A BIBLIOMETRIC ANALYSIS OF STUDIES ON KNOWLEDGE LEVELS, AWARENESS, ATTITUDES, ANXIETY LEVELS, AND RISK PERCEPTION REGARDING DENTAL RADIATION AMONG PATIENTS, DENTAL STUDENTS, AND DENTAL HEALTH PROFESSIONALS.

Abstract:

The aim of this bibliometric study was to assess the scientific development and thematic structure of the literature on the knowledge, awareness, anxiety, risk perception and radiation protection related to dental radiation among patients, dental students and dental health professionals. Bibliometric analysis was performed on 74 publications obtained from Web of Science Core Collection database by Bibliometrix and Biblioshiny. Analyzes of annual scientific production, co-occurrence, thematic map and thematic evolution were done. Scientific production increased especially from 2017 and reached its maximum in 2025. The analyzes revealed that the literature was organized around patient-oriented risk and anxiety and knowledge, awareness and radiation protection. The "Patient" theme maintained its continuity over the periods. The results show that the research structure of dental radiation is multidimensional, and it has been developed significantly in the recent years.

Key words: Dental Radiation, Patients, Dental Students, Dental Health Professionals, Radiation Awareness, Radiation Anxiety, Bibliometric Analysis..

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Introduction: Dental radiographic imaging is an important tool in the diagnosis, treatment planning and post treatment follow-up of diseases of oral and maxillofacial region. The use of traditional techniques such as intraoral and panoramic radiography is still very common in dental practice; however, the emergence of cone beam computed tomography has significantly increased the possibilities for three-dimensional imaging. But the diagnostic benefits come with concerns about radiation exposure and radiation protection related to the use of ionizing radiation in imaging. Therefore, justification and optimization of dental radiographic examinations and their performance based on radiation protection principles are important for both patients and health care professionals (1-5).

The increased use of dental imaging modalities has led to the investigation of knowledge and awareness of dental radiation among patients, as well as their radiation-related anxiety, concerns, and risk perceptions. Inadequate or inaccurate knowledge of the patient concerning the amount of radiation exposure during radiographic examinations, the potential risks of various imaging modes and the radiation protection practices may contribute to the anxiety and concerns about radiographic procedures . Moreover, perceptions of radiation-related risks may influence patients' acceptance of imaging procedures, treatment-related decisions, and communication with healthcare professionals. In this regard, it is important to provide patients with accurate information and clearly communicate the benefits and risks of radiation to support informed decision-making (6-9).

Knowledge and awareness of dental radiation are important not only for patients but also for dental students and dental health professionals. Dentists have important responsibilities in the use of dental imaging modalities for appropriate indications, the justification of radiographic examinations, the optimization of radiation exposure, and the implementation of radiation protection measures. In addition, the knowledge and communication skills of healthcare professionals may play a key role in addressing patients' radiation-related questions and alleviating their potential concerns. It is also important for dental students to acquire adequate knowledge and awareness of radiation biology, radiation safety, and radiation protection during their education for their future clinical practice (6, 10-13).

Accordingly, numerous studies in the literature involving patients, dental students, and dental health professionals have evaluated concepts related to dental radiation, including knowledge, awareness, anxiety, fear, concern, attitude, risk perception, and radiation protection. While patient-oriented studies have primarily focused on radiation knowledge, anxiety, and risk perception, a substantial proportion of studies involving students and healthcare professionals have addressed levels of knowledge and awareness, attitudes, and radiation protection practices. Although numerous studies have been conducted on this topic, information in the literature remains limited regarding trends in the scientific production, conceptual structure, and thematic evolution of research on knowledge, awareness, anxiety, fear, concern, attitude, risk perception, and radiation protection related to dental radiation (10, 14-16). To the best of our knowledge, no bibliometric analysis has been conducted in this field. With the increasing number of studies, evaluating the main research themes, conceptual structure, and trends over time in this field has become increasingly challenging. Bibliometric analysis is a method that can address this gap. It enables the quantitative assessment of the field by examining annual scientific production, co-occurrence analysis, thematic map analysis, and thematic evolution analysis.

