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ORIGINAL RESEARCH

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Laser in pediatric dentistry: a bibliometric analysis

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Abstract

Background: Lasers enable minimally invasive treatment with reduced pain and improved cooperation in children, making them increasingly valuable in pediatric dentistry. In light of their growing relevance, understanding laser applications in this field is important. Therefore, this study aimed to provide a general overview of laser applications in pediatric dentistry via a bibliometric analysis. **Methods**: A search strategy was developed based on predefined inclusion and exclusion criteria. Only English-language original articles and reviews concerning laser applications in pediatric dentistry published before 2025 were included. An electronic search was conducted in the Web of Science database on 25 May 2025. Controlled vocabulary or Medical Subject Headings (MeSH) terms were not employed; instead, a combination of topic-specific keywords was used to guide the search process. Publications that did not align with the scope of the study were excluded, and the final dataset was analyzed using the Bibliometrix software package. **Results**: The analysis demonstrated a steady and continuous increase in the number of publications over time, indicating a progressive rise in scientific attention to this field. Caries Research emerged as both the most influential and the most frequently cited journal in this domain, while Richmond S and Mendes FM were identified as one of the most influential researchers. Keyword mapping revealed that areas such as primary teeth and laser fluorescence remain central research topics, whereas newer trends have increasingly focused on themes related to demineralization and endodontics. **Conclusions**: This study provided the first bibliometric overview of laser applications in pediatric dentistry. By identifying leading contributors, influential journals, and evolving research themes, it offers valuable insight into existing knowledge gaps and highlights potential future directions, suggesting the need for emphasizing laser applications for demineralization and endodontics in primary teeth.

Keywords

Laser; Bibliometric analysis; Children

1. Introduction

Lasers allow minimally invasive treatment of both hard and soft tissues with minimal discomfort, enhancing children's cooperation and contributing to a positive dental experience for patients, parents, and dentists alike, explaining the growing and sustained interest in laser applications in pediatric dentistry [1].

The term "laser" is an acronym for light amplification by stimulated emission of radiation [2]. With continuous advancements in laser technology, various laser-based devices have been introduced and applied in different areas of dentistry. The lasers used in current practice interact with tissues via multiple mechanisms, including hemostasis, vaporization, ablation, microbial inhibition, and tissue destruction, while also exerting biological effects such as biostimulation (photobiomodulation) [3].

Lasers are currently used in various clinical applications, including pain control, caries diagnosis and prevention, assessment of tooth vitality and pulp blood flow, caries removal and cavity preparation, enamel and dentin etching, root canal sterilization and disinfection, pulp capping, pulpotomy procedures, root canal preparation, reduction of dentin hypersensitivity, polymerization of restorative materials, tooth whitening, scaling, gingivectomy, gingivoplasty, periapical soft tissue incisions, frenectomy, and pain reduction and healing of aphthous lesions [4, 5]. Lasers can be applied in pediatric dentistry as effectively as in adults, provided that appropriate dosages and techniques are employed [3, 6, 7]. Considering that cooperation is often more challenging in children than in adults, laser systems can significantly facilitate pediatric dental care [8].

Given the increasing integration of laser technologies in pediatric dental practice, it is essential to present a comprehensive overview of existing research on laser applications, identify prevailing trends, detect knowledge gaps, and highlight influential contributions in the literature. Bibliometric analysis, which quantitatively evaluates scientific publications

within a defined field, provides a transparent, systematic, and reproducible framework that enhances the depth and reliability of literature reviews by assessing productivity, impact, and collaboration patterns across studies. This analytical approach contributes substantially to literature evaluation by offering objective tools that help identify major research areas and leading publications [9–11].

Two primary analytical dimensions are generally used in bibliometric studies: performance analysis and science mapping. Performance analysis focuses on evaluating the productivity and impact of authors, institutions, and countries, whereas science mapping explores the conceptual structure, evolution, and interrelationships within a research field. Data obtained via bibliometric approaches can be visualized using citation analysis, co-citation networks, and keyword mapping, which together illustrate the intellectual structure, developmental trajectory, and thematic connections of the scientific literature [12, 13].

Although bibliometric and citation analyses on laser applications in general dentistry have been reported, to date, no bibliometric study has focused specifically on laser applications in pediatric dentistry. Therefore, the present study aims to provide a general overview of existing research on laser applications in pediatric dentistry via bibliometric analysis, to identify major trends, highlight influential contributions, and reveal emerging areas of interest within this field.

2. Materials and methods

Bibliometric studies commonly use the Web of Science (WoS) Core Collection due to its wide coverage, reliability, and long-term citation tracking, making it an essential resource for assessing scientific productivity [14]. In the present study, an electronic literature search was conducted on 05 May 2025 using the WoS Core Collection. Other databases were not included, as the WoS Core Collection is universally recognized as the primary and most consistent source for bibliometric research, offering comprehensive and standardized citation information that ensures methodological consistency and facilitates comparability with previous bibliometric studies.

2.1 Search strategy

The search was conducted without temporal or language restrictions. Two independent reviewers (NAÜ and EB) performed the search using a predefined and structured strategy. The complete search strategy was summarized in Table 1. Only English-language original and review articles published before 2025 were included. Eligible studies were required to focus on the application of any type of laser or laser-based method in pediatric dentistry and to be indexed under the WoS subject category Dentistry, Oral Surgery & Medicine. Since the year 2025 had not yet concluded at the time of data retrieval, the analysis was limited to publications up to 2024 to ensure reliable year-by-year comparison of publication trends.

2.2 Study selection and data extraction

Two independent authors (NAÜ and EB) reviewed the titles and abstracts of all retrieved publications. Data were cross-checked for accuracy, and discrepancies were resolved via re-examination of the original articles. When consensus could not be reached, the opinion of an independent expert in pediatric dentistry was sought for adjudication. A total of 101 publications were deemed irrelevant to the study scope and were excluded. Ultimately, 480 publications met the inclusion criteria and were analyzed. The complete selection process was illustrated in Fig. 1. The bibliographic dataset is available in the **Supplementary material**.

General bibliometric indicators were extracted from the included studies, comprising titles, authors, publication years, citation counts, countries or regions of origin, journals, references, and keywords. Data analysis was performed using the Bibliometrix R package (Biblioshiny interface). Two complementary analyses were conducted: performance analysis and scientific mapping. The h-, g- and m-index metrics were used to evaluate the scientific influence of journals and authors. In addition, network analyses were performed to identify patterns of keyword co-occurrence, author collaboration, and co-citation relationships among documents and authors.

