

Review on Tumor Radioresistance: A Bibliometric Analysis of Themes, Trends and Research Evolution Between 2016 and 2025

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Abstract

Radioresistance, whether innate or acquired during treatment, is one of the major problems in modern oncology. Despite advances in research in this area, particularly over the last ten years, the conceptual framework of this discipline and the evolution of its thematic priorities remain poorly defined. A bibliometric analysis of 1,164 publications appearing between 2016 and 2025 was conducted to understand the evolution of searches for articles published in the Web of Science Core Collection database. To determine the main research themes on tumor radioresistance, the study primarily relied on an examination of scientific output, authors' keywords and their conceptual frameworks. The evolution of themes related to radioresistance was studied using a thematic trend analysis. For the visual representation of the data, the study used the VOS viewer and Bibliometrix tools. The results show that the scientific output originates primarily from China and the United States. Keyword frequency analysis reveals that tumor radioresistance is associated with important biological mechanisms, including apoptosis and autophagy. Lung, esophageal and nasopharyngeal cancers are the most frequently cited cancer types associated with radioresistance. Alongside the analysis of the fundamental biological mechanisms associated with radioresistance, research is focused on predictive biomarkers and finding therapeutic combinations that can improve the prognosis of oncology patients.

Keywords: Bibliometric Analysis, Cancer, Radiotherapy, Tumor Radioresistance, VOS Viewer.

Introduction

Radiotherapy is a therapeutic modality in oncology that helps improve the clinical condition of cancer patients and prolong their life expectancy. However, its effectiveness is often reduced by radioresistance, in which cancer cells adapt to resist radiation effects (1).

In this regard, radioresistance constitutes an obstacle to cancer treatment strategies and promotes cancer recurrence. Thus, despite advances in oncology research, radioresistance to radiotherapy remains a significant clinical challenge, hindering the effectiveness of radiotherapy treatments and negatively affecting patient prognosis. Indeed, there is a complex array of genes and mechanisms that enable cancer to acclimate to the changes caused by irradiation and acquire resistance to ionizing radiation (2).

Tumor cell resistance is organized into an intrinsic class or an acquired class. Intrinsic radioresistance, also called primary radioresistance,

describes the initial existence of cancer cells with the ability to resist irradiation. Acquired radioresistance occurs when cancer cells become adaptive to changes induced by radiation. Consequently, these cancer cells become resistant to radiotherapy (3).

Thus, the concepts of tumor radioresistance, cell heterogeneity, microenvironmental characteristics and genetic proliferation are always linked in the scientific literature (4). These molecular mutations influence the emergence of cell death escape phenomena, but one leads to an increase in DNA repair capacity. These elements are essential for the survival of post-irradiated cancer cells (5). In this respect, one of the important mechanisms associated with radio resistance is the overexpression of molecules following DNA repair, but also epigenetic regulation. Indeed, significant stimulation of DNA repair pathways can help cancer cells counteract the effects induced by

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radiation (6). Radio resistance is also impacted by the dysregulation of the cellular system and epithelial-mesenchymal evolution (7). Resistance to radiotherapy can be due to intrinsic factors (mainly innate) or acquired factors. Radio resistance is considered intrinsic when cancer cells can multiply and develop despite radiation exposure, independently of the presence of external variables, primarily oxygenation and/or vascularization of tumor cells. Acquired radio resistance, on the other hand, is often associated with DNA damage repair, inflammation, metabolic reprogramming of cancer and modification of the tumor microenvironment (8). The latter consists of all the tissue elements through which the cancer cells originate. This ecosystem is composed of blood vessels, lymphatic vessels, nerve fibers, immune cells and fibroblasts.

This research shows that tumor resistance to radiotherapy stems from a complex interaction between genetic, epitranscriptomic, metabolic and microenvironmental factors. In this regard, despite decades of research, the conceptual framework of this field and the evolution of its thematic priorities remain poorly defined. Indeed, existing narrative reviews on radioresistance (9-11) generally adopt a mechanistic approach, explaining the various mechanisms associated with radioresistance (including DNA repair, hypoxia, stem cells, etc.). However, no study has systematically mapped how the scientific community has organized itself intellectually around this problem.

It is therefore essential to understand the dimensions and topics related to radioresistance to guide future research and develop new therapeutic tactics aimed at optimizing radiotherapy outcomes while reducing the costs associated with radioresistance. The latter could further improve the financial balance of healthcare institutions in oncology, which is characterized by significant resource consumption (12).

The main research question we seek to answer in this study can be formulated as follows:

What is the organization of knowledge and the thematic evolution of current research on tumor radioresistance?

To answer this question, this research attempts to provide an integrative and bibliometric synthesis of current knowledge on tumor radioresistance using VOS viewer and Bibliometrix. These two tools are commonly used for analyzing scientific

literature. VOS viewer, on the one hand, allows the creation and visualization of bibliometric maps. It is characterized by the clear presentation of data through high-quality graphs. Bibliometrix, the main software used in this study, is a bibliometric interface developed by the R software. It is considered an effective tool for analyzing data from various scientific research projects. Examining different bibliometric parameters, such as the number of citations, publications and reference articles, allows for in-depth scientific analysis (13). Thus, the overall objective of this bibliometric analysis applied in this study is to map the scientific output dedicated to tumor radioresistance to identify the main thematic frameworks, the dynamics of the temporal evolution of concepts and the directions for future research. To achieve this overall objective, three specific objectives were defined, namely: Identify the main contributors (influential countries, key sources and most cited articles on tumor radioresistance). Identify research trends and recent advances in this field through keyword analysis. Define research avenues and perspectives based on bibliometric data and current literature.