This study aims to evaluate the scientific literature on knowledge, awareness, anxiety, risk perception, and radiation protection related to dental radiation among patients, dental students, and dental health professionals using bibliometric methods. In this context, annual scientific production, keyword co-occurrence analysis, thematic map analysis, and thematic evolution analysis were performed to comprehensively reveal the current structure, main research themes, and scientific development of the research field over time.

Materials and Methods: The present study was designed as a bibliometric analysis of the scientific literature on knowledge, awareness, anxiety, risk perception, and radiation protection related to dental radiation among patients, dental students, and dental health professionals. Due to the nature of the study design, no human or animal subjects were involved. Therefore, ethical committee approval was not required.

The dataset on the current topic was obtained using the advanced search module of the Web of Science Core Collection database, covering the title, abstract, author keywords, and keywords plus fields, with the following search terms: ("dental radiation knowledge" OR "dental radiation awareness" OR "dental radiation anxiety" OR "dental radiation fear" OR "dental radiation concern*" OR "dental radiation perception*" OR "dental radiation attitude*" OR "dental radiography knowledge" OR "dental radiography awareness" OR "dental radiography

anxiety" OR "dental radiography fear" OR "dental radiography concern*" OR "dental radiography perception*" OR "dental radiography attitude*" OR "dental x-ray knowledge" OR "dental x-ray awareness" OR "dental x-ray anxiety" OR "dental x-ray fear" OR "dental x-ray concern*" OR "dental x-ray perception*" OR "CBCT knowledge" OR "CBCT awareness" OR "CBCT anxiety" OR "CBCT concern*" OR "CBCT perception*" OR "CBCT attitude*") AND (patient* OR "dental student*" OR "dentistry student*" OR dentist* OR "dental practitioner*" OR "dental professional*") NOT (phantom* OR dosimetr* OR "effective dose" OR "absorbed dose" OR "organ dose" OR "dose measurement" OR "dose calculation" OR "Monte Carlo"). Publications from 1990 to 2026 were evaluated to ensure the inclusion of recent articles in the dataset. To avoid language bias, publications in all languages were included in the dataset. The abstracts of the retrieved articles were manually screened, and articles unrelated to the current topic were excluded. In addition, only articles and reviews related to the topic were included in the study, while editorial letters and congress and meeting proceedings were excluded to ensure the homogeneity of the dataset. The data were downloaded from the Web of Science Core Collection database as a BibTeX file, and the Biblioshiny interface was used for bibliometric analysis through the bibliometrix package (version 5.3.0) running in R (version 4.6.0) and RStudio. Annual scientific production was analyzed to evaluate the performance characteristics of the current research field, while co-occurrence network, thematic map, and thematic evolution analyses were performed to reveal its conceptual structure.

Network-based clustering approaches were used to investigate the conceptual structure of the literature. In the co-occurrence analysis conducted to evaluate the conceptual structure of knowledge, awareness, anxiety, risk perception, and radiation protection related to dental radiation among patients, dental students, and dental health professionals, terms appearing in the abstracts (Abstracts) of the publications were used, and the relationships among the terms were examined through network structures generated using the association normalization method and the Louvain clustering algorithm. Terms were standardized to reduce the influence of different terms expressing the same or similar concepts on the analysis results. In addition, general and methodological terms that did not represent the conceptual structure of the research topic were excluded from the analysis. In the resulting network structure, nodes represent terms appearing in the abstracts, node size represents the frequency of term occurrence, links between nodes represent co-occurrence relationships among terms, and link thickness represents the strength of co-occurrence. Different colors represent thematic clusters within the literature.

Thematic map analysis was performed to evaluate the thematic structure of the literature on knowledge, awareness, anxiety, risk perception, and radiation protection related to dental radiation among patients, dental students, and dental health professionals. All keywords were used in the analysis, the Louvain clustering algorithm was applied, and the α parameter was set to 0.5. Synonymous terms and singular and plural forms were standardized to reduce the influence of different terms expressing the same or similar concepts on the analysis results. The 100 most frequently used keywords were included in the analysis, and themes below the

specified minimum cluster frequency were excluded. The positions and levels of development of the themes within the literature were examined according to their centrality and density values; accordingly, the themes were classified as motor themes, basic themes, niche themes, and emerging or declining themes.