3. Results

3.1 Main information

Between 1986 and 2024, a total of 480 publications were identified, demonstrating a consistent annual growth rate of 9.89%. Overall collaboration levels were high, with an average of 4.74 co-authors per publication, whereas single-author studies were relatively uncommon (n = 14). International collaboration accounted for 22.5% of all publications, indicating that most research activity in this field remains primarily conducted within national boundaries. The average citation count per publication was 19.88, suggesting a moderate yet steady scholarly influence within the discipline (Fig. 2).

3.2 Annual scientific production and average citations per year

As illustrated in Fig. 3, publication output remained relatively low and stable between 1986 and 2000. However, a marked and sustained increase was observed from 2001 onwards, with the highest number of publications recorded in 2024. The average number of citations per year was highest for publications from 2001, followed by a period of relative stability between 2008 and 2012, which indicates an expansion of research activity in recent decades, accompanied by a consistent scholarly impact over time.

3.3 Most relevant countries by corresponding author and scientific production

Figs. 4,5 presented the distribution of scientific production and international collaboration among countries engaged in research on laser applications in pediatric dentistry. Brazil ranks first in total publication output (n = 191) but exhibits a relatively low international collaboration rate of 11%, indicating that most of its research is conducted within national institutions. The United Kingdom, which ranks fourth in pub-

TABLE 1. Search strategy.

Search Step	Search String (Boolean Operators)	Filters Applied
#1	TS = ("laser" OR "photobiomodulation" OR "PBM" OR "PBMT" OR "PDT" OR "DIAGNODENT" OR "QLF" OR "Quantitative Light-induced Fluorescence" OR "Quantitative Light Fluorescence" OR "LLLT" OR "low level laser therapy" OR "laser fluorescence" OR "laser scanning microscopy" OR "CLSM" OR "Soprolife")	None
#2	TS = ("pediatric-patients" OR "preschool-children" OR "children" OR "childhood" OR "child" OR "Primary teeth" OR "Primary tooth" OR "primary molar" OR "primary molars" OR "primary dentition" OR "immature permanent teeth" OR "immature permanent tooth")	None
#3	#1 AND #2	Web of Science Categories: Dentistry Oral Surgery Medicine Publication Years: 2025 Exclude Document Type: Article or Review Article Language: English

TS: Topic; PBM: Photobiomodulation; PBMT: Photobiomodulation therapy; PDT: Photodynamic therapy; DIAGNODENT: A laser-based device used for caries detection; QLF: Quantitative light-induced fluorescence; LLLT: Low-level laser therapy; CLSM: Confocal laser scanning microscopy.

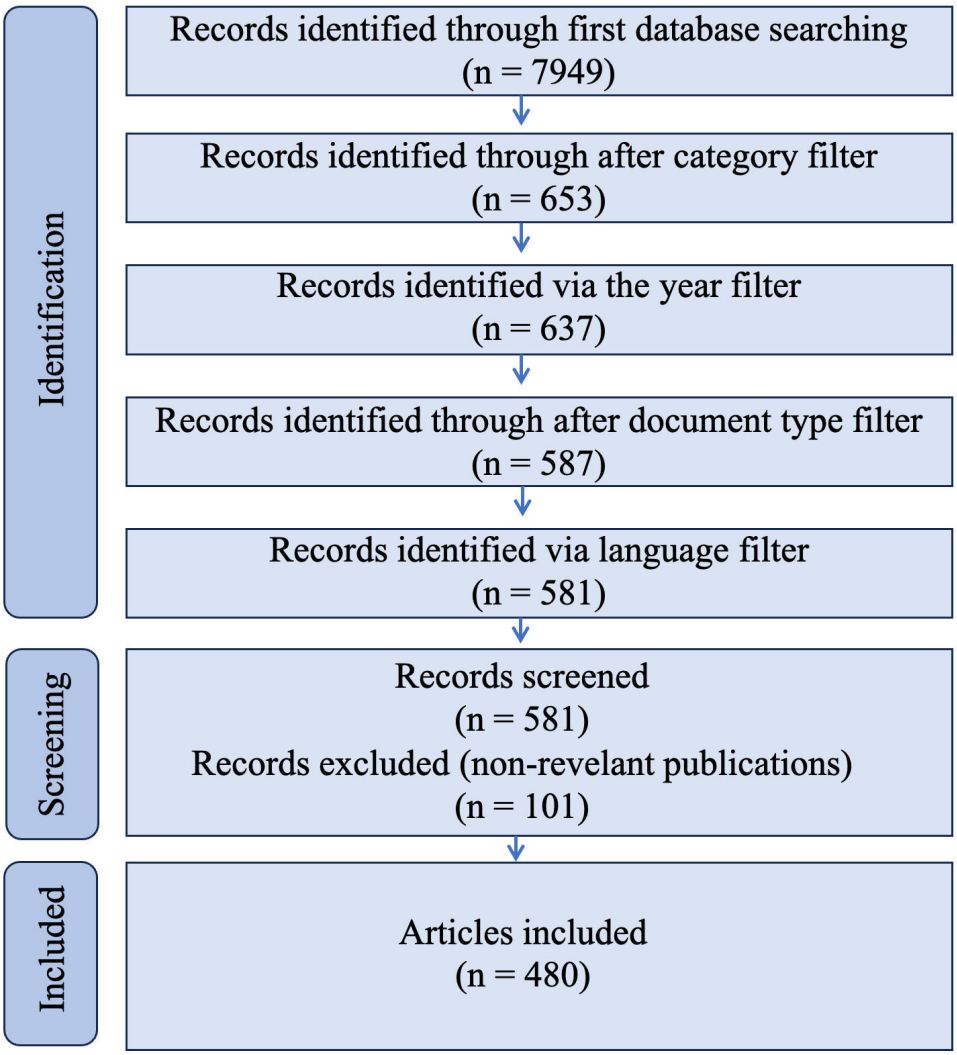

FIGURE 1. Flowchart illustrating the study selection protocol.