Methodology

This study analyzes current research on radioresistance in oncology. To achieve this objective, we used a bibliometric analysis. The rise of this technique can be attributed to its flexibility in relation to different computer applications, such as Bibliometrix and VOS viewer, as well as various information sources such as Web of Science. Bibliometric analysis seeks to identify major trends in a specific field or journal, authors and citation patterns, while providing an overview of the intellectual context of a given sector.

The study involved a series of phases, including literature review, data acquisition and preliminary processing, bibliometric analysis, keyword review and trend and content analysis. By adopting this methodical approach, we aimed to provide a comprehensive and in-depth examination of the research topic, which facilitated the identification of contemporary trends, patterns and the structure of the literature. This approach ensured that all relevant publications were considered and that the analysis and interpretation of the collected data

were carried out efficiently. Figure 1 highlights the main phases of the approach used in the article.

Searching the Database and Screening

The first phase of the study involved conducting an exhaustive search of the WOSCC. The choice is justified by the following factors, notably:

- rigorous selection of journals indexed by the database,
- presents an export format directly usable with VOS viewer without major preprocessing and compatibility with RStudio (14),
- represents the most frequently used database in medicine bibliometrics (15).

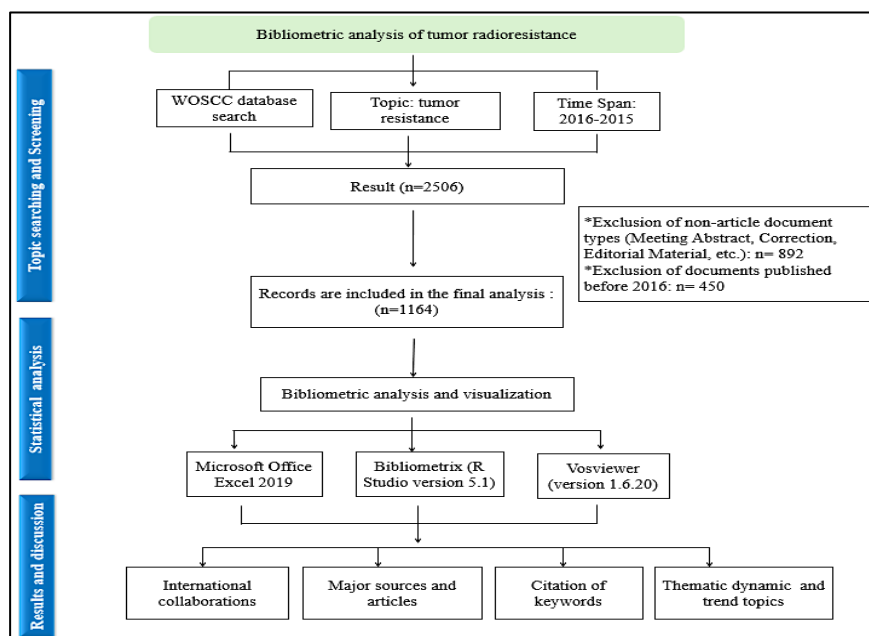


Figure 1: Key Phases of the Approach Used in the Article

To conduct the study, we selected an appropriate set of keywords. The search strategy included keywords present in the title:

TI= ("radiotherapy resistance" OR "radioresistance" OR "radiation resistance" OR "radioresistant" OR "radio-resistant" OR "resistance to radiotherapy" OR "resistance to radiation") AND (cancer OR tumor* OR carcinoma OR neoplasm* OR malignan* OR oncology))

The search period covers articles published from 2016 to 2025, with data collection completed on 13 October 2025.

Initially, the search generated 2506 entries. However, the exclusion of non-article document types (meeting abstracts, corrections, editorial material, etc.) as well as articles published outside the search period (documents published before 2016) resulted in only 1164 articles being retained.

For later study, the recovered data were exported in several formats. To emphasize recent advancements in radiation resistance, the study focuses on publications published during the last ten years, from 2016 to 2025. We selected a

comprehensive set of information from the selected articles, including title, authors, field of study, document category, affiliation keywords, country of origin and year of publication. This data was then organized for further analysis.

Statistical Analysis Using VOS Viewer and Bibliometrix Software

In the second phase of the analysis, a bibliometric study was conducted using VOS viewer (version 1.6.20) and Bibliometrix in RStudio (R version 5.1), two tools commonly used to review scientific literature. Thus, the technique continued by examining the key elements of a bibliometric study. First, an analysis of scientific output will identify the main contributors (influential countries), the quantitative evolution of publications, the main sources of this output and the most cited articles on tumor radioresistance. Next, a keyword frequency analysis will identify the most recurring concepts in the literature. In this regard, a multiple correspondence analysis (MCA) will identify thematic groupings and conceptual relationships between the main research areas. Lastly, a thematic analysis will

show how the subjects under study have changed over time and identify new or developing themes in the field. The frequency, conceptual proximity and temporal distribution of keywords in the various visualizations will be examined to understand the findings. VOS viewer and Biblioshiny will be the main tools used to create the maps and visualizations.