In the thematic evolution analysis, terms appearing in the abstracts of the publications were used, the Louvain clustering algorithm was applied, and the α parameter was set to 0.5. To reduce the influence of different terms expressing the same or similar concepts on the analysis results, synonymous terms and singular and plural forms were standardized, and different terms expressing similar concepts were merged under relevant common headings. The 450 most frequently used terms in the abstracts were included in the analysis, and themes with a cluster frequency below 10 per thousand were excluded. The minimum weight index for evaluating the links between themes was set to 0.1. To evaluate the temporal changes in themes and the relationships between periods, the dataset was divided into two periods: 1991–2017 and 2018–2026.

Results: A total of 74 publications were examined. The annual scientific production remained relatively low until 2017 and subsequently showed a marked increasing trend despite fluctuations over the following years. The highest scientific production was observed in 2025, while 2026 was partially evaluated (Figure 1).

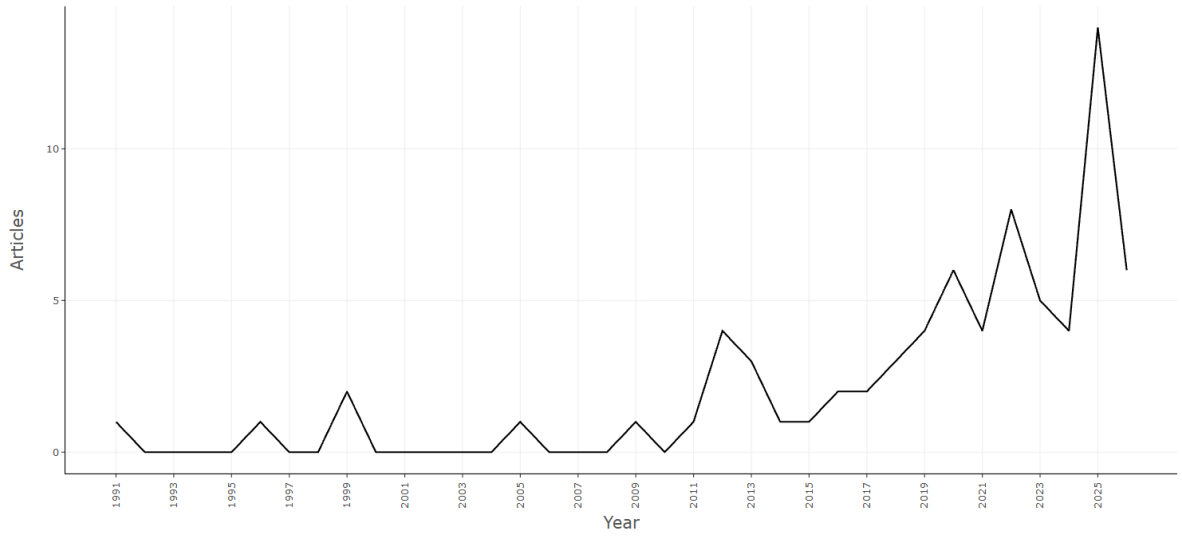

Figure 1. Annual scientific production on dental radiation knowledge, awareness, anxiety, and radiation protection among patients, dental students, and dental health practitioners.

The co-occurrence analysis revealed that the terms were grouped into two main clusters. The red cluster included the terms “radiation protection”, “knowledge”, “safety”, “dental student”, “dental professional”, “attitude”, “practice”, “radiation”, “questionnaire”, “awareness”, “ionizing”, “radiological”, “scores”, and “significantly”. Within this cluster, “dental professional” and “questionnaire” were identified as the terms with the largest node sizes. The blue cluster included the terms “patient”, “CBCT”, “anxiety”, “risk”, and “scans”. Within this

cluster, “patient” was identified as the term with the largest node size (Figure 2).

