION

A bibliometric analysis revealed that research on infrared thermography in the field of flaps primarily focuses on evaluating the effectiveness of infrared monitoring for estimating flap perfusion.¹ According to Feng et al., the various applications of infrared imaging in acupuncture, due to its ability to visualize temperature in real time and monitor cerebral blood flow, bring tangible benefits to the field.¹⁴

For instance, Zakaria et al.¹⁵ mentioned that infrared thermography research is characterized by increasing research activity, technological advances and significant clinical emphasis. Increasing publications and studies have highlighted the value of thermography as a tool for the early detection, prevention, and management of complications.

Conversely, a bibliometric study by Tang et al.,¹⁶ which included 820 publications on the relationship between thermal ablation and thyroid nodules, detailed 646 articles and 174 reviews. This study revealed the trend of annual publications in this field from 2000 to 2021.¹⁶ In our study on infrared thermography and thermal therapies in dentistry, a total of 41 papers from 23 sources, including 36 articles, 1 book chapter, and 4 reviews, were identified from 2019 to 2024.

According to Barba-Rosado et al.,¹⁷ a bibliometric analysis indicates that photodynamic and photothermal therapies are highly effective for treating cancer, outperforming other therapies. The combination of these therapies not only enhances the delivery of photosensitizers but also exerts a synergistic effect. These therapies are considered very effective in treating complex diseases, with their effectiveness varying based on the individual and the disease state and have proven beneficial for those who require them.¹⁷

Finally, Song et al.¹⁸ mentioned that the bibliometric analysis also highlighted that thermal ablation should not be considered in patients unsuitable for active surveillance. However, for those who wish to avoid surgery, thermal ablation may be a viable option, provided it is performed in a specialized center and by an experienced operator.¹⁸ Thermal ablation, a branch of thermal therapy, uses heat to remove tissue in a controlled manner using lasers, thereby reducing the risk of infection, especially in tumors and benign lesions, and improving clinical outcomes.

Research on infrared thermography and thermal therapies in dentistry is an emerging field that has garnered increasing interest in recent years. Although the number of available studies is limited, these topics are gaining relevance and providing more detailed explanations. The current information is insufficient, making it challenging to obtain accurate and realistic data. Consequently, there is a pressing need to generate new articles on infrared thermography and thermal therapies in dentistry to address the existing paucity of information. The articles and studies available in repositories such as PubMed and the Scopus database are outdated and scarce, highlighting the necessity to enhance the information

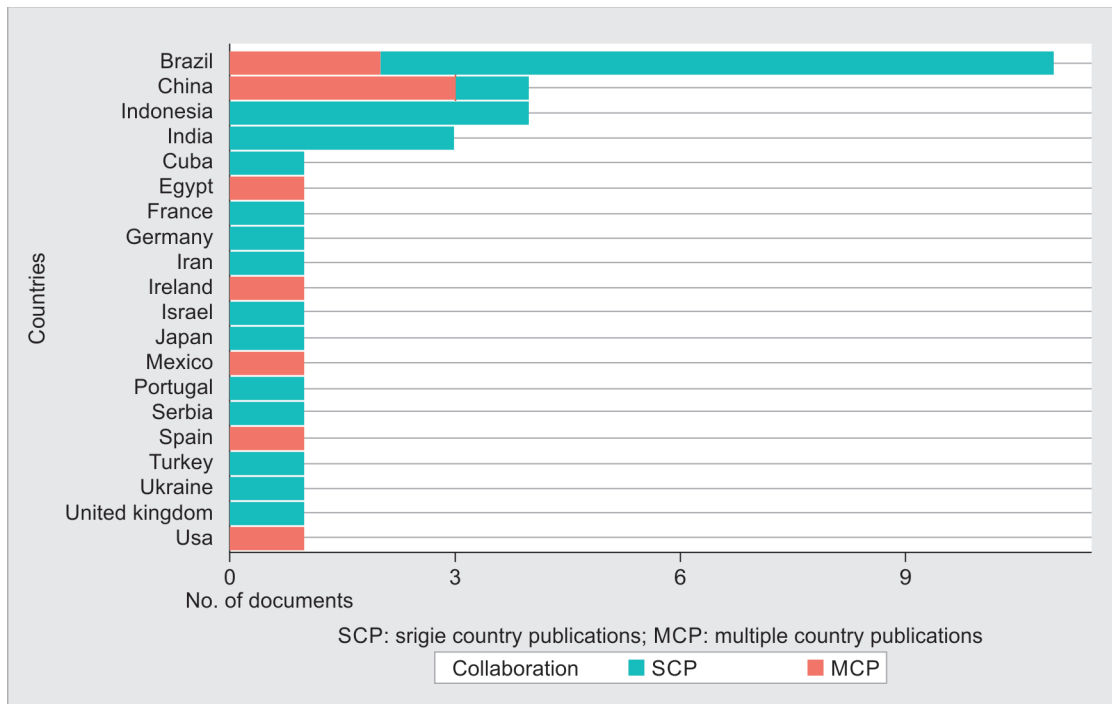


Fig. 4: Corresponding author’s countries

by integrating these two topics and offering criteria and opinions for future research. The RAMIBS analysis has effectively organized the topic of infrared thermography and thermal therapies in dentistry, facilitating a better understanding and structure for future publications.¹³

The present study aligns with previous findings regarding the growing relevance and applications of infrared thermography and thermal therapies in the field of dentistry. Additionally, this study evaluates aspects such as international collaboration and the use of specific keywords, providing a more detailed view of research trends and impacts in this area. The strengths and relevance of this research lie in its ability to offer a coherent and well-supported perspective to the reader. Nevertheless, the topic remains understudied, and the lack of clarity and experimentation has limited the research. Infrared thermography is crucial for determining heat in laboratory processes and environments requiring such evaluations, complementing thermal therapies in dentistry. These innovations enable the application of heat to various components and materials, facilitating the development of methods and treatments. Consequently, the precision of infrared thermography and thermal therapies in dentistry can be progressively enhanced.

CONCLUSION

A significant participation of international co-authorships was evidenced, with Brazil being one of the leading countries in scientific production in this field. Likewise, journals such as the journal of thermal analysis and calorimetry have played a prominent role in the dissemination of these studies, reflecting the relevance of the subject according to Bradford’s law. Collaborations between nations such as Brazil, the United States, China and Canada underline the importance of global scientific cooperation in this field. Finally, the fact that almost half of the articles were published in high impact

journals (Q1 and Q2) reinforces the significance of the research in the dental scientific literature.

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