Results and Discussion

The initial observation concerns the number of

documents per year. Figure 2 shows that the number of documents between 2016 and 2025 varies from 70 to 131. Analysis of publication progression indicates an increase in the volume of documents each year until 2020. Since that year, growth has stabilized from 2020 to 2025. The year 2025 shows a decrease, which can be explained in large part by the fact that the year is not yet over (data collection was carried out on 13 October 2025) and the total number of publications will likely continue to grow for this year.

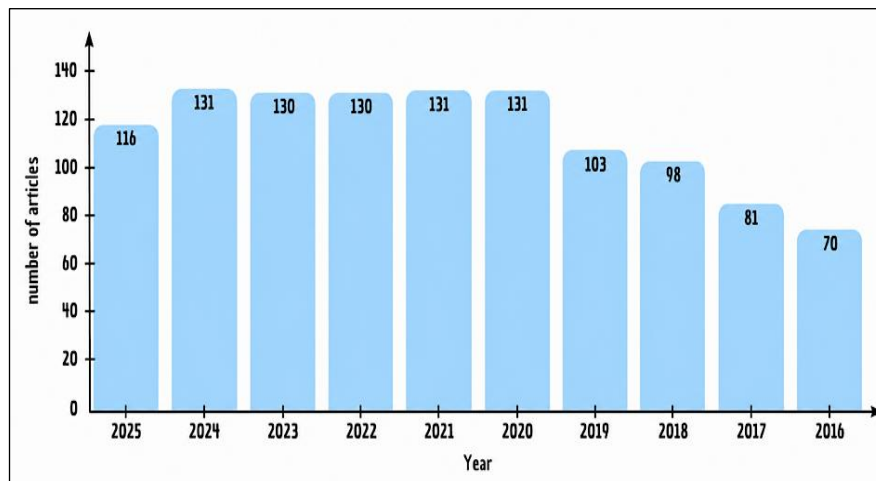


Figure 2: Number of Articles Published Per Year Between 2016 and 2025

International Collaborations

Figure 3 presents the mapping of scientific production and collaboration between countries using VOSviewer imagery and Table 1 illustrates the data relating to co-authors. The information

found reveals a network dominated by China ('People's Republic of China'), accounting for 716 publications (representing 62% of articles published), 15,869 citations and a total link weight of 86. This demonstrates China's leading role in scientific output in this sector.

Table 1: Ten Main Countries Related to Recent Research

Country (Pays)	Documents	Citations	Total Link Strength
People's Republic of China	716	15869	86
USA	147	5519	104
South Korea	64	1598	10
Germany	59	1409	28
Japan	56	1271	8
Taiwan	34	637	10
England	23	617	28
Italy	20	458	13
Australia	17	596	15
France	17	208	9
India	17	305	8

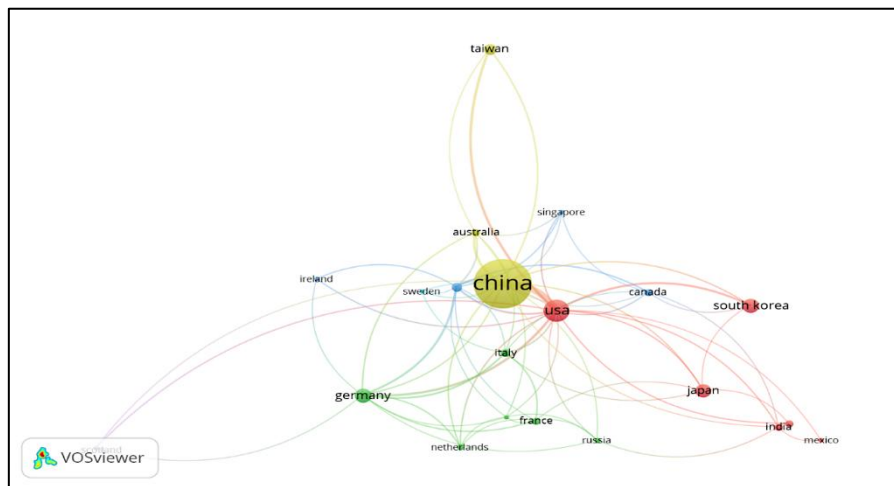


Figure 3: Mapping Scientific Production and Countries' Collaboration

European nations represented by Germany with 59 citations, the United Kingdom with 23 citations, France with 17 citations and Italy with 20 citations. Although these countries are recognized for their academic excellence, their individual volumes are significantly more modest. Germany appears to be the nerve center of European scientific production in this sector, linked to numerous collaborators. Western Europe (Germany, France, the Netherlands, Italy, Ireland) is highlighted in blue-green. This highlights the relative independence of the European bloc, which has its own dense

network of interconnections and its own institutions.

