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Global Trends and Hotspots in Tongue Cancer Research: A Bibliometric Analysis (2014-2024)

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KEYWORDS

Tongue Cancer,
Bibliometric Analysis,
Research Hotspots,
HPV,
Personalized Treatment

ABSTRACT

This study conducts a bibliometric analysis of 1,553 tongue cancer-related publications from 2014 to 2024, sourced from the Web of Science database, to uncover global research trends, hotspots, key contributors, and future directions in the field. Results indicate a significant rise in research activity, with China, the United States, and Japan leading in output and international collaboration. Emerging hotspots include the use of advanced technologies such as artificial intelligence, deep learning, and radiomics for early diagnosis, prognostic evaluation, and treatment, as well as a growing focus on younger patient populations and immunotherapy strategies. Future research should emphasize interdisciplinary collaboration, integrating bioinformatics, imaging, and clinical studies, while fostering international cooperation and data sharing to advance understanding of tongue cancer pathogenesis and improve treatment outcomes, survival rates, and quality of life for patients.

1. Introduction

Tongue cancer is a malignant tumor that occurs in the oral tongue, and it is one of the most common types of oral squamous cell carcinoma (Sung et al., 2021). It not only jeopardizes the patient's life and health but also severely affects their ability to eat, speak, and socialize. In recent years, the incidence of tongue cancer has been on the rise globally, particularly in regions lacking effective early screening and preventive measures (Sung et al., 2021). According to the World Health Organization's report, tongue cancer ranks among the top five most common malignant tumors of the head and neck, with approximately 300,000 new cases diagnosed annually worldwide (Tan et al., 2023). Because tongue cancer often lacks obvious symptoms in its early stages, most patients are diag nosed at an advanced stage, resulting in a five-year survival rate of less than 50% (Chinn & Myers, 2015; Leemans et al., 2011). Currently, the main treatment for tongue cancer is a

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comprehensive approach, primarily involving surgical resection, supplemented by radiation therapy, chemotherapy, targeted therapy, and immunotherapy (Zanoni, Patel, et al., 2019). Therefore, research on tongue cancer not only helps optimize clinical treatment strategies but also holds the potential to improve patient survival and quality of life through early diagnosis and intervention.

Bibliometric analysis is a statistical method based on public literature databases (such as Web of Science), which uses statistical data to analyze published information (such as books, journal articles, datasets, blogs) and their associated metadata (such as abstracts, keywords, citations). It aims to describe or display the relationships between published works and serves as a practical tool for assessing research trends (Ninkov et al., 2022). This method can analyze frequently occurring keywords in the articles and popular terms that have emerged in recent years, thereby providing supporting evidence for future research trends. Bibliometric analysis helps identify influential researchers, key studies, and emerging trends, promoting strategic planning and decision-making in scientific research (Cheng et al., 2023). The achievements of bibliometric analysis are reflected in its widespread application across various scientific fields, from medicine to environmental science. These analyses play a crucial role in mapping research activities and assessing the contributions of different countries and institutions to global knowledge (Cheng et al., 2023; Wei et al., 2022).

CiteSpace is a tool for bibliometric analysis, designed to visualize and analyze trends and patterns in scientific literature, helping researchers identify key points and emerging trends (Cortese et al., 2022). In this study, CiteSpace software was used to perform co-occurrence analysis of literature related to tongue cancer, constructing a knowledge map to visualize research dynamics, evolving patterns, and development processes. The analysis aims to identify academic research hotspots in this field and provide new insights and references for future related research.

2. Methods

2.1. Data Source and Retrieval Strategy

The Web of Science (WOS) core database, provided by Clarivate Analytics, is widely regarded as the preferred data source for bibliometric analysis, as it covers a wide range of academic fields and high-quality scholarly publications (Liu et al., 2023). Therefore, this study selected the WOS core database as the primary data source. On March 24, 2024, we performed an English-language search in the WOS core database for all articles related to tongue cancer published from January 1, 2014, to March 24, 2024. The search string was: (((((TS=("tongue cancer")) OR TS=("tongue neoplasm")) OR TS=("carcinoma of tongue")) OR TS=("tongue cancers")) OR TS=("tongue squamous cancer")) OR TS=("tongue squamous carcinoma")). The inclusion criteria were: (1) articles written in English; (2) only research articles included, excluding letters, reviews, conference abstracts, etc.; (3) studies focused on tongue cancer; (4) to ensure data consistency and minimize potential bias from daily database updates, all relevant literature was retrieved and screened on the same day.

2.2. Analysis Method

This study used CiteSpace software (version 6.1.6) for visualization analysis and Microsoft Excel (2021) for data management and publication trend analysis. The parameters for CiteSpace were set as follows: time slices from 2014 to 2024, with each slice representing one year, and the selection criteria were based on the g-index (g2≤k σ i≤gci, where k∈Z+, k=25). The literature was visualized and analyzed with respect to countries/regions, institutions, references, and keywords.

In the generated graphs, N represents the number of network nodes, E represents the number of connecting edges, and density refers to the network density. Modularity is an indicator of network modularity. A higher modularity Q value indicates a better clustering effect in the network. A Q value greater than 0.3 suggests that the clustering structure is significant. The silhouette value is used to measure the homogeneity of the network, with values close to 1 indicating higher homogeneity, and values greater than 0.5 suggesting that the clustering structure is reasonable.

