

# **International Journal of Research Publication and Reviews**

Journal homepage: www.ijrpr.com ISSN 2582-7421

# **Exploring Two Decades of Research on Oral Cancer: A Comprehensive Scopus Bibliometric Exploration (1998-2024)**

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#### ABSTRACT:

Due to the increase in innumerable cases of oral cancer, the escalation in mortality rates within society is becoming more pronounced. This impact ripples through individuals, families, communities, and healthcare systems, casting a shadow. Presently, researchers are placing greater emphasis on ameliorating the prevention of tumor growth and predicting the survival time of patients. Bibliometric analysis, including the potential use of neutrosophic tools for decision making, neutrosophic numerical measures, and neutrosophic theory for machine learning to improve predictive models stands as a rigid, robust, and prevailing method for ascertaining and probing large extensive collections of organized data. It aids in the recognition of significant facets within the specific field and enables a thorough bibliometric analysis to be performed on a dataset comprising 2483 records extracted from a database spanning the period from 1998 to 2024, allowing us to arrive at better-informed decisions. Taking inspiration from prior research, we adopted this approach for our current exploration. This current investigation utilizes data gathered from Scopus spanning the years 1998 to 2024, facilitating a bibliographic analysis of 2483 records concerning oral cancer. The bibliometric results have shown the publications' tendencies, categorizations of the field, global distributions, prominent journals, and citation patterns. Additionally, the countries contributing significantly, as well as the leading authors and institutions are highlighted. Furthermore, analysis of the network map delineates the evolution of cancer survival time prediction in the past, present, and future as well. The outcomes of this research will significantly contribute to the comprehension of progress, trends, and worldwide scope of cancer survival, which will assist in recognizing primitive research and will serve as a source of supervision for future research.

Keywords-Bibliometric analysis, oral cancer, net map, citations.

# **1. INTRODUCTION**

Today's world scenario is drastically changing due to time constraints, lack of proactive health, and modernised living standards, which have led to major non-communicable diseases like cancer emerging across males and females. GLOBOCAN 2020 estimates that the loss of human life in India in 2020 is 851678 and specifically in oral cancer, there are 135 929 cases of death [1]. Approximately 54,540 new cases and 11,580 deaths are reported to be caused by oral cancer in the United States in 2023, according to the most recent estimate American Cancer Society [2]. Whereas, all types of new cancer diagnoses in the US in 2023 are projected to be 1,958,310 and deaths to be 609,820 [3]. It is estimated that approximately 90% of oral cancers worldwide are caused by tobacco use, alcohol consumption, or both [4]. Oral cancer is primarily influenced by genetic and epigenetic factors. Epigenetic patterns may be affected by several lifestyle factors, including stress, obesity, poor nutrition, physical activity, exposure to environmental toxins like Ultraviolet rays and Human papillomavirus (HPV), mastication of betel nuts, smoking, consumption of alcohol, and usage of other tobacco items [5]. Cancers that form in various parts of the mouth, such as the front of the tongue, mouth lining, inside of the cheeks and lips, the gums, in the back of the throat, and the area behind the wisdom teeth are referred to as mouth or oral cancers [4]. There are several symptoms of oral cancer, including inflammation or ulcers that do not heal and cause pain and bleeding. Earlier research reveals a predominant focus on employing methods and materials centred around early cancer detection, cancer categorization, survival prediction, including the potential use of neutrosophic tools for decision making, neutrosophic numerical measures, and neutrosophic theory for machine learning to improve predictive models [6]-[9]. As the absence of research on survival time prediction has contributed to the swift escalation in mortality rates, it remains of utmost significance to engage in oral cancer-related studies aimed at mitigating adverse effects on individuals, financial aspects, and society at large. Also, predicting survival time is an essential endeavour in the diagnosis of oral cancer because it aids clinicians in estimating the quality of a patient's life, assessing cancer risks, and guiding doctors' decisions to sidestep ineffectual treatments. This not only conserves time but also diminishes treatment expenses [10]. Integrating neutrosophic set-based heterogeneous data mining and neutrosophic statistics could offer innovative insights into handling diverse cancer datasets and predicting patient outcomes more accurately.