Ten Major Sources of Scientific Output

Table 2 presents a comparison of the 10 best journals in terms of publications in the field. This comparison focuses on the number of documents published, their number of citations, the total link strength and the impact factor. It reveals a wide diversity of publications focused on oncology, molecular biology and biochemistry.

Table 2: Comparison Between the 10 Best Journals in Terms of Publication

Source	Documents	Citations	Total Link Strength	Impact Factor
Cell death and disease	44	1369	4761	9.60
International Journal of Molecular Sciences	28	315	3460	4.90
Frontiers in Oncology	27	536	3320	3.30
Cancer Letters	24	737	3150	10.10
Scientific Reports	22	543	2530	3.90
Cancers	21	327	2447	4.40
Oncotarget	23	859	2423	1.70
Journal of Experimental and Clinical Cancer Research	17	1040	1962	12.60
Journal of Translational Medicine	17	396	1862	7.50
Journal of Cancer	16	237	1432	3.30

In the scientific field, regardless of the number of publications and citations, we find that Cell Death and Disease (9.60 Impact Factor / 44 documents / 1369 citations) has accumulated the highest number of citations and documents. This indicates that it constitutes the core of the publication network. We also discovered Cancer Letters, which

combines an excellent impact factor with satisfactory productivity, with 24 publications. With an average rate of 30.7 citations per article, it is the second most influential journal in terms of quality.

In terms of quality, J. Exp. Clin. Canc. Res is perceived as the journal with the highest quality

level. It has a very high citation count (12.60 index) and a remarkable number of citations despite only 17 documents (an average of 6110 citations/document), making it the leader in excellence for this research. Although the Impact Factor of the journal *Oncotarget* [1.70] is modest compared to other publications in the field, it has published 23 articles that have generated 859 citations. This could mean that it publishes highly debated content that receives numerous citations. Similarly, the *Int. J. Mol. Sci.* (Impact Factor 4.90 / 28 publications / 315 citations) has played a decisive role in publishing fundamental research on molecular factors related to radioresistance. This journal is positioned as a major player in the publication of fundamental research. The number of citations in the journal *Front. Oncol.* Impact factor 3.30 / 27 publications / 536 citations

far exceed that of *IJMS*, 315 citations. This indicates that the *Frontiers in Oncology* publications in this corpus are considered more relevant or more widely discussed within the specific scientific community.

Main Articles Referenced in Relation to Tumor Radioresistance

Over the past twenty years, the scientific community has gradually organized its work around a central question: why do some tumors show resistance to radiotherapy and what are the molecular and cellular processes involved? This seemingly trivial question has spawned a large research network bringing together molecular biologists, radiation oncologists, bioinformaticians and radiation chemists. Table 3 presents the main articles cited in relation to tumor radioresistance.

Table 3: The Most Cited Articles

Article Title	Year and Source Title	Total Citations	Annual Citation Rate	Reference
The epitranscriptome m6A writer METTL3 promotes chemo- and radioresistance in pancreatic cancer cells	2018, International Journal of Oncology	328	41.00	(16)
FTO regulates the chemo-radiotherapy resistance of cervical squamous cell carcinoma (CSCC) by targeting -catenin through mRNA demethylation	2018, Molecular Carcinogenesis	311	38.88	(17)
A targetable CoQ-FSP1 axis drives ferroptosis- and radiation-resistance in KEAP1 inactive lung cancers	2022, Nature Communications	307	76.75	(18)
Role of KEAP1/NRF2 and TP53 Mutations in Lung Squamous Cell Carcinoma Development and Radiation Resistance	2017, Cancer Discovery	270	30.00	(19)
The JAK2/STAT3/CCND2 Axis promotes colorectal Cancer stem cell persistence and radioresistance	2019, Journal of Experimental & Clinical Cancer Research	239	34.14	(20)
Lactate-Modulated Immunosuppression of Myeloid-Derived Suppressor Cells Contributes to the Radioresistance of Pancreatic Cancer	2020, Cancer Immunology Research	189	31.50	(21)
MST4 Phosphorylation of ATG4B Regulates Autophagic Activity, Tumorigenicity and Radioresistance in Glioblastoma	2017, Cancer Cell	187	20.78	(22)
Polyoxometalate-Based Radiosensitization Platform for Treating Hypoxic Tumors by Attenuating Radioresistance and Enhancing Radiation Response	2017, American Chemical Society Nano	177	19.67	(23)
Profiling and bioinformatics analyses reveal differential circular RNA expression in radioresistant esophageal cancer cells	2016, Journal of Translational Medicine	166	16.60	(24)
Radiation-induced miR-208a increases the proliferation and radioresistance by targeting p21 in	2016, Journal of Experimental &	165	16.50	(25)

human lung cancer cells

Clinical Cancer
Research

The two publications, listed in order of citation (1st and 2nd), deal with the epitranscriptome (METTL3, FTO), the new frontier in gene regulation. This research has shown that chemical modification of RNA (ribonucleic acid) is not a mere detail, but an essential process that allows cancer cells in the pancreas and cervix to resist chemotherapy and radiotherapy.

The article in third place deals with the CoQ-FSP1 axis and ferroptosis is the one that receives the highest annual citation rate [76.75], despite its recent publication in 2022 in NAT COMMUN. This suggests that ferroptosis is one of the most promising and popular mechanisms for overcoming treatment resistance.