This study primarily measures the following: (1) Analysis of the number of publications, collaboration networks between countries/regions, journals, and institutions;(2) Author and co-cited author network analysis, which helps reveal the collaboration patterns and influence among authors;(3) Cited literature analysis, which includes network maps, timeline graphs, and reference burst graphs. Co-citation analysis refers to the situation where two or more articles are simultaneously cited by one or more subse-

quent articles, indicating a co-citation relationship between these articles. This is a method for measuring the strength of relationships between publications;(4) Keyword analysis, which includes keyword clustering analysis, keyword time-zone graph analysis, and keyword burst analysis. The keyword clustering graph focuses on reflecting the structural characteristics between clusters and highlights key nodes and important connections. The keyword time-zone graph shows the evolution of high-frequency keywords over time. Keyword burst analysis helps explore rapidly emerging topics within the field.

Ethical review is not applicable for this type of study.

3. Results

3.1. Publication Trends

A total of 1,553 articles related to tongue cancer were retrieved in this study. The data show that from 2015 to 2016, the number of publications increased slowly. From 2016 to 2019, the number of articles grew steadily, while from 2019 to 2021, there was an explosive growth in publications (Figure 1). This reflects the increasing attention to tongue cancer research over the past decade. Although the number of articles declined after reaching its peak in 2021, it still remained at a high level compared to the previous ten years.

3.2. Country / Region of Publication

This study includes publications from 73 different countries and regions. Among all countries, China leads with 355 articles, accounting for 22.86%, followed by Japan (268 articles, 17.26%) and the United States (219 articles, 14.10%). Despite China's dominance in the number of publications, its centrality is only 0.16, ranking fourth. In contrast, the United States ranks third in total publications, but with a centrality of 0.25, it holds the top position, reflecting its core role in international collaboration. England (centrality 0.23) and India (centrality 0.22) follow closely, highlighting their significant roles in international cooperation. Notably, despite England's relatively small publication count of 26 articles (1.67%, ranked 15th), its centrality is ranked third, indicating its prominent position in international collaboration. The most frequent collaboration occurs between the United States and China.

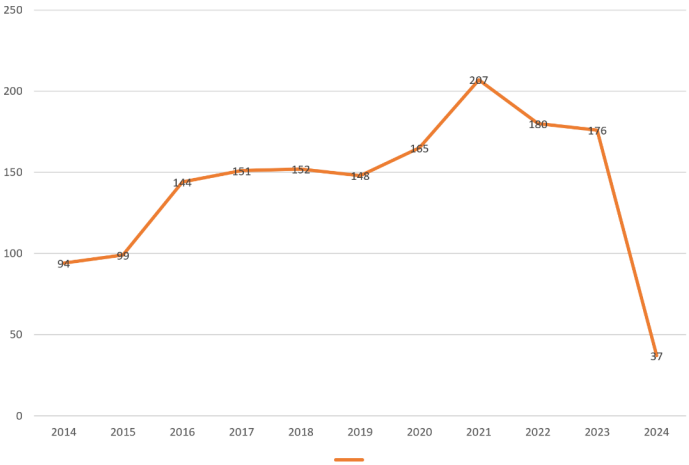
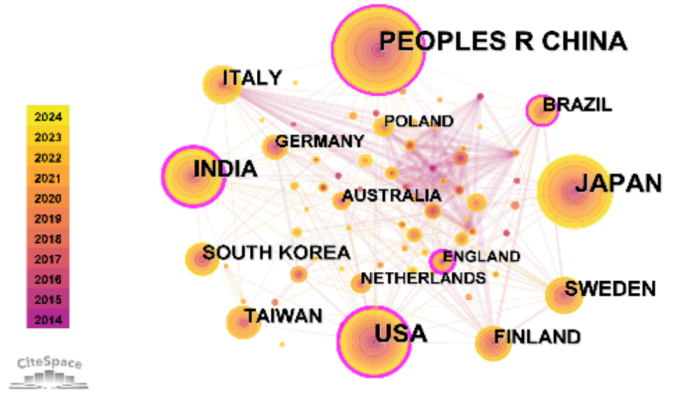


Figure 1 | Number of publications per year



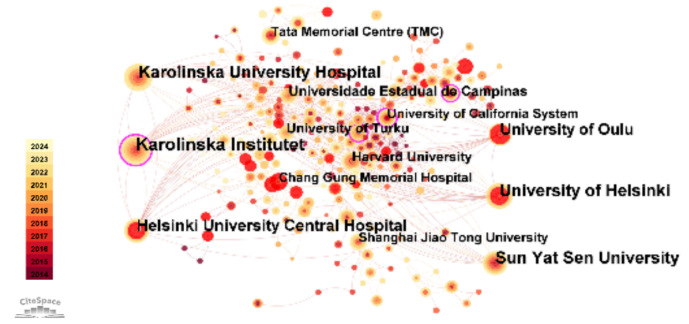


Figure 3 | Analysis of research institutions

3.3. Research Institutions

CiteSpace software was used to analyze 353 institutions contributing to tongue cancer research, as shown in Figure 3. Table 3 lists the top 10 institutions by the number of published studies from 2014 to 2024. The data shows that these top 10 institutions published a total of 415 research articles, accounting for 26.72% of all publications. The institution with the most publications is Karolinska Institutet (73 articles, 4.70%), followed by University of Helsinki (63 articles,