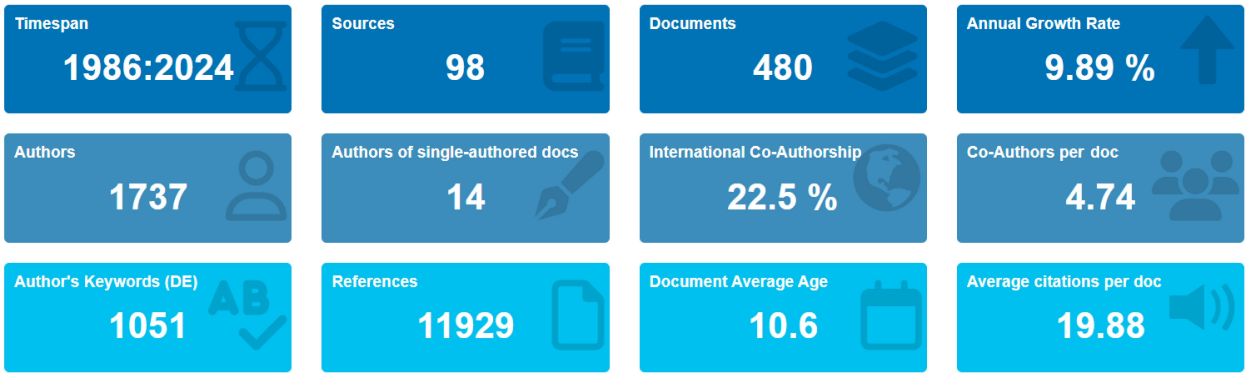

FIGURE 2. Main bibliometric indicators. doc: document.

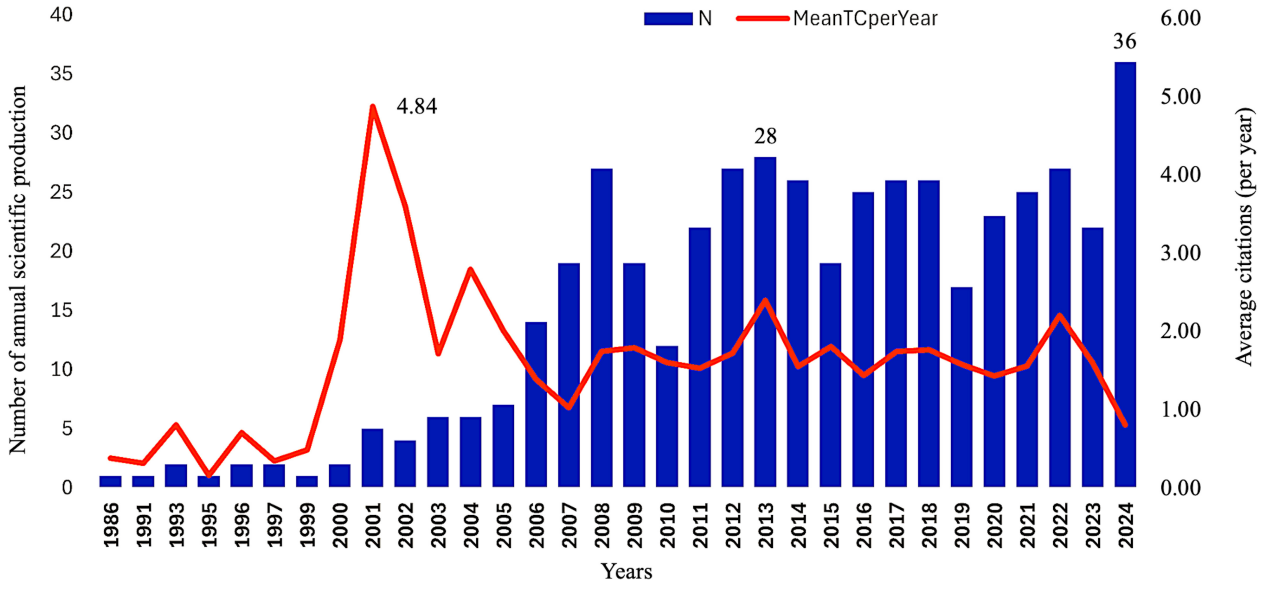

FIGURE 3. Annual scientific production and average citations per year. N: Number of publications; TC: Total citations.

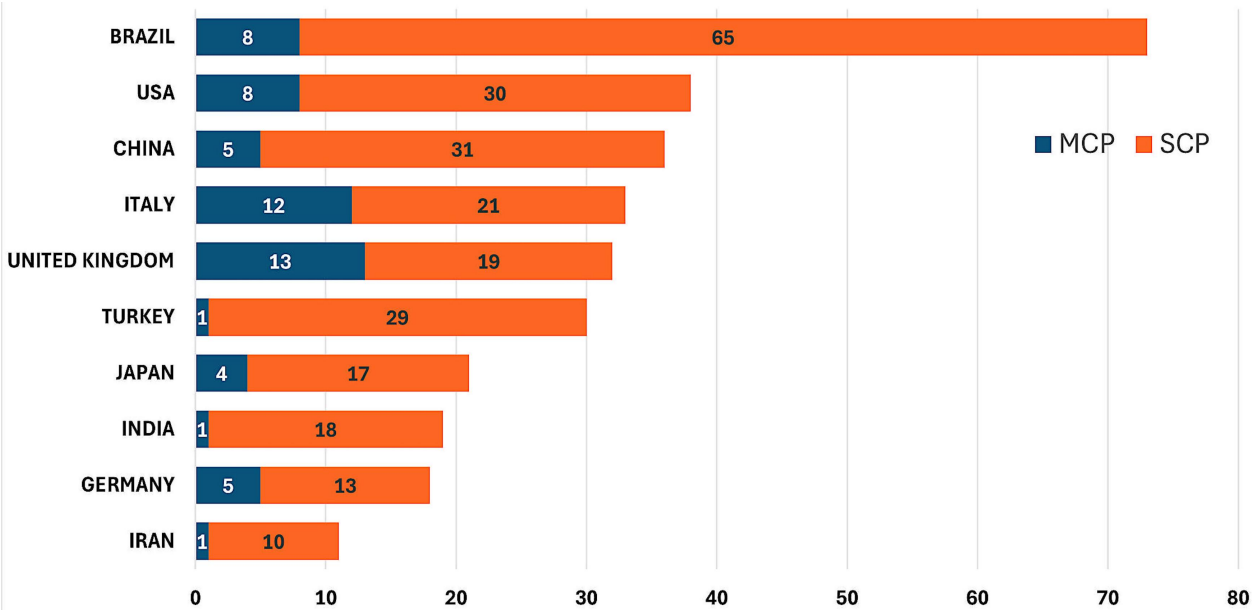

FIGURE 4. Most relevant countries by corresponding author. MCP: Multiple country publications; SCP: Single country publications.