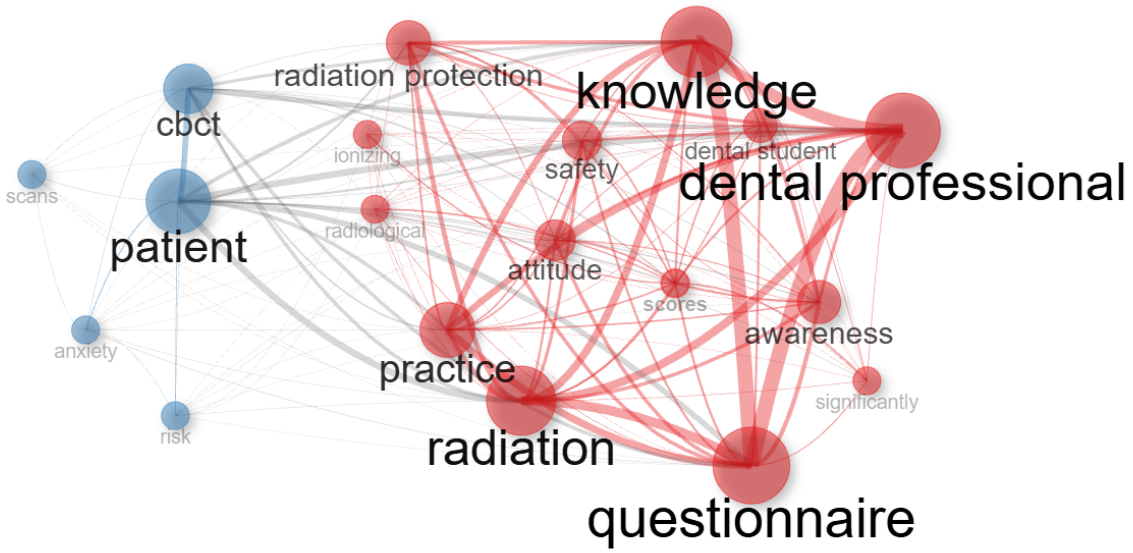

Figure 2. Co-occurrence network of terms related to dental radiation knowledge, awareness, anxiety, risk perception, and radiation protection among patients, dental students, and dental health professionals.

The thematic map analysis identified seven thematic clusters. The theme consisting of the keywords “risk”, “population”, and “anxiety” was located in the motor themes quadrant. The theme consisting of the keywords “knowledge”, “dental radiography”, and “attitude” was positioned at the boundary between motor themes and basic themes. The theme consisting of the keywords “radiation protection”, “radiation”, and “awareness” was located in the basic themes quadrant. The theme consisting of the keyword “questionnaire survey” was located in the niche themes quadrant, while the theme consisting of the keywords “pediatric dentistry” and “3d imaging” was positioned close to the centrality boundary between niche themes and motor themes. The themes consisting of the keywords “ionizing-radiation” and “dental education” were located in the emerging or declining themes quadrant (Figure 3).