The articles ranked 4th, 5th and 6th highlight tumor defense mechanisms. Survival modes and immune system function:

Escape Pathways: Analysis of the JAK2/STAT3/CCND2 pathways (5th rank) and the regulation of KEAP1/NRF2 and TP53 mutations (4th rank) highlights the signaling and stress mechanisms that cancer stem cells use to maintain their existence.

Immune System Suppression: The study of myeloid-derived suppressor cells (6th rank) emphasizes that resistance does not depend solely on the tumor cell, but also the tumor

microenvironment, where the immune system is continuously deactivated by the accumulation of lactate.

The article, which ranks seventh, highlights the importance of autophagy in treatment resistance. It demonstrated that glioblastoma cells use a phosphorylation process to preserve their viability when subjected to radiotherapy.

The article ranked eighth highlights that the issue of radioresistance is a technological challenge, where the use of nanomaterial-based platforms is being explored to radiosensitize hypoxic tumors.

Articles ranked 9th and 10th highlight the growing importance of non-coding RNAs, whether circular RNAs or microRNAs. The latter, sometimes induced by radiation itself, acts as a powerful relay to the resistance of cancer.

Review and Citation of Keywords on Tumor Radioresistance

The bibliometric study of keywords has highlighted the hierarchical conceptual structure of the scientific field dedicated to tumor radioresistance. The frequency diagram shown in Figure 4 illustrates three degrees of thematic importance, reflecting both the progression of the field and its constantly evolving research priorities.

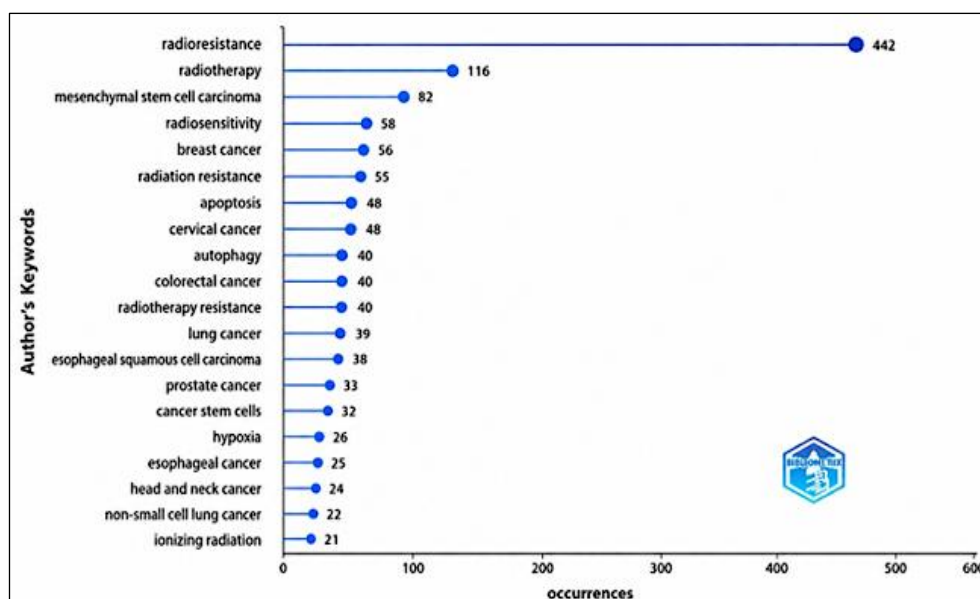


Figure 4: Keywords Most Frequently Cited by Authors

The term "radioresistance," cited 442 times, is considered the most frequently used word. It thus represents the driving force behind research related to the various mechanisms associated with radioresistance.

Next, we find the term "radiotherapy," cited 116 times, which demonstrates that this term is associated with radioresistance. Radioresistance is considered an obstacle to the effective use of radiotherapy.

Radioresistance is found in several types of cancer. It is primarily nasopharyngeal cancer, cited first [82], followed by esophageal cancer [64], lung cancer [61] and breast cancer [56], which is cited fourth. Nasopharyngeal cancer is the most studied in the literature. This is mainly explained by the observation that radiotherapy is the primary treatment modality. This cancer is also very prevalent in Asia, which aligns with the dominance of research on the Asian continent, particularly in China.

The term "radiosensitivity," cited 68 times, presents the epidemiological profile of cancer patients, where some develop resistance while others exhibit radiosensitivity.

Regarding the molecular factors impacting radioresistance, we find apoptosis, cited 48 times, which justifies its important role in post-radiation cell survival. Autophagy, cited 40 times, is considered the mechanism that helps cancer cells escape radiation-induced death.

Thematic Dynamics and Future Directions of Research on Tumor Radioresistance

The analysis of the evolution of cancer radioresistance research between 2016 and 2025 was conducted using multiple correspondence analysis (MCA) and trind-topic analysis.

The MCA performed on the authors' keyword citations shows a two-dimensional organization, explaining 49.59% of the total variance (Figure 5). This percentage supports the conceptual validity of the radioresistance research. The resulting Figure 5 highlights certain elements describing related biological processes, with a vertical axis contrasting intrinsic radioresistance (the cellular level) with extrinsic radioresistance (hypoxia). The horizontal axis intersects radiosensitivity with radioresistance.