Table 1 | Top 10 Research Institutions

Rank	Count	Centrality	Research Institutions
1	73	0.24	Karolinska Institutet
2	63	0.03	University of Helsinki
3	62	0.05	Karolinska University Hospital
4	58	0.09	Sun Yat Sen University
5	51	0.01	Helsinki University Central Hospital
6	42	0.02	University of Oulu
7	28	0.05	Universidade Estadual de Campinas
8	26	0	University of Turku
9	25	0.07	Harvard University
10	23	0.01	Tata Memorial Centre (TMC)

4.06%) and Karolinska University Hospital (62 articles, 3.99%).

3.4. Analysis of Authors and Co-Cited Authors

A total of 450 researchers have contributed to the publication of relevant literature in this field. Among them, Salo, Tuula ranks first with 37 publications, followed by Dalianis, Tina (29 publications) and Almangush, Alhadi (23 publications). The visual analysis graph displays the influence of each author, where each circle represents an author. The size of the circle reflects the number of publications by that author, and the thickness of the connecting lines between circles indicates the level of collaboration between authors (Figure 4).

In the co-citation analysis, a total of 564 authors formed co-citation relationships. Among these authors, JEMAL A has the highest citation count with 185 citations, followed by DCRUZ AK (132 citations)

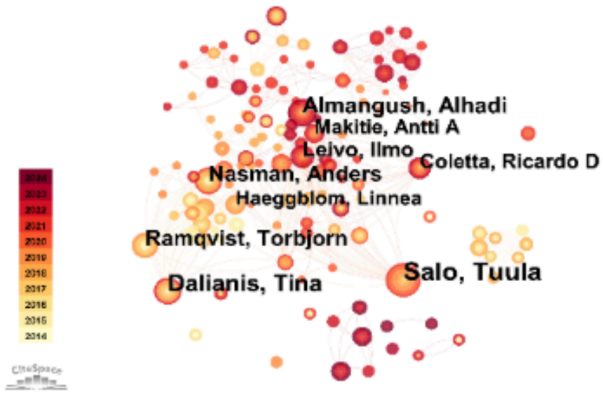


Figure 4 | Analysis of authors

Table 2 | Top 10 Authors and Co-Cited Authors

Rank	Count	Centrality	Authors	Rank	Count	Centrality	Co-Cited Authour
1	37	0.02	Salo, Tuula	1	185	0.02	JEMAL A
2	29	0.01	Dalianis, Tina	2	132	0.05	DCRUZ AK
3	23	0	Almangush, Alhadi	3	123	0.04	GANLY I
4	22	0.01	Nasman, Anders	4	110	0.09	ALMANGUSH A
5	21	0.01	Ramqvist, Torbjorn	5	105	0.02	WARNAKULASURIYA S
6	19	0	Leivo, Ilmo	6	101	0.04	CHATURVEDI AK
7	18	0.01	Coletta, Ricardo D	7	100	0.04	YUEN APW
8	15	0	Makitie, Antti A	8	97	0.02	HUANG SH
9	15	0.01	Haeggblom, Linnea	9	82	0.1	GILLISON ML
10	13	0	Kakimoto, Naoya	10	78	0.02	FERLAY J

and GANLY I (123 citations). In terms of network centrality, COOPER JS has the highest centrality at 0.14, followed by GILLISON ML (0.1), while ALMANGUSH A and BRANDWEIN-GENSLER A share the third position with a centrality of 0.09. This indicates the significant influence and central role of these authors in the field of tongue cancer research (Figure 5).

3.5. Journals of Publication and Co-Cited Journals

In the field of tongue cancer research, ORAL ONCOLOGY is the journal with the highest number of publications, with 71 articles, followed by HEAD AND NECK-JOURNAL FOR THE SCIENCES AND SPECIALTIES OF THE HEAD AND NECK (66 articles) and CANCERS (30 articles). In terms of impact factor, CANCERS ranks first among the top ten academic journals, with an impact factor of 5.2. The number of publications, impact factor, and JCR rankings of the top 10 journals are listed in Table 3.

Among the 638 co-cited journals, ORAL ONCOLOGY has the highest citation count, with 989 citations, followed by HEAD NECK-J SCI SPEC (908 citations) and LARYNGOSCOPE (509 citations). The impact factor and JCR rankings of the top 10 co-cited journals are shown in Table 3.