Augmenting the efficacy of oral cancer prevention and mitigating the potential for oral cancer advancement, it is our conviction that *neutrosophic tools for big data analytics* combined with Bibliometric analysis is the best tool to use. In recent years, a multitude of scholars have undertaken extensive bibliographic analyses in several fields of research [11]–[13]. It is the statistical analyses and quantitative method used to evaluate and measure various aspects of scientific literature and publication which includes the publication relationships, books, articles, journal impact factors, analysis of the posting trends and hotspot prediction. By analyzing bibliometric information in the specific field, researchers will gain a clearer picture of the research situation and be able to develop further in-depth research references [14]. Bibliometric analysis has become increasingly popular in various fields of

research, encompassing clinical studies of COVID-19, squamous cell carcinoma of the oral cavity, heat stroke, as well as other spheres of research [15]–[17]. Addressing our concern, the realm of cancer research is replete with innumerable scholarly articles. This presents a substantial challenge as researchers grapple with the task of categorizing noteworthy journals and papers, while also seeking suitable co-authors who contributed to the latest advancements. *Neutrosophic logic for feature learning, classification, regression, and clustering* can play a critical role in this categorization. Thus, the current investigation identifies emerging research trends and popular topics within the field. This study will highlight the areas that are of interest and attention and will make it possible to monitor how these patterns evolve. By analyzing the existing literature, bibliographic analysis can reveal areas that are under-represented or neglected in cancer research, thereby helping to identify potential research gaps.

To be precise, a bibliometric analysis of 2483 data about oral cancer from year 1998 to 2024 has been accomplished for this study. The following are the main contributions that this research has made: (1) examined the production and citation trends over different years. (2) identifying the leading nation in productivity along with the highest-performing academic establishments. (3) evaluating different origin journals and notable writers. (4) investigating the frequently utilized combinations of keywords. The subsequent sections of the paper are organized as follows: Section 2 outlines the methodologies employed in the research. Section 3 presents the outcomes of the bibliometric analysis. Subsequently, in Section 4, a comparison was conducted between the current study and prior research. Moving forward to Section 5, an in-depth discussion was carried out, followed by the presentation of conclusions, limitations, and prospects for future research in the final Section 6.

# 2. MATERIAL AND METHODS

The research methodology implemented in this study encompassed two primary phases the accumulation of data and a comprehensive bibliometric analysis of the gathered information. The initial stage involved the extraction of pertinent scientific data from a designated database. This dataset was subsequently subjected to meticulous bibliometric analysis, aimed at unveiling various dimensions inherent within the information. The collection of data was undertaken through an in-depth review of existing literature, aimed at uncovering key findings and identifying possible areas where research is lacking. This approach helped establish the parameters of the information covered [18]. Systematic reviews of literature were carried out using an iterative process that involved defining relevant search terms, reviewing existing literature, and conducting comprehensive investigations [19]. To facilitate the bibliometric analysis, specialized visualization tools were ingeniously devised in response to the surging volume of articles [18], [20]. A visual representation of the entire methodology can be observed in Figure 1. This research framework draws inspiration from a similar methodology previously employed by researchers for bibliometric analysis [21]. Guided by preceding research, we have embraced an analogous research design for our intended study.

The data collection phase was initiated on August 9, 2024, resulting in the retrieval of a substantial dataset comprising 152140 records from the Scopus database, employing keyword phrases. Following a thorough process of eliminating records, the remaining dataset consisted of 143,633 records generated from various sources such as articles, books and conferences. This dataset underwent further refinement, involving the application of filters based on subject area, document type, and specific research domains. Subsequently, a meticulous analysis led to the selection of a final dataset consisting of 2483 records, which were deemed suitable for the bibliometric analysis.

Each of the selected 2483 records underwent a comprehensive extraction process to acquire essential details such as publication titles, publication dates, abstracts, cited references, author names and affiliations, journal attributes (name, volume, page numbers, etc.), and author-provided keywords. Thereafter, a comprehensive bibliographic analysis was performed, which aimed to identify major sources, countries, affiliations, publication years, authors and significant works within the realm of oral cancer research. Additionally, an exploration of author-supplied keywords' co-occurrence was conducted to discern patterns in research growth and to propose potential future research directions.