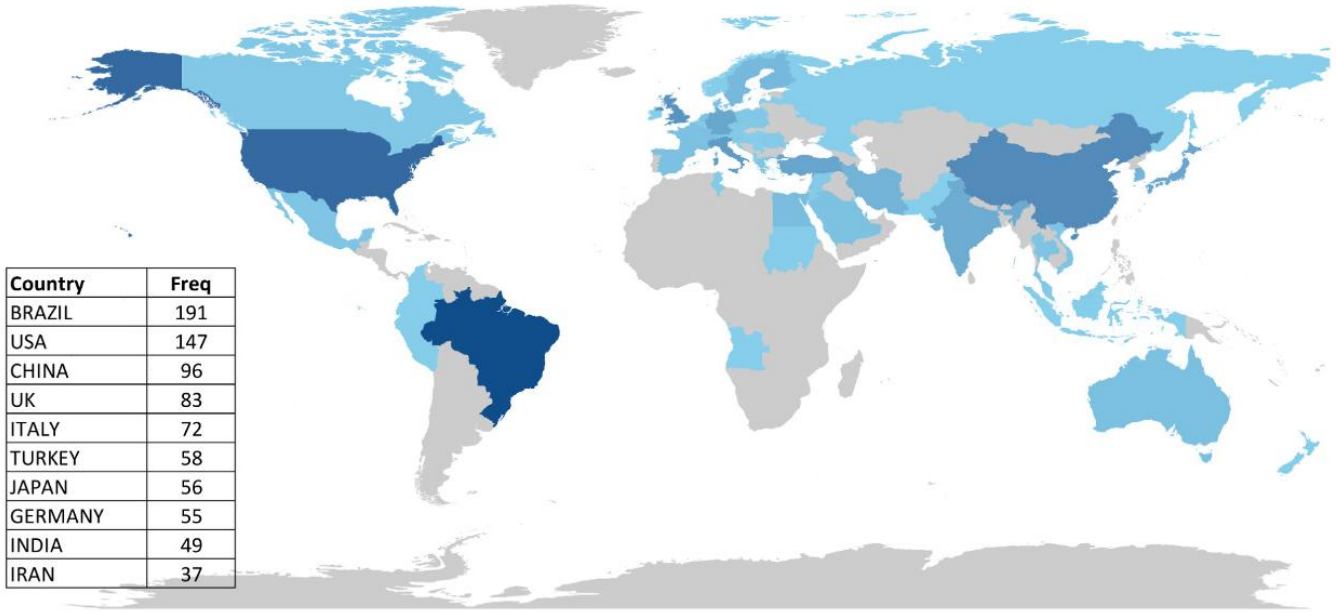

FIGURE 5. Countries' scientific production. Countries that have not contributed to the field are shown in grey. Contributing countries are represented on a color scale, where lighter shades denote lower output and darker shades indicate higher production levels. Freq: frequency.

lication count (n = 83), demonstrates the highest international collaboration rate (40.6%), reflecting its active participation in global research networks and strong cross-border scientific partnerships. Turkey, although contributing 30 publications, shows minimal international collaboration (3.3%), suggesting a predominance of domestically focused studies. Collectively, these findings reveal distinct variations in both research productivity and the degree of international cooperation among the leading countries in this field.

3.4 Sources' local impact

Table 2 summarized the ten most influential journals in the field, ranked according to their h-index. Caries Research emerges as the leading and most frequently cited source, demonstrating sustained influence and a strong citation record. The International Journal of Pediatric Dentistry exhibits the highest m-index, indicating substantial impact achieved within a comparatively short publication period. The Journal of Dentistry stands out with the highest g-index, suggesting that a large proportion of its articles have received exceptionally high citation counts. In addition, more recently established journals such as the Journal of Clinical Pediatric Dentistry and Clinical Oral Investigations display relatively elevated m-index values, reflecting their rapid and growing influence in the discipline. Collectively, these results underscore notable differences among journals in terms of publication productivity, citation impact, and the pace at which they have contributed to advancing research on laser applications in pediatric dentistry.

3.5 Authors' local impact and production over time

The analysis of author productivity and scholarly impact within the field was presented in Table 3. Authors were ranked according to their h-index values, and the ten most influential contributors are shown. Examination of the data indicates that Richmond S—who published his first article in 2006—emerges as one of the most impactful researchers in this domain. With an h-index of 14, a g-index of 19, and an m-index of 0.70, this author has accumulated a substantial number of citations and achieved considerable influence within a relatively short academic career. Mendes FM has demonstrated sustained productivity over an extended period, whereas Primozic J and Ovsenik M have achieved notable citation impact despite entering the field more recently. These patterns collectively illustrate both long-term productivity and emerging academic influence among leading authors. Fig. 6 displays the temporal distribution of publications and total citations per year for the ten most prolific and influential authors in the field. Each circle in the figure corresponds to publications produced during a given year, with circle size representing the number of publications and color intensity indicating the average citation rate per year. Richmond S recorded the highest average citation rate, publishing five articles in 2014 with an average of 10.08 citations per year (TCpY = 10.08).

3.6 Collaboration and co-citation network

Fig. 7 presented the author collaboration network constructed from joint publications within the field. The analysis identifies 13 distinct clusters, with the most prominent and interconnected groups centered around Mendes FM and Richmond S, underscoring their pivotal roles in promoting collaborative

TABLE 2. Sources' local impact.

Source	h-index	g-index	m-index	TC	NP	PY_start
Caries Research	17	22	0.680	843	22	2001
International Journal of Pediatric Dentistry	15	20	0.789	428	32	2007
Journal of Dentistry	13	21	0.394	554	21	1993
European Journal of Pediatric Dentistry	12	19	0.667	377	24	2008
Cleft Palate-Craniofacial Journal	11	13	0.423	327	13	2000
European Archives of Pediatric Dentistry	11	18	0.579	337	20	2007
European Journal of Orthodontics	11	17	0.355	399	17	1995
Clinical Oral Investigations	10	13	0.556	294	13	2008
Journal of Clinical Pediatric Dentistry	10	14	0.588	242	27	2009
Pediatric Dentistry	10	19	0.476	376	21	2005

TC: Total citations; NP: Number of publications; PY_start: Starting year of publication; h-index: Hirsch index; g-index: egghe's g-index; m-index: m-quotient.