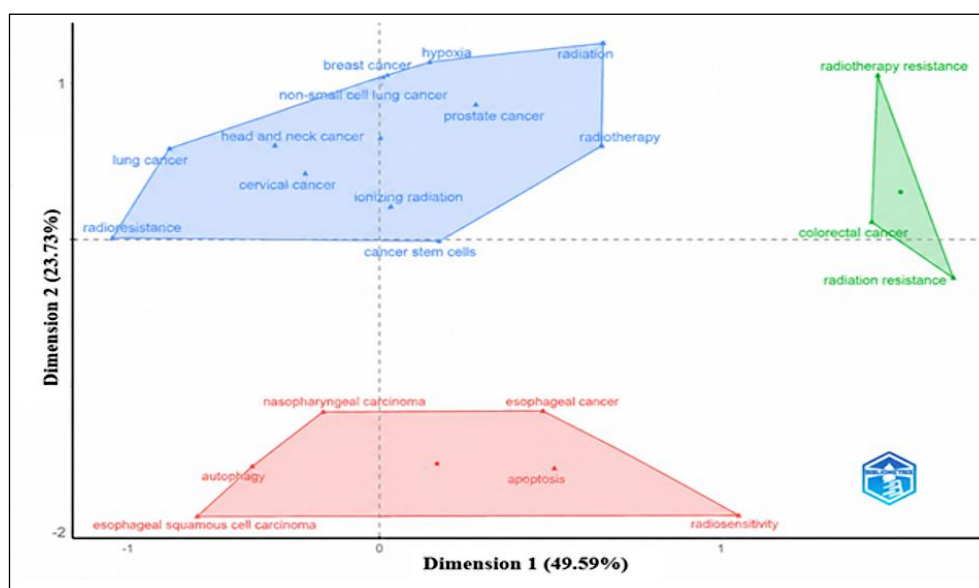


Figure 5: Multiple Correspondence Analysis for the Keywords' Authors

Scientific research is primarily organized around two main axes, as illustrated in Figure 5. The horizontal axis (Dimension 1, 49.59%) contrasts the most resistant cancer types (colon and rectal cancers) with radiation-sensitive cancer types (nasopharyngeal and esophageal carcinomas).

The vertical axis (Dimension 2, 23.73%) contrasts, on the one hand, lung, breast and cervical cancers, which exhibit extrinsic radioresistance, primarily associated with hypoxia and the tumor microenvironment and on the other hand, digestive cancers, which primarily exhibit intrinsic radioresistance, linked to alterations in DNA repair

pathways and signaling pathways. In this perspective, the MCA map presents three conceptual frameworks:

Group 1 concerns radioresistance related to hypoxia. It is found in hypoxic malignant cancers, notably lung, breast, cervical, head and neck cancers and concerns

Group 2 consists mainly of colorectal cancers. These cancers represent the form of intrinsic radioresistance.

Group 3 includes esophageal and nasopharyngeal

cancers, which initially appear sensitive to radiotherapy but subsequently develop resistance following suppression of the apoptosis system and activation of the autophagy system.

All three groups describe biological mutations where the positive or negative response to radiotherapy is linked to the combination of several intrinsic and extrinsic factors, repair and plasticity processes. The study of trending topics at the Figure Highlight a three-period temporal between 2016 and 2025.

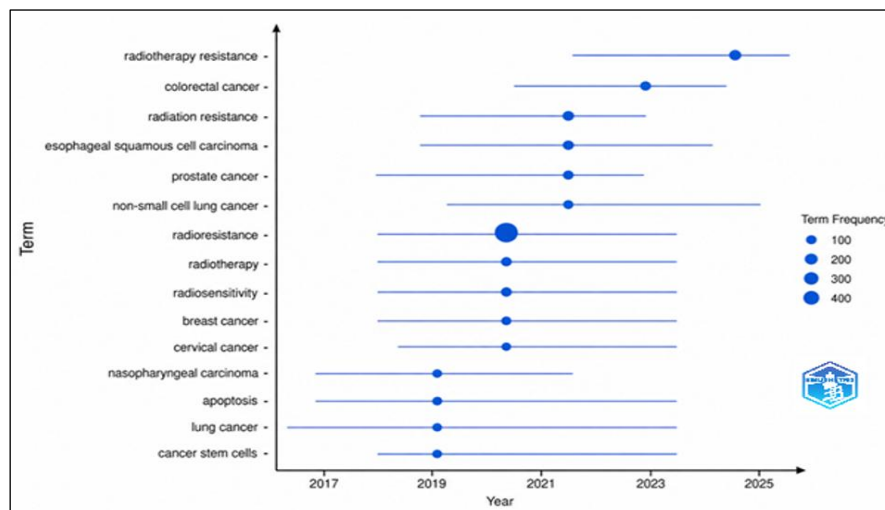


Figure 6: Trend Topic of Keywords' Authors

To understand the molecular factors associated with radiobiology, the first phase [2017-2019] focused on describing the biological mechanisms, namely apoptosis, hypoxia and autophagy. Lung and nasopharyngeal cancers were the first cancer types studied.