Integral to this research was the utilization of the "Scopus" database, a freely accessible resource renowned for its comprehensive coverage. Managed by Elsevier, Scopus stands as a leading database, encompassing diverse search databases that facilitate academic and technological exploration [22]. Its extensive scope spans over 82.4 million records containing 34,346 peer-reviewed journals, multiple conference proceedings, and the selected books, making it a repository of choice for esteemed international journals [23]. The prominent scientific citation search and analytical information platform offered by Elsevier is Scopus. This multifunctional tool serves as a support for diverse scientific tasks across various knowledge domains, functioning both as a research aid and a dataset for extensive data-intensive studies. Over the preceding decades, Scopus has been harnessed in a multitude of academic studies, finding its application in thousands of published works [24]. The analysis of the various scientific documents retrieved from the Scopus database was executed through the utilization of VOSviewer, an influential bibliometric analysis tool accessible at www.VOSviewer.com. This tool was developed by van Eck and Waltman [21], [25]. Distinguished by its capacity for effective graphical representation, VOSviewer proves invaluable in visually portraying intricate data. Its proficiency in rendering complex content is pivotal for the clear visualization and interpretation of extensive information [26].



# Fig. 1 Showcases the methodology employed for collecting and analyzing data.

# 2.1 DESCRIBING THE INITIAL SEARCH RESULTS

In the study, a thorough search method involving titles, keywords, and abstracts was employed. This approach utilized the syntax: "oral" AND "cancer" OR "oral-cancer". We established limits to refine the search within the subject area for only engineering and computer science, articles from 1975 to 2024, published in the English language. Abstracts from numerous sources such as journal articles, conference papers, books, and book chapters were extracted using specific keywords and titles. Data collection pertaining to oral cancer centred largely on the Scopus database, which encompassed significant journals. Employing filters as illustrated in Figure 1, we narrowed down to 2483 pertinent records exclusively relevant to this study. The limitations and data selection process are delineated in Table 1. Drawing inspiration from a previous study [21], we have adapted a similar research design for our current work.

Table 1: The p	arametric selection of data
Data selection approach	
Search Interval	1998-2024
Terminology	Abstract, article title, and various combination of keywords
Node Type	Nation, authors, referenced publication, key terms, and citations
Search technique	Retrieval based on the subject domain
Search Keyword	"oral" AND "cancer" OR "oral-cancer"
Database	Scopus
Search result	2483 Records

# 3. FINDINGS FROM BIBLIOMETRIC ANALYSIS

The bibliometric analysis aims to explore the trends in publications, leading journals, countries, authors, and institutions through the utilization of various tools and technologies. Furthermore, it seeks to anticipate new models and methods for detecting oral cancer, utilizing the VOSviewer tool.

# **3.1 PUBLICATIONS OF ORAL CANCER**

The exploration into oral cancer detection and its associated domains commenced a quarter-century ago in 1998. The inception of this journey saw the emergence of 5 publications in 1998, followed by 22 in 2004, 46 in 2010, 99 articles in 2015, and a notable surge to 347 articles in 2022, all presented in Table 2. The initial phase displayed limited publication output. Notably, the last decade spanning from 2014 to 2024 stands out as the most prolific period, as per research findings. Building upon insights from prior studies, our proposed research adopts a similar framework. Illustrated in Figure 2, the publication count. On closer examination of the data, it becomes clear that the year 2005 comes out with the highest frequency of cited articles among all the years. This indicates that the research output of the year 2005 received a remarkably substantial amount of attention and citation activity compared to other years.