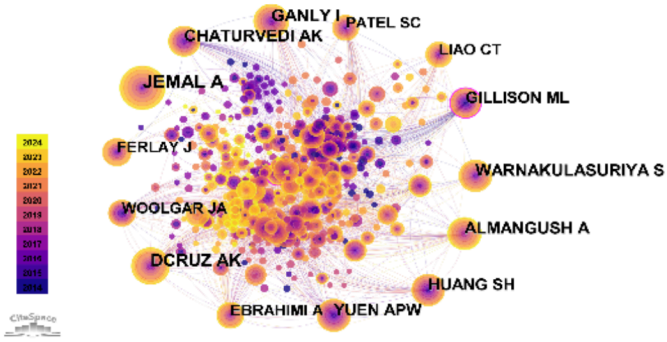


Figure 5 | Analysis of Co-Cited Author

Figure 7 | Co-Cited Journal Analysis

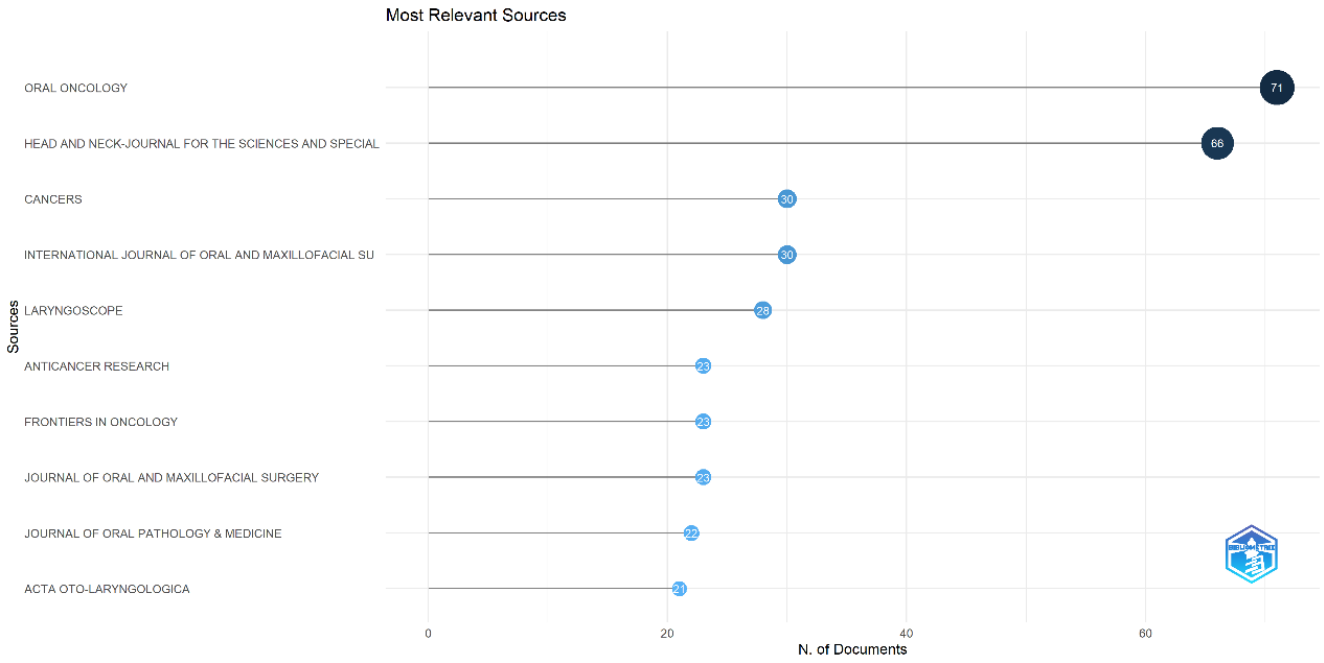


Figure 6 | Number of Publications by Journal

Table 3 | Top 10 Journals by Number of Publications and Co-Citation Count

Rank	Count	Journal	IF	JCR	Rank	Count	Cited Journal	IF	JCR
1	71	ORAL ONCOLOGY	71	4.0	1	71	ORAL ONCOL	4.0	Q2
2	66	HEAD AND NECK-JOURNAL FOR THE SCIENCES AND SPECIALTIES OF THE HEAD AND NECK	66	2.3	2	66	HEAD NECK-J SCI SPEC	2.3	Q2
3	30	CANCERS	30	4.5	3	30	LARYNGOSCOPE	2.2	Q1
4	30	INTERNATIONAL JOURNAL OF ORAL AND MAXILLOFACIAL SURGERY	30	2.2	4	30	CANCER-AM CANCER SOC	6.1	Q1
5	28	LARYNGOSCOPE	28	2.2	5	28	PLOS ONE	2.9	Q1
6	23	ANTICANCER RESEARCH	23	1.6	6	23	J CLIN ONCOL	18.97	Q1
7	23	FRONTIERS IN ONCOLOGY	23	3.5	7	23	INT J CANCER	5.7	Q1
8	23	JOURNAL OF ORAL AND MAXILLOFACIAL SURGERY	23	2.3	8	23	J ORAL MAXIL SURG	2.2	Q2
9	22	JOURNAL OF ORAL PATHOLOGY & MEDICINE	22	2.7	9	22	CANCER RES	12.5	Q1
10	13	ACTA OTO-LARYNGOLOGICA	21	1.2	10	13	CA-CANCER J CLIN	4.0	Q2