The second period [2020-2022] was primarily marked by the addition of more in-depth research concerning the concept of radiosensitivity, primarily incorporating other types of cancer such as breast, cervical and esophageal cancer. Radiotherapy and radiosensitivity are the two research areas linking molecular biology with the evolution of the clinical status of cancer patients.

The latest phase, between 2023 and 2025, linking radioresistance to colorectal cancer, demonstrates the evolution of radiotherapy as a therapeutic modality, which is being developed for other complex cancer types with acquired resistance.

Studying the link between molecular factors and the application of radiotherapy can be considered a key perspective for research on radioresistance. This involves exploring molecular markers directly associated with radioresistance and discovering

new mechanisms, such as ferroptosis and DNA repair. This technique aims to identify predictive biomarkers and to find therapeutic combinations that can improve the prognosis of oncology patients.

Conclusion

The structural advancements, cooperative interactions and emerging themes in tumor radioresistance research throughout the past ten years were emphasized by this bibliometric analysis. The analysis of 1164 papers showed a trend in scientific output where American and Chinese contributions are crucial to the spread of knowledge. According to thematic developments, tumor resistance to radiation therapy is thought to be a complex collection of complementary mechanisms that include both genetic defects and microenvironmental variables. All things considered; this bibliometric analysis revealed a development in the field of tumor radioresistance research.

Analysis of scientific research published between 2016 and 2025 reveals a conceptual dynamic.

Initial research began to understand the molecular factors associated with radioresistance, particularly apoptosis, autophagy and hypoxia, specifically in respiratory tract cancers, especially lung and nasopharyngeal cancers. Research subsequently expanded to address radiosensitivity as a phenomenon explained in certain types of cancer, such as breast, cervical and esophageal cancers. Researchers also integrated radiotherapy and radiosensitivity as the two main axes for linking molecular biology to the evolution of the clinical status of cancer patients.

Finally, the close link between radioresistance and colorectal cancer illustrates the adoption of therapeutic innovations in radiotherapy to treat complex cancer types exhibiting acquired resistance.

From a therapeutic standpoint, tumors exhibiting intrinsic resistance can be treated by targeting DNA repair pathways or inducing metabolic adaptations. Furthermore, therapeutic approaches targeting hypoxia could be used when resistance is due to microenvironmental variations. Moreover, the adaptations observed in certain malignant cancers, particularly those of the nasopharynx and esophagus, underscore the need to develop innovative therapeutic modalities capable of limiting the spread of tumor resistance.

Thus, the future revolves around the convergence of biology, data science and clinical practice to develop personalized radiation oncology capable of predicting, preventing and overcoming tumor resistance.

However, like all research, this study has limitations. The bibliometric analysis relies on a single database, namely WOSCC, which may introduce selection bias. Some important publications may be excluded, thus limiting the comprehensiveness of the results.

Abbreviations

DNA: Deoxyribonucleic Acid, IF: Impact Factor, MCA: Multiple Correspondence Analysis, RNA: Ribonucleic Acid, WOSCC: Web of Science Core Collection.

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Author Contributions

Aicha Rifai: Original Manuscript Draft, Conceptualization, Methodology, Anasse Benabdallah: Methodology, Formal Analysis, Laila Bouguenouch: Supervision, Validation of Results, Manuscript Review, Touria Bouhafa: Supervision, Manuscript Review, Final Editing.

Conflict of Interest

The authors have no competing interests (financial or otherwise) to declare.

Data Availability

The corresponding author can provide the datasets created and examined for this study upon reasonable request.

Declaration of Artificial Intelligence (AI) Assistance

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article. The authors take full responsibility for the originality, interpretation and accuracy of the content.

Ethics Approval

Not Applicable.

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References

- Zhu L, Wu K, Ma S, Zhang S. HDAC inhibitors: A new radiosensitizer for non-small-cell lung cancer. *Tumori J.* 2015;101(3):257-62. <https://doi.org/10.5301/tj.5000347>
- Chorna I. Molecular mechanisms underlying cancer cell radioresistance. *Polonia University Scientific Journal.* 2022;48(5):142-51. doi: 10.23856/4818
- Su Y, Li T. Radioresistance via lipid metabolism: intrinsic, acquired and tumor microenvironment. *Precis Nutr.* 2024;3(2). e00068. doi: 10.1097/PN9.000000000000068
- Suwa T, Kobayashi M, Nam JM, Harada H. Tumor microenvironment and radioresistance. *Experimental & molecular medicine.* 2021;53(6):1029-35. doi: 10.1038/s12276-021-00640-9.
- Wu Y, Song Y, Wang R, Wang T. Molecular mechanisms of tumor resistance to radiotherapy. *Molecular Cancer.* 2023;22(1):96. doi: 10.1186/s12943-023-01801-2
- Carlos-Reyes A, Muñiz-Lino MA, Romero-Garcia S, López-Camarillo C, Hernández-de la Cruz ON.