TABLE 3. Authors' local impact.

Author	h-index	g-index	m-index	TC	NP	PY_start
Richmond S	14	19	0.700	736	19	2006
Mendes FM	13	23	0.565	559	24	2003
Braga MM	11	19	0.550	361	19	2006
Imparato JCP	8	10	0.364	282	10	2004
Matos R	8	8	0.471	246	8	2009
Novaes TF	8	11	0.471	257	11	2009
Primozic J	8	9	0.571	271	9	2012
Olivi G	7	14	0.389	223	15	2008
Ovsenik M	7	9	0.500	226	9	2012
Toma AM	7	7	0.389	356	7	2008

TC: Total citations; NP: Number of publications; PY_start: Starting year of publication; h-index: Hirsch index; g-index: egghe's g-index; m-index: m-quotient.

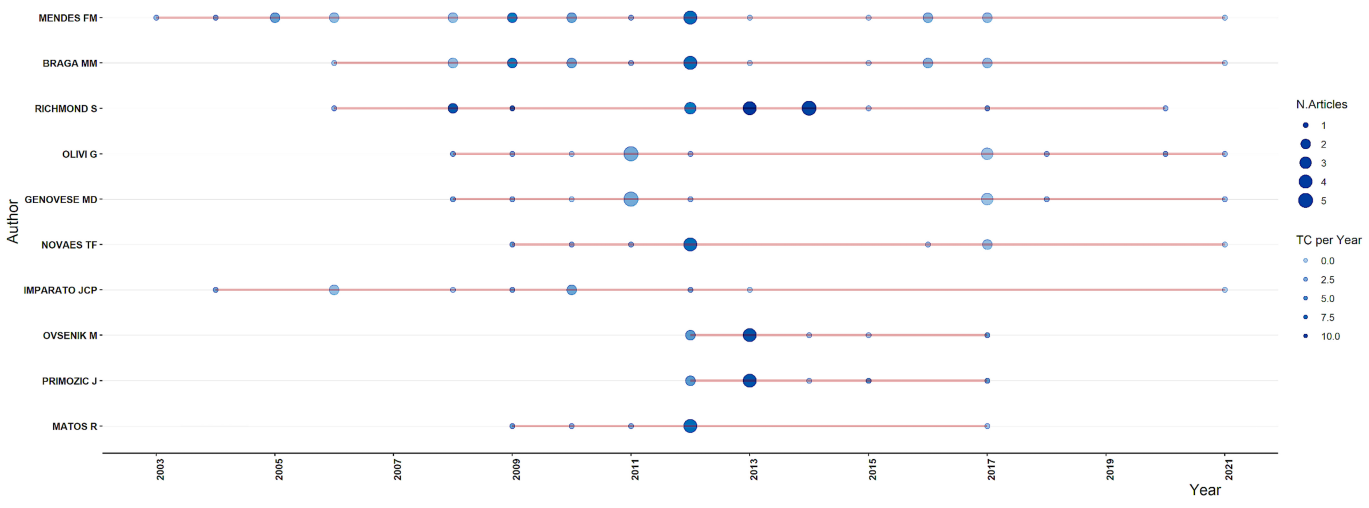

FIGURE 6. Authors' production over time. N: Number of publications; TC: Total citations.

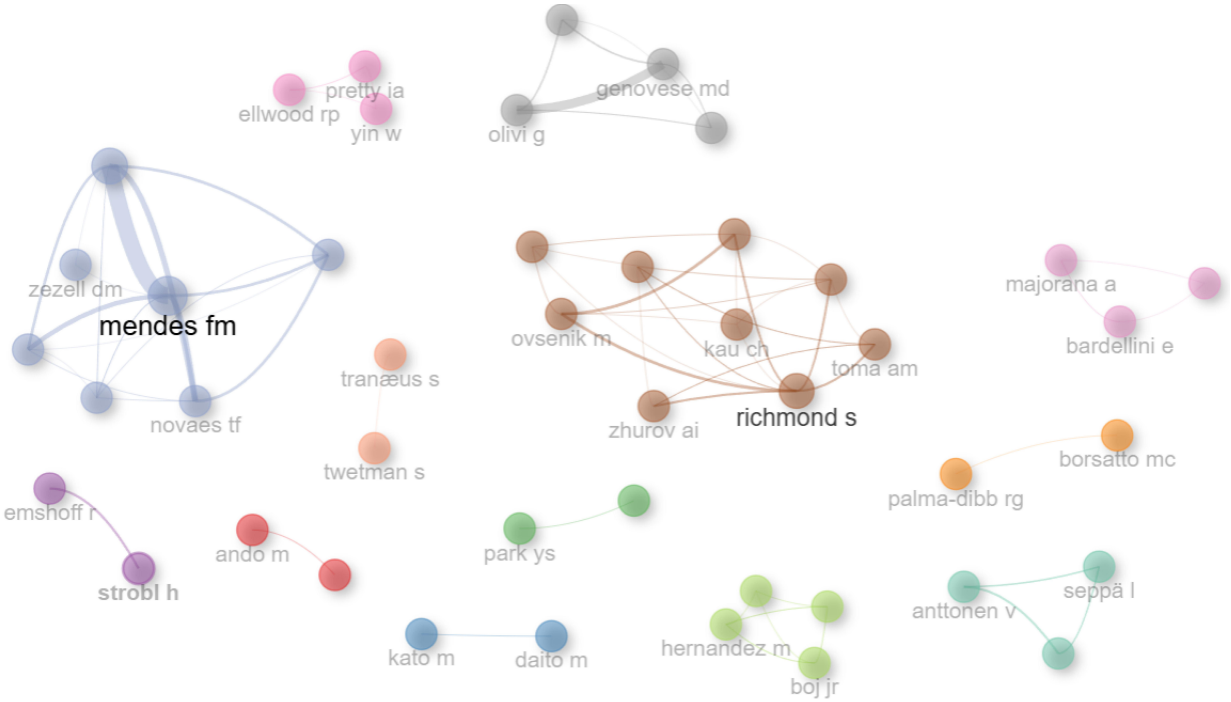

FIGURE 7. Author collaboration network.

research activity. Within each cluster, authors predominantly collaborate with colleagues in the same group, whereas inter-cluster connections remain limited. This pattern suggests that research in laser applications in pediatric dentistry is primarily organized around relatively independent teams, each contributing to specific thematic or methodological areas. The network thus delineates both the leading contributors and the structural patterns of collaboration that characterize scholarly interactions in this domain.