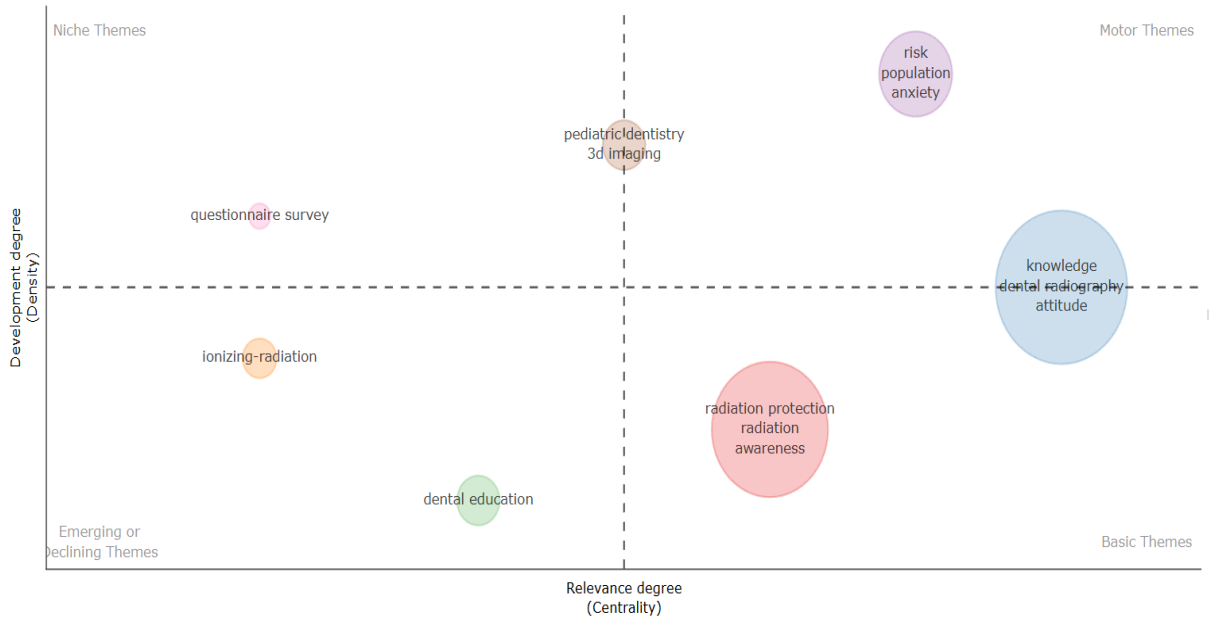

Figure 3. Thematic map of research on dental radiation knowledge, awareness, anxiety, risk perception, and radiation protection among patients, dental students, and dental health professionals.

The thematic evolution analysis revealed various thematic continuities and changes between the 1991–2017 and 2018–2026 periods. In the first period, the themes “CBCT”, “dental professional”, “compared”, “anxiety”, “patient”, and “safety” were observed, whereas the themes “knowledge”, “patient”, “radiation”, “ensure”, and “scores” were identified in the second period. The “dental professional” theme in the first period was linked to the “knowledge” and “radiation” themes in the second period, while the “anxiety” theme was linked to the “patient” and “radiation” themes. In addition, the “safety” theme was associated with the “radiation” theme in the second period. The “Patient” theme persisted across both periods and showed a direct link between the two periods (Figure 4).

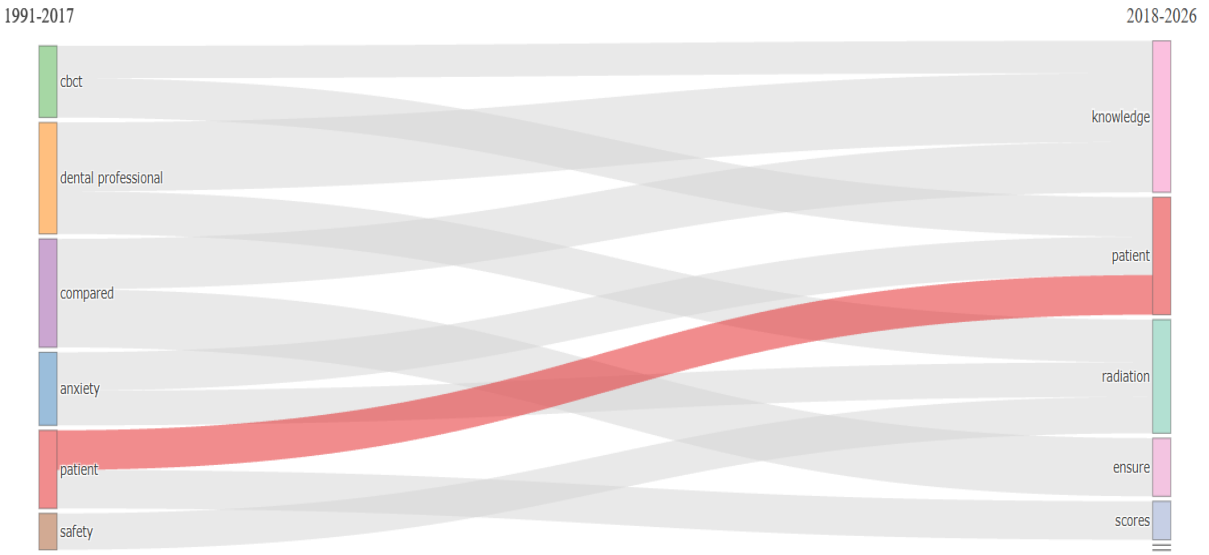

Figure 4. Thematic evolution of research on dental radiation knowledge, awareness, anxiety, risk perception, and radiation protection among patients, dental students, and dental health professionals.