Table 4 | Top 10 Cited References

Rank	Count	Cited Reference	Centrality	Year	DOI
1	58	Elective versus Therapeutic Neck Dissection in Node-Negative Oral Cancer	0.14	2015	10.1056/NEJMoa1506007
2	44	Changing epidemiology of oral squamous cell carcinoma of the tongue: A global study	0.05	2017	10.1002/hed.24589
3	38	Head and Neck cancers-major changes in the American Joint Committee on cancer eighth edition cancer staging manual	0.05	2017	10.3322/caac.21389
4	33	Rising incidence of oral tongue cancer among white men and women in the United States, 1973-2012	0.16	2017	10.1016/j.oraloncology.2017.02.019
5	31	Depth of invasion, tumor budding, and worst pattern of invasion: Prognostic indicators in early-stage oral tongue cancer	0.08	2014	10.1002/hed.23380
6	25	Classification of GLOSSECTOMIES: Proposal for tongue cancer resections	0.02	2019	10.1002/hed.25466
7	25	Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries	0.01	2021	10.3322/caac.21660
8	24	AJCC CANCER STAGING MANUAL	0.02	2017	-
9	22	Long-term regional control and survival in patients with “low-risk,” early stage oral tongue cancer managed by partial glossectomy and neck dissection without postoperative radiation	0.15	2013	10.1002/cncr.27872
10	21	Survival outcomes after treatment of cancer of the oral cavity (1985-2015)	0.09	2019	10.1016/j.oraloncology.2019.02.001

3.6. Co-Cited Literature Analysis and Citation Burst

Co-citation analysis reflects, to some extent, the key literature in a research field. By analyzing the high-frequency co-cited literature, we identified the top 10 core articles in this field, which are of significant reference value for current research. Among them, the article with the highest citation burst intensity and the most citations was published in 2015 in The New England Journal of Medicine (impact factor 158.5, Q1 level), titled "Elective versus Therapeutic Neck Dissection in Node-Negative Oral Cancer" (D'Cruz et al., 2015). This study showed that, in oral cancer patients without neck lymph node metastasis, elective neck dissection was more effective in reducing postoperative complications compared to therapeutic neck dissection, without affecting the overall survival rate of patients. This finding provides important guidance for the surgical treatment strategies of tongue cancer and has contributed to the development of personalized treatment plans.

Citation burst analysis is a powerful tool that helps researchers and decision-makers better understand and grasp the development dynamics and trends of a research field, as well as identify the literature that has received significant attention during a specific period of time.

3.7. Analysis of Keywords and Burst Keywords

Keywords play a crucial role in academic articles, as they concisely express the content of the paper, quickly and accurately revealing the topic and research focus, helping readers rapidly understand the scope and core content of the research. In this study, the keywords of the included publications were visualized and analyzed using CiteSpace software (Figure 9). The most frequently occurring keyword was "tongue cancer," appearing 606 times, followed by "head" (553 times), "squamous cell carcinoma" (529 times), "oral cancer" (230 times), and "cancer" (202 times). The co-occurrence analysis of keywords re-

Top 25 References with the Strongest Citation Bursts

References	Year	Strength	Begin	End	2014 - 2024
Chaturvedi AK, 2011, J CLIN ONCOL, V29, P4294, DOI 10.1200/JCO.2011.36.4596, DOI	2011	8.03	2014	2016	
Patel SC, 2011, J CLIN ONCOL, V29, P1488, DOI 10.1200/JCO.2010.31.7883, DOI	2011	7.56	2014	2016	
Attner P, 2010, INT J CANCER, V126, P2879, DOI 10.1002/ijc.24994, DOI	2010	7.5	2014	2015	
Siegel R.L., 2020, ANTI-CANCER DRUG, V70, P7, DOI 10.1097/CAD.0000000000000617, DOI	2020	7.37	2020	2016	
Ganly I, 2012, CANCER-AM CANCER SOC, V118, P101, DOI 10.1002/cncr.26229, DOI	2012	7.05	2014	2017	
Ang KK, 2010, NEW ENGL J MED, V363, P24, DOI 10.1056/NEJMoa0912217, DOI	2010	6.96	2014	2015	
Leemans CR, 2011, NAT REV CANCER, V11, P9, DOI 10.1038/nrc2982, DOI	2011	6.13	2014	2016	
Näsman A, 2013, PLOS ONE, V8, P0, DOI 10.1371/journal.pone.0077025, DOI	2013	4.97	2014	2018	
Ganly I, 2013, CANCER-AM CANCER SOC, V119, P1168, DOI 10.1002/cncr.27872, DOI	2013	6.99	2015	2018	
Nordfors C, 2013, EUR J CANCER, V49, P2522, DOI 10.1016/j.ejca.2013.03.019, DOI	2013	5.32	2015	2018	
Almangush A, 2014, HEAD NECK-J SCI SPEC, V36, P811, DOI 10.1002/hed.23380, DOI	2014	8.81	2016	2019	
DCruz AK, 2015, NEW ENGL J MED, V373, P521, DOI 10.1056/NEJMoa1506007, DOI	2015	14.04	2017	2020	
Ebrahimi A, 2014, JAMA OTOLARYNGOL, V140, P1138, DOI 10.1001/jamaoto.2014.1548, DOI	2014	9.02	2018	2019	
[Anonymous], 2017, AMERICAN JOINT COMMITTEE ON CANCER, V0, P0	2017	7.02	2018	2020	
Abu-Ghanem S, 2016, JAMA OTOLARYNGOL, V142, P857, DOI 10.1001/jamaoto.2016.1281, DOI	2016	5.92	2019	2021	
Alsaffar HA, 2016, J OTOLARYNGOL-HEAD N, V45, P0, DOI 10.1186/s40463-016-0172-0, DOI	2016	5.22	2019	2021	
Ng JH, 2017, HEAD NECK-J SCI SPEC, V39, P297, DOI 10.1002/hed.24589, DOI	2017	9.56	2020	2021	
Murakami R, 2019, ACAD RADIOL, V26, PE180, DOI 10.1016/j.acra.2018.08.021, DOI	2019	6.77	2020	2021	
Tota JE, 2017, ORAL ONCOL, V67, P146, DOI 10.1016/j.oraloncology.2017.02.019, DOI	2017	6.6	2020	2021	
Ansarin M, 2019, HEAD NECK-J SCI SPEC, V41, P821, DOI 10.1002/hed.25466, DOI	2019	5.39	2020	2024	
Amin MB., 2017, AJCC CANCER STAGING MANUAL, V0, P0	2017	9.3	2021	2022	
Hussein AA, 2017, EUR J CANCER, V82, P115, DOI 10.1016/j.ejca.2017.05.026, DOI	2017	5.9	2021	2022	
Sung H, 2021, CA-CANCER J CLIN, V71, P209, DOI 10.3322/caac.21660, DOI	2021	8.42	2022	2024	
Zanoni DK, 2019, ORAL ONCOL, V90, P115, DOI 10.1016/j.oraloncology.2019.02.001, DOI	2019	7.3	2022	2024	
Tarabichi O, 2019, LARYNGOSCOPE, V129, P662, DOI 10.1002/lary.27403, DOI	2019	6.56	2022	2024	