Fig. 8 illustrated the co-citation network among authors in the field. Four major clusters were identified, with the red cluster exhibiting the strongest citation relationships and being centered on Lussi A. This finding indicates that Lussi A and closely associated authors, including Ekstrand KR, Bade JD, Mendes FM, and Shi XQ, are frequently cited together, reflecting their significant collective influence in shaping the foundational literature on laser applications in pediatric dentistry.

Fig. 9 illustrated the co-citation network of publications within the field, revealed six distinct clusters. The blue cluster, centered on Lussi A (2001), exhibits the strongest interconnections, particularly with earlier studies by Lussi A (1999) and Shi XQ (2000), indicating a continuous and closely associated line of influential research. The red cluster, centered on Ekstrand KR (1997), represents another major group of frequently co-cited publications, reflecting an alternative but complementary stream of foundational studies. Collectively, the co-citation network delineates the intellectual structure of the field, demonstrating how seminal works are interlinked via shared citation patterns.

3.7 Author keywords co-occurrence network

The co-occurrence network of author keywords revealed the principal research themes and their interrelationships within the field (Fig. 10). The terms “primary teeth” and “laser fluorescence” appear as central nodes, signifying that clinical management of primary teeth and the use of laser-based diagnostic techniques are dominant areas of focus. Strong associative links between related keywords such as “caries detection” and “laser fluorescence” suggest the presence of well-established research linkages, whereas distinct clusters organized around “laser” and “children” represent emerging subthemes and evolving domains of inquiry. Overall, the network reflects both the core topics that define the field and the thematic interconnections that underpin ongoing research development.

3.8 Thematic evolution

Fig. 11 presented the thematic evolution of research topics from 1986 to 2024 using a Sankey diagram. During the initial phase (1986–2007), research primarily concentrated on foundational topics such as “cleft lip and palate” and “primary teeth”. In the subsequent period (2008–2017), these early themes expanded and diversified, with emerging emphasis on “three-dimensional analysis”, while new topics such as “endodontics” and “ankyloglossia” appeared, reflecting a broadening of research scope. In the most recent phase (2018–2024), “demineralization” and “endodontics” emerged as prominent focal points, indicating a shift toward preventive and therapeutic applications of laser technology. Overall, the thematic evolution demonstrates both the continuity of established research areas and the dynamic emergence of new directions, highlighting the progressive maturation and diversification of

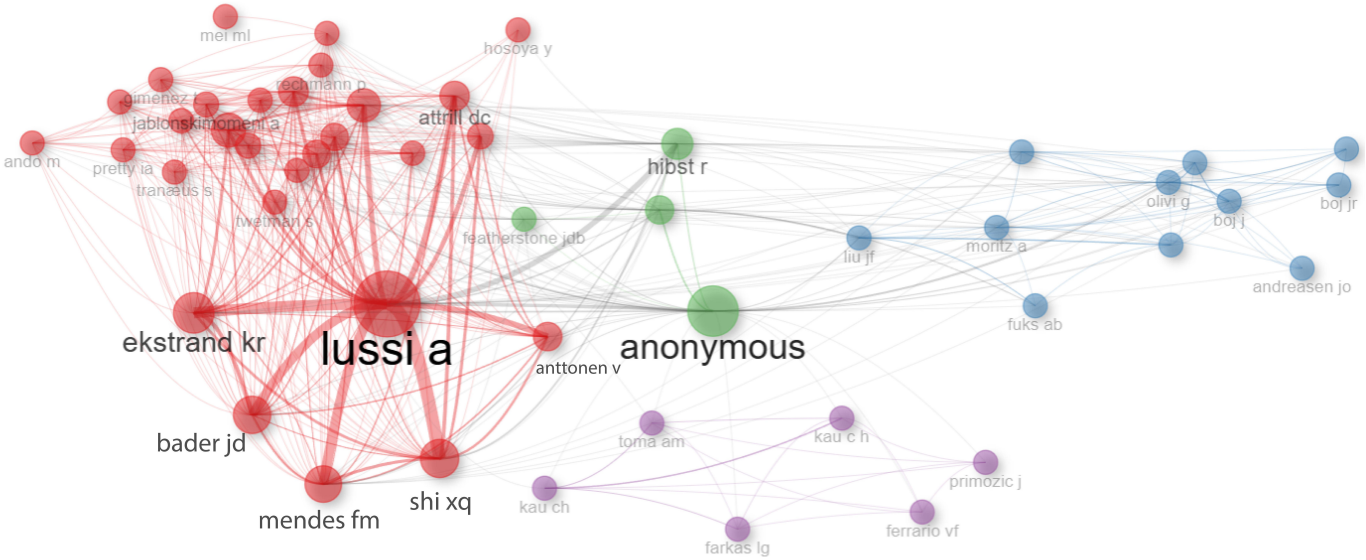

FIGURE 8. Authors co-citation network.

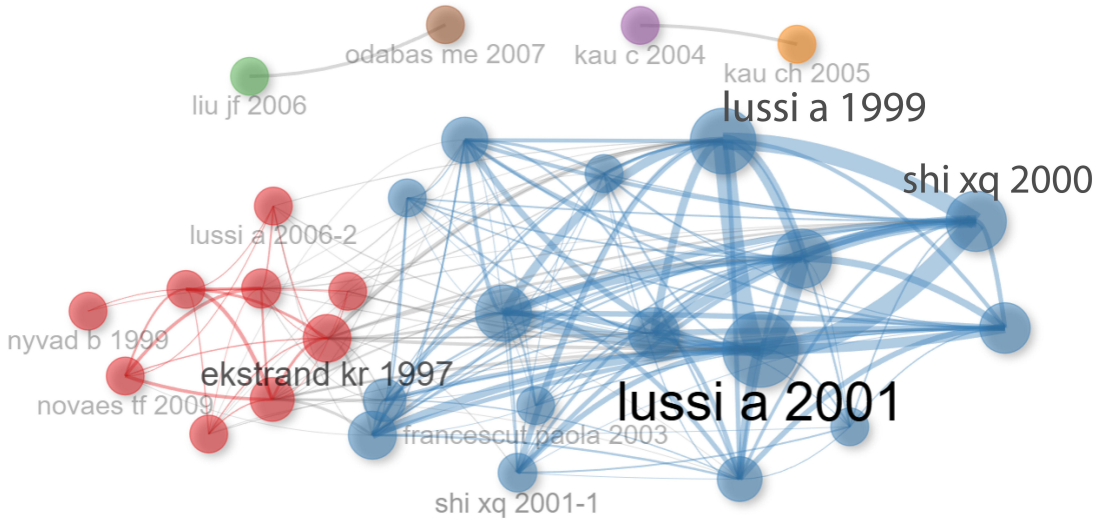

FIGURE 9. Publications co-citation network.