Discussion: Although dental radiographic imaging is an important component of diagnosis and treatment planning in dentistry, the use of ionizing radiation may raise concerns among patients regarding its potential effects and health risks. Insufficient knowledge among patients regarding the amount of radiation exposure from dental radiographs and its potential biological effects may influence their risk perception and anxiety related to radiation. Therefore, increasing patients' knowledge and awareness of dental radiation and providing them with accurate information about the benefits and potential risks of radiographic procedures are important. Indeed, patient-oriented studies have addressed knowledge, awareness, anxiety, and risk perception related to dental radiation as interrelated research topics. Dental students and dental health professionals constitute another important dimension of dental radiation research. The appropriate justification of radiographic examinations, optimization of radiation exposure, and implementation of radiation protection principles in clinical practice are closely related to practitioners' knowledge, awareness, and attitudes regarding these issues. Therefore, numerous studies in the literature have evaluated the knowledge, attitudes, and practices of dental students and dental health professionals regarding radiation safety and protection. The number of studies conducted in this field continues to increase (6, 7, 9, 17-24). The present bibliometric analysis brings together these distinct yet interrelated research areas and reveals the scientific development, conceptual structure, and thematic changes over time within the dental radiation literature.

The increase in annual scientific production, particularly after 2017, indicates that research interest in different aspects of dental radiation has intensified over time. This trend may be associated with the growing importance of issues related to radiation exposure, radiation safety, and radiation protection in parallel with technological advances in dental radiology and the expanding applications of imaging modalities. With the increasing use of advanced imaging modalities, the justification of radiographic examinations, optimization of radiation dose, and implementation of radiation protection principles have become increasingly important. However, research on dental radiation has not been limited to technical and dosimetry-based topics; patients' knowledge, awareness, risk perception, and anxiety regarding radiation, as well as the knowledge, awareness, attitudes, and practices of dental students and dental professionals regarding radiation safety, have also been increasingly addressed in research. Accordingly, the increase in scientific production observed in recent years may be associated not only with advances in dental imaging technologies but also with growing scientific interest in patient safety, radiation risk perception and anxiety, and the knowledge, awareness, education, and radiation protection practices of students and practitioners (6, 10, 12, 24-27).

The two main clusters identified in the co-occurrence analysis indicate that the dental radiation literature is structured around two interrelated research areas. In the first area, centered

on dental professionals and dental students, the co-occurrence of concepts related to knowledge, awareness, attitude, practice, safety, and radiation protection indicates that radiation safety has been addressed in the literature not only in terms of theoretical knowledge but also in terms of how this knowledge is reflected in clinical attitudes and practices. Indeed, studies conducted among dental professionals and students have reported differences in levels of knowledge and awareness regarding radiation protection, as well as in attitudes and practices, highlighting the importance of radiation safety education. In contrast, the clustering of CBCT, anxiety, and risk within the second patient-oriented area indicates that the patient-related dimension of dental imaging has been addressed particularly in the context of radiation risk perception and anxiety regarding imaging procedures. It has been reported that insufficient knowledge of dental radiation and uncertainties regarding radiation exposure may influence patients' risk perceptions and that certain aspects of radiographic procedures may cause anxiety among patients. The interconnection between these two thematic structures further indicates that the radiation safety and professional competence area and the patient-oriented risk and anxiety area have not been addressed as completely independent research areas in the literature (6, 10-12, 14, 21, 27, 28).

The thematic map findings indicate that the dental radiation literature is structured around both patient-oriented research and research areas focusing on knowledge, attitudes, and radiation safety. The positioning of the theme consisting of “Risk”, “population”, and “anxiety” among the motor themes indicates that, in addition to the technical aspects of radiation, individuals' radiation-related risk perception and anxiety have become well-developed and central research topics in the field. Reports that knowledge levels regarding dental radiographic examinations and uncertainties concerning radiation exposure may be associated with individuals' risk perceptions and anxiety support the position of this theme. The positioning of the “Knowledge”, “dental radiography”, and “attitude” theme at the boundary between motor and basic themes indicates that knowledge and attitude are central concepts connected to different research areas within the dental radiation literature. Similarly, the positioning of the “radiation protection”, “radiation”, and “awareness” theme among the basic themes indicates that radiation safety and awareness of radiation protection constitute one of the fundamental research areas in the literature. This may be related to the unavoidable use of ionizing radiation in dental radiographic examinations and the continuing importance of justification, optimization, and radiation protection principles for both patients and dental professionals in minimizing the potential biological effects of radiation. In addition, the increasing use of imaging technologies, particularly three-dimensional imaging modalities, may have contributed to maintaining the relevance of knowledge and awareness regarding radiation dose optimization and appropriate protective practices. In contrast, the higher density but borderline centrality of the “pediatric dentistry–3d imaging” theme suggests that these topics represent a research area that is well developed internally but has more limited connections with the broader research network. The positioning of the term “Questionnaire survey” among the niche themes indicates that questionnaire-based studies constitute an internally developed, specialized, and specific research area within the literature on knowledge, awareness, anxiety, risk perception, and radiation protection related to dental radiation among