- Biological Adaptations of Tumor Cells to Radiation Therapy. *Frontiers in Oncology*. 2021;11: 718636. doi: 10.3389/fonc.2021.718636
7. Liu YP, Zheng CC, Huang YN, He ML, Xu WW, Li B. Molecular mechanisms of chemo- and radiotherapy resistance and the potential implications for cancer treatment. *MedComm*. 2021;2(3):315-40. doi: 10.1002/mco2.55
 8. Zhou T, Zhang LY, He JZ, *et al.* Mechanisms and perspective treatment of radioresistance in non-small cell lung cancer. *Front Immunol*. 2023;14. doi: 10.3389/fimmu.2023.1133899
 9. Yu Y, Yu J, Ge S, Su Y, Fan X. Novel insight into metabolic reprogramming in cancer radioresistance: A promising therapeutic target in radiotherapy. *Int J Biol Sci*. 2023;19(3):811-28. doi: 10.7150/ijbs.79928
 10. Vischioni B, Barcellini A, Magro G, Rotondi M, Durante M, Facoetti A, Thariat J, Orlandi E. Radioresistant, Rare, Recurrent and Radioinduced: 4Rs of Hadrontherapy for Patients Selections. *Int J Part Ther*. 2024;15: 100737. doi: 10.1016/j.ijpt.2024.100737
 11. Youssef A, Sahgal A, Das S. Radioresistance and brain metastases: a review of the literature and applied perspective. *Front Oncol*. 2024;14: 1477448. doi: 10.3389/fonc.2024.1477448
 12. Benabdallah A, Jellouli T. Application of a cost calculation approach in medical oncology: case of Hassan II university hospital in Morocco. *Cost Effectiveness and Resource Allocation*. 2023;21(1):53. doi: 10.1186/s12962-023-00462-8
 13. Wei W, Jiang Z. A bibliometrix-based visualization analysis of international studies on conversations of people with aphasia: Present and prospects. *Heliyon*. 2023; 9(6). doi: 10.1016/j.heliyon.2023.e16839
 14. Aria M, Cuccurullo C. bibliometrix: An R-tool for comprehensive science mapping analysis. *J Informetr*. 2017;11(4):959-75. doi: 10.1016/j.joi.2017.08.007.
 15. Byrne NM, Tambe P, Coulter JA. Radiation response in the tumour microenvironment: Predictive biomarkers and future perspectives. *J Pers Med*. 2021;11(1):53. doi: 10.3390/jpm11010053
 16. Taketo K, Konno M, Asai A, *et al.* The epitranscriptome m6A writer METTL3 promotes chemo- and radioresistance in pancreatic cancer cells. *Int J Oncol*. 2018;52(2):621-9. doi: 10.3892/ijo.2017.4219
 17. Zhou S, Bai ZL, Xia D, *et al.* FTO regulates the chemoradiotherapy resistance of cervical squamous cell carcinoma (CSCC) by targeting β -catenin through mRNA demethylation. *Mol Carcinog*. 2018;57(5): 590-7. doi: 10.1002/mc.22782
 18. Koppula P, Lei G, Zhang Y, *et al.* A targetable CoQ-FSP1 axis drives ferroptosis- and radiation-resistance in KEAP1 inactive lung cancers. *Nature Communications*. 2022;13(1):2206. doi: 10.1038/s41467-022-29905-1
 19. Jeong Y, Hoang NT, Lovejoy A, *et al.* Role of KEAP1/NRF2 and TP53 Mutations in Lung Squamous Cell Carcinoma Development and Radiation Resistance. *Cancer Discov*. 2017;7(1):86-101. doi: 10.1158/2159-8290.Cd-16-0127
 20. Park SY, Lee CJ, Choi JH, *et al.* The JAK2/STAT3/CCND2 Axis promotes colorectal Cancer stem cell persistence and radioresistance. *Journal of Experimental & Clinical Cancer Research*. 2019;38(1):399. doi:10.1186/s13046-019-1405-7
 21. Yang X, Lu Y, Hang J, *et al.* Lactate-Modulated Immunosuppression of Myeloid-Derived Suppressor Cells Contributes to the Radioresistance of Pancreatic Cancer. *Cancer Immunol Res*. 2020;8(11):1440-51. doi: 10.1158/2326-6066.Cir-20-0111
 22. Huang T, Kim CK, Alvarez AA, *et al.* MST4 Phosphorylation of ATG4B Regulates Autophagic Activity, Tumorigenicity and Radioresistance in Glioblastoma. *Cancer Cell*. 2017;32(6):840-55. doi: 10.1016/j.ccell.2017.11.005
 23. Yong Y, Zhang C, Gu Z, *et al.* Polyoxometalate-Based Radiosensitization Platform for Treating Hypoxic Tumors by Attenuating Radioresistance and Enhancing Radiation Response. *ACS Nano*. 2017;11(7):7164-76. doi: 10.1021/acsnano.7b03037
 24. Su H, Lin F, Deng X, *et al.* Profiling and bioinformatics analyses reveal differential circular RNA expression in radioresistant esophageal cancer cells. *Journal of Translational Medicine*. 2016;14(1):225. doi: 10.1186/s12967-016-0977-7
 25. Tang Y, Cui Y, Li Z, *et al.* Radiation-induced miR-208a increases the proliferation and radioresistance by targeting p21 in human lung cancer cells. *Journal of Experimental & Clinical Cancer Research*. 2016;35(1):7. doi: 10.1186/s13046-016-0285-3

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