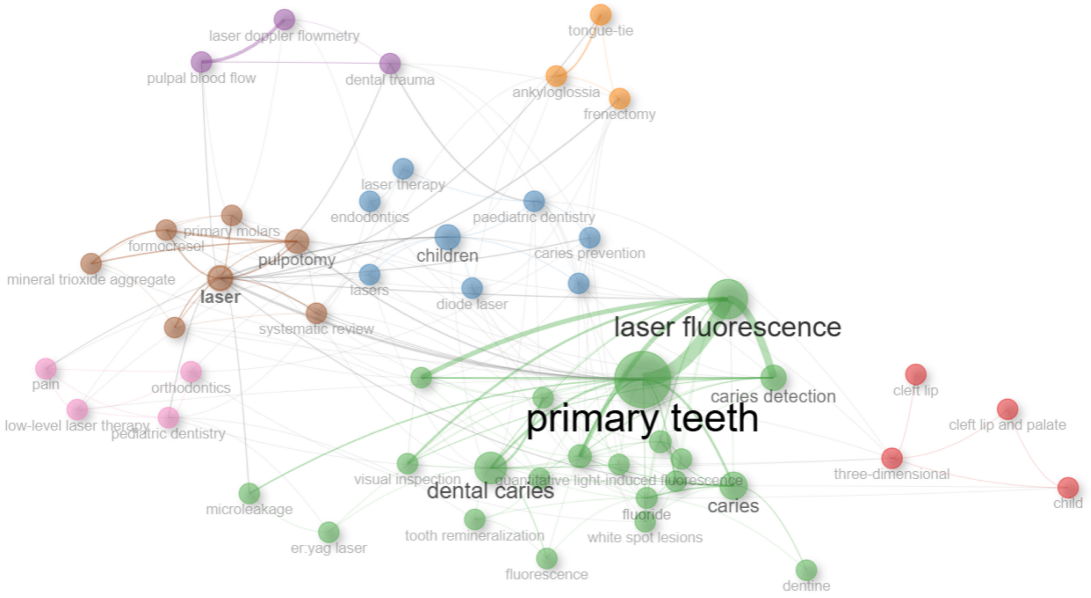

FIGURE 10. Author keywords co-occurrence network.

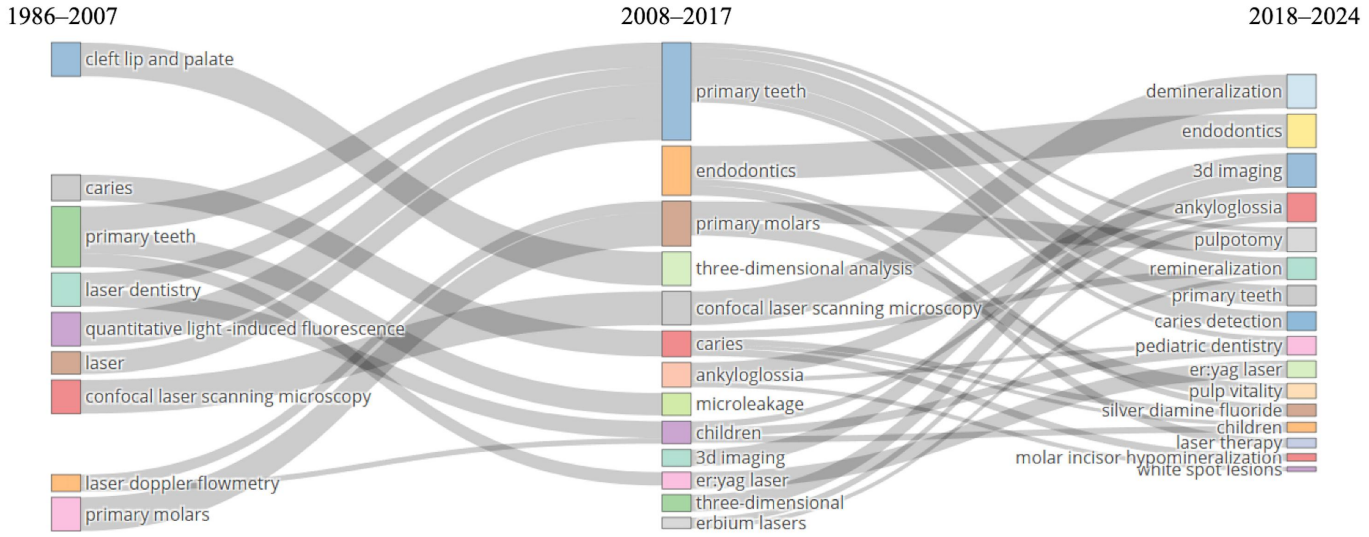

FIGURE 11. Thematic evolution of research topics.

the field over nearly four decades.

4. Discussion

The WoS database is one of the most extensively used and recognized sources for bibliometric and citation analysis, with broad disciplinary and geographical coverage [15]. In the present study, articles and reviews related to the use of lasers in children under the "Dentistry, Oral Surgery & Medicine" category were identified and analyzed using the WoS database. Although other databases, such as Scopus and PubMed, provide extensive coverage, WoS was chosen for its consistent indexing system, standardized bibliographic data, and suitability for citation-based analyses such as co-authorship, co-citation, and keyword co-occurrence. Its widespread use in previous dentistry bibliometric studies also allows comparison with existing literature. While PubMed lacks complete citation data and Scopus may produce inconsistencies due to different algorithms, WoS offers more reliable results for this analysis.