patients, dental students, and dental health professionals. Although the positioning of the “Dental education” and “ionizing-radiation” themes within the emerging or declining themes quadrant indicates their peripheral position in the current thematic map, the thematic map alone does not allow these themes to be distinguished as either emerging or declining (6, 7, 12, 26, 29, 30)

The thematic evolution findings indicate that research on dental radiation has shifted over time from imaging modalities and practitioner-oriented topics toward knowledge, radiation, and patient-oriented topics. The prominence of the “dental professional” theme in the first period and its subsequent links to the “knowledge” and “radiation” themes suggest that studies focusing on dental professionals have gradually evolved within the framework of radiation knowledge and radiation-related topics. Similarly, the transition of the “safety” theme to the “radiation” theme indicates that research interest in radiation safety continued in the subsequent period within a broader radiation-related framework. The association of the “Anxiety” theme with both the “patient” and “radiation” themes in the subsequent period indicates that radiation-related anxiety continued to be addressed over time within patient-oriented research and radiation-related assessments. In particular, the direct continuity of the “patient” theme across both periods indicates that patients have remained one of the main study groups in dental radiation research over an extended period. Furthermore, the increasing prominence of the “knowledge” theme in the second period suggests that the assessment of radiation-related knowledge among patients and dental professionals, in addition to radiation exposure and safety, has become a more visible research area in the current literature. In line with this thematic direction, future research may increasingly focus on more comprehensive studies that jointly evaluate radiation-related knowledge and awareness, risk perception, anxiety, attitudes, and radiation protection practices among patients, dental students, and dental professionals.

This study has several limitations. First, the analyses were based solely on publications indexed in the Web of Science Core Collection database. Therefore, some relevant studies indexed in Scopus, PubMed, or other bibliographic databases but not covered by WoSCC may have been excluded from the analysis. Nevertheless, the comprehensive coverage of WoSCC, its widespread use in bibliometric research, and its provision of standardized bibliographic and citation data support the reliability of the findings. In addition, the results of the keyword and thematic analyses depend on the terminology used in the publications and the accuracy of the bibliographic records. Although terms expressing the same or similar concepts were standardized before the analysis, the influence of terminological variations may not have been completely eliminated. Finally, due to the nature of bibliometric analyses, the present study provides information on scientific production, research trends, and thematic structure in the field of knowledge, awareness, attitudes, anxiety, risk perception, and radiation protection related to dental radiation; however, it does not provide a direct assessment of the methodological quality, level of evidence, or clinical outcomes of the studies included in the analysis.

Conclusion: This bibliometric study revealed the development and thematic structure of the scientific literature on knowledge, awareness, attitudes, anxiety, risk perception, and radiation protection related to dental radiation among patients, dental students, and dental health professionals. The findings showed that scientific production in this field has increased particularly in recent years and that the literature is structured around interrelated research areas involving patient-oriented risk and anxiety, as well as knowledge, awareness, and radiation protection. The thematic analyses revealed that "risk", "anxiety", "knowledge", "radiation protection", and "awareness" are important components of the field, while the "patient" theme has maintained its continuity over time. These findings indicate that research on dental radiation is not limited to technical aspects of radiation safety and protection but has a multidimensional structure that also encompasses patient perceptions and anxiety, as well as the knowledge, awareness, and attitudes of students and dental professionals. Future studies evaluating these different dimensions together may contribute to improving patient communication, education, and safe radiographic practices related to dental radiation.

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