Figure 8 | References with the Strongest Citation Bursts

veals the research hotspots and trends. In the keyword co-occurrence map, the size of the nodes and circles reflects the frequency of keyword occurrence. The larger the node, the more concentrated and frequent the research on that keyword.

In the burst keyword analysis, "young patients" is the keyword with the longest burst duration. In recent years, keywords such as "machine learning," "MRI," "accuracy," "interstitial brachytherapy," and "disease-free survival" have also significantly increased, indicating that research on tongue cancer in young patients has become a research hotspot over the past decade. Future research trends are likely to focus on more advanced and precise diagnostic methods for tongue cancer, such as the application of machine learning and radiomics in tongue cancer diagnosis, as well as studies on interstitial brachytherapy and disease-free survival rates.

Figure 9 l Analysis of Keyword

Top 25 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2014 - 2024
overexpression	2014	4.7	2014	2016	
favorable prognostic factor	2014	3.92	2014	2015	
e cadherin	2014	3.29	2014	2017	
neck cancer	2014	3.08	2014	2015	
speech	2014	2.86	2014	2015	
prognostic significance	2014	2.79	2014	2017	
breast cancer	2014	4.56	2015	2017	
down regulation	2015	4.12	2015	2017	
prostate cancer	2015	3.88	2015	2017	
colorectal cancer	2016	4.23	2016	2018	
radiation	2017	3.01	2017	2019	
nasopharyngeal carcinoma	2017	3.01	2017	2019	
floor	2015	3.62	2018	2021	
total glossectomy	2018	3.34	2018	2019	
biomarkers	2018	2.97	2018	2020	
defects	2018	2.78	2018	2021	
resistance	2019	4.63	2019	2022	
young patients	2020	3.62	2020	2024	
head and neck	2017	2.84	2020	2021	
machine learning	2021	3.64	2021	2024	
tonsillar	2021	3.25	2021	2022	
mri	2018	3.01	2021	2024	
accuracy	2019	3.24	2022	2024	
interstitial brachytherapy	2022	3.24	2022	2024	
disease-free survival	2022	2.89	2022	2024	

Figure 10 l Top 25 Keywords with the Strongest Citation Bursts

4. Discussion

4.1. General Information

In recent years, despite significant progress made by numerous researchers in the study of tongue cancer, it remains a global challenge. Over the past decade, the number of publications on this disease has steadily and rapidly increased, with 1,553 relevant publications selected from the WOS database. Visualization analysis indicates that Sweden, Finland, China, and the United States have made the most significant contributions to tongue cancer research in the past decade. China not only has the highest number of publications (n=355) but is also one of the most frequent collaborators with other countries. In terms of centrality, the United States ranks first. However, the collaboration between these countries has yet to reach an ideal level.

These studies include the work of 450 authors from 73 different countries. Among them, Salo, Tuula from Finland is the most influential author in the field, having published the most research.Salo, Tuula's significant contributions to tongue cancer research have greatly advanced the understanding of the disease's pathology and molecular mechanisms. Her research has provided important insights into prognostic markers and histopathological features, which are key to optimizing treatment decisions. In particular, her collaborative study with Almangush A. on the discovery of prognostic markers, such as invasion depth, has played a crucial role in improving patient prognostic prediction (Almangush, Bello, et al., 2015; Almangush et al., 2017).