# 3.2 CITATION ANALYSIS

VOSviewer enables scholars to enrich their understanding of knowledge and emerging trends using co-citation networks [27]–[29]. Citation and cocitation are distinct measures employed in bibliometric analysis. Articles with high citation rates hold more sway within the subject compared to those with fewer citations, underscoring their greater importance in the field [30]. Citation analysis is instrumental in gauging the influence of research references. The frequency of citations reflects their significance within a particular field. Furthermore, it enables researchers to spot emerging trends and popular subjects by studying citation patterns. This understanding assists scholars in focusing on pertinent and current research domains[31].

Year wise Publication	Count of Documents	% of 2483	Year wise Publication	Count of Documents	% of 2483
1998	5	0.2%	2011	78	3.14%
1999	11	0.44%	2012	61	2.46%
2000	7	0.28%	2013	71	2.86%
2001	17	0.68%	2014	99	3.99%
2002	17	0.68%	2015	99	3.99%
2003	10	0.4%	2016	114	4.59%
2004	22	0.89%	2017	133	5.36%
2005	25	1.01%	2018	166	6.69%

 Table 2: Yearly Breakdown of Published Research on Oral Cancer

2006	25	1.01%	2019	178	7.17%
2007	32	1.29%	2020	234	9.42%
2008	43	1.73%	2021	262	10.55%
2009	40	1.61%	2022	347	13.98%
2010	46	1.85%	2023	271	10.91%



Fig. 2 The annual Publishing Patterns and the mean of total citations per year

# 3.2.1 EXPLORING HIGH-OUTPUT RESEARCH ARTICLES

Citations serve to assess the importance of publications within a designated field of research. These citations highlight the research achievements of scholars within a specific field. A local citation happens when other research papers mention a specific paper in the same field, while a global citation is the total number of times a specific paper is mentioned across all research papers and sources, showing its relevance and overall impact in the broader academic community. Figure 3 presents a compilation of the articles on oral cancer that have received the highest number of citations. Motivated by earlier studies [21], [32], we're adopting a similar methodology to conduct the bibliometric analysis.

Figure 3 illustrates that the works authored by Ivan H. El-Sayed et al. [33] are prominently cited, amassing a total of 1788 citations. The article with the second highest number of citations was penned by Yin Win et al. (TC - total citations = 1261, ACPY - average citation per year = 66.37) [34]. Subsequently, publication authored by Bhirde et al. (TC = 782, ACPY = 52.13) [35], Naidu et al. (TC = 536, ACPY = 21.44) [36], Zhang et al. (TC = 503, ACPY = 41.92) [37], Huang et al. (TC = 501, ACPY = 29.47) [38], Chenthamara et al. (TC = 442, ACPY = 88.40) [39], Butt et al. (TC = 406, ACPY = 31.23) [40], Zhang et al. (TC = 385, ACPY = 48.13 [41], Sung et al. (TC = 378, ACPY = 25.20) [42] follow in descending order of citation frequency.

# 3.2.2 TOP COUNTRIES AND CITATIONS IN ORAL CANCER RESEARCH

A total of 2,483 research publications originating from 103 different countries were carefully chosen for analysis. The nations that stand out in terms of publishing volume are outlined in Table 3. This table highlights the most productive regions, with the forefront, the United States contributing 543 publications. Following the United States, India has 510 publications, China with 492 publications, Taiwan with 208 publications, Japan with 135 publications, Italy with 117 publications, the United Kingdom with 97 publications, South Korea with 93 publications, Brazil with 81 publications, and Germany with 78 publications.

Notably, United States contributions have attracted substantial attention from scholars and carry significant influence compared to the output of other countries. It emerges as a dominant publisher of high-impact research, reflected in its notably high citation count. Consequently, within this group of prolific nations, India emerged as a research leader. To visually represent the country-wise corresponding author's productivity, refer to Figure 4. The method employed for this examination is co-authorship, with countries being the focus of the study. The approach employed is full counting, ensuring a comprehensive assessment. Out of the total of 103 countries studied, a minimum threshold of five publications was set to determine the scope of inclusion. Consequently, 52 countries met or exceeded this threshold, making them eligible for consideration in the analysis. The resulting insights provide a comprehensive overview of the distribution of corresponding author productivity across various nations, shedding light on the collaborative nature of research endeavours within and between countries.