The increase in publication trend observed since 2001 reflects a growing academic interest in laser applications within pediatric dentistry. This increase may be partly attributed to the wider commercial availability of laser devices, their growing acceptance in clinical practice, supportive healthcare policies, and the expansion of research funding by universities. These factors have improved accessibility to laser systems, facilitating their integration into dental practice.

It has also been observed that many countries actively contribute to research on laser applications in pediatric dentistry, indicating that academic interest in this topic is globally distributed. A previous bibliometric study [16] identified Brazil as one of the most influential countries in laser-related research, and the results of the present study are consistent with that finding. The dominance of certain countries likely reflects differences in research funding, access to advanced technology, and institutional support, emphasizing the influence of socio-economic and infrastructural factors on research productivity.

International collaboration has been shown to enhance the quality, visibility, and citation impact of research, thereby contributing to the advancement of scientific knowledge. In the present study, Turkey ranked as the sixth largest contributor to the field but demonstrated the lowest rate of international collaboration. This limited participation may be related to factors such as insufficient research funding, restricted access to laser technology, language barriers, or a lower institutional focus on global cooperation. In contrast, the United Kingdom exhibited the highest level of collaboration. This can be explained by easier access to scientific data and publications, as well as by the expansion of international academic partnerships, which have strengthened its global engagement in this area.

The identification of the most productive journals provides further insight into research trends and dissemination patterns within the field. While Caries Research remains the most influential and highly cited journal, newer sources such as the International Journal of Pediatric Dentistry, Journal of Clinical Pediatric Dentistry, and Clinical Oral Investigations have rapidly achieved high levels of impact. This indicates that researchers in pediatric laser dentistry increasingly rely on these field-specific, high-impact journals for both accessing and disseminating knowledge, which may contribute to the advancement and wider adoption of laser applications in clinical settings. Furthermore, factors such as open-access publication models and increased international visibility have likely enhanced the influence of these journals by promoting broader dissemination and accessibility of research findings.

Collaboration networks identify the key authors who facilitate knowledge exchange and methodological development within the field. Collaboration among authors plays an important role in accessing resources, learning new skills and techniques, and improving efficiency and productivity [17, 18]. Authors such as Mendes FM and Richmond S dominate this area of research, likely due to their consistent publication records and their central positions within collaborative networks.

A previous bibliometric analysis [16] reported that most publications focused on the use of lasers to assist in the di-

agnosis of dental caries, a widespread oral health problem. Similarly, in the present study on laser applications in children, the frequent occurrence of keywords such as "laser fluorescence" and "primary teeth" indicates that diagnostic applications, particularly those related to caries detection, remain a primary focus. There are clear parallels between the general bibliometric analysis of caries diagnosis conducted by Melo *et al.* [19] and the results of this study. Consistent with our findings, their analysis identified Mendes FM as the most prolific author and Caries Research as the most prominent journal. Moreover, the keywords "child", "fluorescence", and "Diagnodent" were frequently observed in both studies. These similarities suggest that comparable bibliometric findings obtained from different populations confirm the continuing importance of laser technologies in the diagnosis of dental caries. The results also indicate that scientific interest in laser-based diagnostic methods in children is increasing in parallel with broader trends in dental research, and that these methods are gradually establishing a stable position in both academic and clinical contexts. Bibliometric analyses of pediatric dentistry journals in previous studies have further emphasized the centrality of caries research [20, 21]. The present study extends this perspective by demonstrating that laser-based diagnostic techniques are being increasingly explored as innovative tools within this well-established research domain.

The recent appearance of the keywords "demineralization" and "endodontics" likely reflected a trend toward minimally invasive treatment and suggested that modern laser-assisted methods were increasingly used to support or replace traditional endodontic techniques in pediatric patients. The emergence of keywords such as Low-level laser therapy (LLLT), frenectomy, ankyloglossia, pain, remineralization, white spot lesions, microleakage, and laser Doppler flowmetry suggested areas that were relatively underexplored. The limited frequency and diversity of these keywords may not only reflect insufficient investigation but also signal potential new directions and innovative applications of laser technology in pediatric dentistry, highlighting promising areas for future research.

To our knowledge, this is the first study to analyse the characteristics of publications addressing laser applications specifically in paediatric dentistry using bibliometric parameters. However, this study has limitations. Using only WoS restricted the analysis to English-language articles and reviews, possibly excluding other relevant studies. Excluding other publication types (conference proceedings, editorials, short communications) may have limited coverage of emerging trends. Using author keywords may also have constrained identification of new themes. Future studies could integrate multiple databases, broader publication types, and consider self-citation or author name ambiguity to achieve a more comprehensive view. Despite these limitations, the study provides a reference for researchers on laser applications in pediatric dentistry and emerging research directions.

5. Conclusions

This bibliometric analysis offers an overview of research trends on the use of laser technology in pediatric dentistry. The study indicates that diagnostic applications, particularly the use of laser fluorescence for detecting caries in primary teeth, remain the most frequently investigated area. The recent emergence of research themes such as demineralization and endodontics suggests potential directions for future investigation.

ABBREVIATIONS

TS, Topic; PBM, Photobiomodulation; PBMT, Photobiomodulation therapy; PDT, Photodynamic therapy; QLF, Quantitative light-induced fluorescence; LLLT, Low-level laser therapy; CLSM, Confocal laser scanning microscopy; DIAGNODENT, A laser-based device used for caries detection; Soprolife, A laser fluorescence device used for early caries diagnosis; doc, Document; DE, Authors' keywords; MCP, Multiple country publications; SCP, Single country publications; Freq, Frequency; h-index, Hirsch index; NP, Number of publications; TC, Total citations; TC/NP, Citations per paper; PY_start, Starting year of publication; WoS, Web of Science; g-index, egghe's g-index; m-index, m-quotient; MeSH, Medical Subject Headings.

AVAILABILITY OF DATA AND MATERIALS

The full bibliographic dataset is available as **Supplementary material**.

AUTHOR CONTRIBUTIONS

NAÜ—designed the research study; wrote the manuscript. NAÜ and EB—performed the research; analyzed the data. Both authors contributed to editorial revisions of the manuscript and approved the final version.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

ACKNOWLEDGMENT

Not applicable.

FUNDING

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.jocpd.com/files/article/2049751219310608384/attachment/Supplementary%20material.xlsx.

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