Additionally, her research on the molecular basis of tongue cancer, in collaboration with Zlotogorski-Hurvitz A. and Alabi RO., has enhanced diagnostic and monitoring strategies (Alabi et al., 2020; Zlotogorski-Hurvitz et al., 2016). Salo's interdisciplinary approach has facilitated a comprehensive understanding of tongue cancer, from clinical characteris-

tics to treatment interventions, as reflected in her numerous high-impact publications.

The Karolinska Institutet in Sweden and the University of Helsinki in Finland are the highest-producing institutions. The Karolinska Institutet has a significant impact in the field of tongue cancer research, with studies spanning from virology to clinical outcomes and epidemiology. In 2014, Dalianis T. provided insights into carcinogenic viruses associated with tongue cancer, opening new avenues for understanding cancer mechanisms and potential therapeutic targets (Dalianis, 2014). Alabi RO., in studies from 2020 and 2019 on digital health technologies and molecular characteristics of tongue cancer, not only revealed innovative diagnostic and monitoring methods but also highlighted the molecular diversity in tongue cancer cases (Alabi et al., 2019, 2020).

Nasman A., in studies conducted in 2015 and 2020, explored the epidemiology and clinical outcomes of HPV-positive tongue cancer, significantly impacting clinical practice and patient management strategies (Näsman et al., 2015; Stephen et al., 2010). Nordfors C.'s 2014 study contributed to the understanding of genetic mutations associated with tongue cancer, which is crucial for personalized medical approaches (Nordfors et al., 2014).

Additionally, Ramqvist T.'s 2015 research focused on the role of viruses in tongue cancer, providing foundational knowledge for the field, with significant implications for prognosis and treatment strategies (Näsman et al., 2015). Almangush A.'s 2018 study concentrated on histopathological factors in prognosis (Almangush et al., 2018), while Haeggblom L. and Heikkinen I.'s 2019 research further explored the clinical and pathological impacts of tongue cancer treatment (Haeggblom et al., 2019; Heikkinen et al., 2019).

The Helsinki institution has played a significant leadership role in the field of tongue cancer research, particularly in the areas of disease diagnosis, pathological features, surgical treatment, and the optimization of treatment strategies. Almangush A.'s series of studies have provided important insights into the understanding and treatment of tongue cancer. For example, his 2017 study introduced new prognostic markers for tongue cancer (Almangush et al., 2017), his 2015 research delved into the histopathological features of tongue cancer (Almangush, Bello, et al., 2015), and another 2015 study analyzed the impact of surgical resection margins on treatment outcomes (Almangush, Coletta, et al., 2015). Additionally, his 2018 research focused on the microenvironmental factors of the disease, laying the foundation for the development of new therapeutic targets (Almangush et al., 2018). These studies have not only advanced the understanding of the biological characteristics of tongue cancer but also facilitated innovations in clinical treatment methods, improving disease management outcomes.

Co-citation analysis reflects, to some extent, the key literature in this research field. By analyzing high-frequency co-cited literature, we identified the top 10 core articles in this field, which showcase the multifaceted progress in tongue cancer research. DCruz AK's 2015 study, published in The New England Journal of Medicine, reported a comparison between surgery and radiation therapy for tongue cancer, emphasizing the potential advantages of precise surgical treatment (D'Cruz et al., 2015). Ng JH's 2017 study, published in Head and Neck-Journal for the Sciences and Specialties of the Head and Neck, explored the impact of treatment method selection on patient survival (Ng et al., 2017). Lydiatt WM's 2017 work, published in Cancer Journal, summarized the epidemiological data and prevention strategies for tongue cancer (Lydiatt et al., 2017). Tota JE's 2017 research, published in Oral Oncology Journal, investigated the role of HPV in the development of oral cancer (Lydiatt et al., 2017), while Almangush A.'s 2014 study focused on the application of molecular markers in prognostic evaluation (Almangush et al., 2014). Ansarin M's 2019 study explored how innovative surgical techniques can improve treatment outcomes (Ansarin et al., 2019). Sung H.'s 2021 article in Cancer Journal provided the latest global statistics and trends on oral cancer (Sung et al., 2021).

The AJCC Cancer Staging Manual, 8th Edition (published in 2017 by the American Joint Committee on Cancer) provides detailed guidance for clinicians on the staging of tongue cancer (Edition et al., 2017). Ganly I's 2013 study revealed the cytogenetic characteristics of tongue cancer and their association with patient prognosis (Ganly et al., 2013). Zanoni DK's 2019 research, published in Oral Oncology Journal, assessed the effect of neoadjuvant therapy on improving survival rates in patients with locally advanced tongue cancer (Zanoni, Montero, et al., 2019).

4.2. Research Hotspots or Trends

As a core summary of the research content, keyword analysis is an important method for identifying research hotspots and development trends. Keyword co-occurrence analysis reveals the relationships between various research topics by examining the frequency and patterns of keywords appearing together. The analysis indicates that research in areas such as "young patients," "machine learning," "MRI," and "interstitial brachytherapy" is emerging as a new hotspot in tongue cancer research. The frequent occurrence of these keywords suggests that future research may focus more on young patients with tongue cancer and early diagnostic technologies. The analysis identifies current research hotspots in the field of tongue cancer and possible future development trends.

In recent years, artificial intelligence (AI) and deep learning methods have gained widespread attention in the early diagnosis and prognostic prediction of tongue cancer. The study by Ting-Guan Sun et al. demonstrated the potential of using AI in CECT imaging to non-invasively predict the proliferation status of TSCC before surgery (Sun et al., 2022). Mingxin Yu et al. proposed a novel classification method using deep convolutional neural networks and optical fiber Raman spectroscopy to distinguish between tongue squamous cell carcinoma (TSCC) and non-tumor tissue (Yu et al., 2019). The integration of artificial intelligence has significantly improved the diagnostic accuracy of imaging and reduced subjective bias to some extent. Umberto Committeri et al. combined clinical data with radiomics features from CT scans to predict the risk of metastatic lymph nodes and tumor grading related to tongue cancer, and developed a supportive approach for managing lymph nodes (Committeri et al., 2022). Radiomics-based analysis techniques, which extract a large number of quantitative features from medical imaging, can predict the treatment response and prognosis of tongue cancer, offering valuable insights for the development of personalized treatment plans.

An increasing number of studies have found that the incidence of tongue cancer is rising among young patients, a trend that has attracted widespread attention globally. Research suggests that the rising incidence of tongue cancer in young populations may be related to lifestyle, environmental factors, and genetic susceptibility (Ferreira E Costa et al., 2022). For instance, smoking, alcohol consumption, and human papillomavirus (HPV) infection have all been directly linked to the occurrence of oral cancer, and the widespread presence of these factors in young individuals may partially explain this trend (Hübbers & Akgül, 2015). Studies also indicate that the clinical behavior and prognosis of HPV-positive tongue cancer differ from those of HPV-negative tongue cancer, with HPV-positive patients typically having a better prognosis. Based on this, early screening and detection strategies for HPV infection biomarkers (such as salivary biomarkers) are becoming a key focus of research.

In the treatment strategy for tongue cancer, the depth of surgical resection and the status of the resection margins are considered key indicators for prognostic prediction. Previous studies have shown that the degree of margin clearance is closely related to local recurrence rates. In addition, innovative adjuvant therapies, such as immunotherapy and targeted therapy, have been shown to improve survival rates in patients at high risk of recurrence. For HPV-positive tongue cancer patients, the response rate to immunotherapy is significantly higher than that for HPV-negative patients. This finding provides important insights for the development of personalized treatments and novel therapies.

In recent years, the tumor microenvironment and immune microenvironment have been found to play a critical regulatory role in the occurrence and progression of tongue cancer. Studies have shown that cancer-associated fibroblasts (CAFs) in the tongue cancer microenvironment play a key role in regulating the migration and invasion of tumor cells (Ba et al., 2019). Additionally, epigenetic modifications (such as DNA methylation and histone modifications) have become key molecular regulatory mechanisms in tongue cancer (Lu et al., 2015), providing new research directions for the development of personalized and targeted therapies.

With advancements in diagnostic technology, an increasing number of early tongue cancer cases are being identified in young patients. This highlights the importance of early diagnosis and treatment, as early diagnosis not only significantly improves cure rates but also enhances the quality of life for patients (Khijmatgar et al., 2024). Therefore, understanding the trend of younger patients is crucial for public health policymakers, healthcare professionals, and researchers, in order to develop effective prevention, screening, and intervention strategies.

4.3. Limitations

Although this study successfully revealed global trends and hotspots in tongue cancer research through the comprehensive analysis of a large number of publications, it also has some notable limitations. One limitation is the single data source, restricted to the WOS database, which may lead to the neglect of some high-quality studies not included in the database, potentially affecting the representativeness of the research. Future studies should consider a multi-database strategy, incorporating data from other databases such as Scopus and PubMed. In addition, while keyword co-occurrence analysis can reveal research trends, it still has limitations in capturing more subtle dynamic changes. To address this, future research could introduce deep learning-based topic modeling methods to more comprehensively capture research trends and hotspots in the field of tongue cancer.

5. Conclusion

This study systematically analyzed the research achievements in the field of tongue cancer using bibliometric tools, revealing the research hotspots, key contributors, international collaboration networks, and future development trends. The analysis indicates that global attention to tongue cancer research has significantly increased over the past decade, with China, the United States, and Japan playing important roles in research output and international collaboration in this field. Through keyword co-occurrence and burst analysis, this study identified several research hotspots in the field of tongue cancer, including the application of new technologies such as artificial intelligence and deep learning in early diagnosis and prognostic evaluation, as well as the trends of younger patients and immunotherapy strategies.

In the future, tongue cancer research should place greater emphasis on interdisciplinary collaboration, integrating bioinformatics, imaging, and clinical research to further explore the pathogenesis and treatment strategies of tongue cancer. At the same time, strengthening international research collaboration and data sharing will help promote the global development of tongue cancer research and ultimately achieve the goal of improving patient survival rates and quality of life.

Conflict of Interest:

None declared.

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