Fig. 3 10 Most globally cited articles in oral cancer

Table 3: Most Productive Court	ntries
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Countries	TP
USA	543
India	510
China	492
Taiwan	208
Japan	135
Italy	117
United Kingdom	97
South Korea	93
Brazil	81
Germany	78

Abbreviation: TP, total publications



🙈 VOSviewer

Fig. 4 Country productivity

# **3.3 PROMINENT JOURNALS**

Presented in Table 4 is an extensive summary of key journals that contribute to the realm of oral cancer research. This compilation encompasses 609 journals that have featured studies in this domain. Among these, the top most influential journals are also highlighted. This assessment is substantiated by the works of researchers mentioned in References [32], [43], [44], [45] [21], all of whom have corroborated the same methodology.

An examination of Table 4 discloses that the journal "International Journal of Molecular Sciences", boasting an impressive h-index of 230, emerges as the most prolific contributor. This journal has an aggregate publication count of 470 and has garnered 7856 citations since its inaugural publication in 2000. Notably, the journal "Biomaterials," with an h-index of 418 and a total count of 6127 citations, secures the second position in terms of prominence. Its engagement with oral cancer research commenced in 1980. Among the leading journals in terms of publication frequency, "Biomaterials" is followed by "Journal of Biomedical Optics" with a total of 2871 citations, "Nano Letters" with a total of 2825 citations, and "ACS Nano" also with a total of 2825 citations, in sequential order. An insightful analysis of Table 4 reveals that both the "International Journal of Molecular Sciences" and "Biomaterials" amass substantial citation counts; however, it's worth noting that "Biomaterials" maintains a bit lower count of total publications as compared to the International Journal of Molecular Sciences".

	Table 4: Pro	ominent Journals		
Journals	PSY	Total Publication	Total Citation	h_index
International journal of molecular sciences	2000	470	7856	230
Biomaterials	1980	60	6127	418
Journal of Biomedical Optics	1996	78	2871	154
Nano letters	2001	9	2825	531
acs nano	2007	15	1703	448
Nanomedicine: nanotechnology, biology, and medicine	2005	29	1386	143
Biosensors and bioelectronics	1990	24	1361	222
Critical reviews in food science and nutrition	1980	15	1264	193
Nanomedicine	2006	42	1169	127
Photomedicine and laser surgery	2004	24	943	77

Abbreviations: PSY, publication starting year; h-index, hirsch index.

# 3.4 DISTINGUISHED AUTHORS AND THEIR PRODUCTIVITY THROUGH LOKTA'S LAW

During the studied period, a collective total of 6926 publications were authored, either individually or in collaboration. Author productivity in this specific field adheres to Lotka's law, as defined by researchers [46]. The most prolific authors, along with their affiliations, initial publication year, and overall publication count, are compiled in Table 5. Researchers have adopted the same methodology as referenced in [21], [32], [43], [47].

The analysis highlights Wang Y as the most prolific author, with a remarkable 51 published articles. Wang Y initiated their research contributions in the oral cancer domain in 2007. Following closely is Zhang Y, credited with 41 publications, while LI Y secures the third position with 34 publications. LIU Y and Zhang X have each authored 32 and 31 articles, respectively. Moreover, Wang J, Zhang H, Zhang L, Wang X, and Chen Z have contributed 26, 25, 24, 23, and 22 publications in that respective order. Regarding total citations, Zhang Y and Wang Y stand out with 1245 and 904 citations, respectively, followed by LI Y with 881 citations. On the other end of the spectrum, Zhang X has accrued the lowest citation count, amounting to 303, accompanied by 31 publications. To visualize the authors with the highest productivity in the realm of oral cancer, refer to Figure 5.

Author	<b>Total Publication</b>	Total Citation	PSY
Wang Y	51	904	2007
Zhang Y	41	1245	2009
LI Y	34	881	2002
LIU Y	32	449	2013
Zhang X	31	303	2008
Wang J	26	510	2011
Zhang H	25	721	2007
Zhang L	24	733	2006
Wang X	23	502	2013
Chen Z	22	678	2004

Abbreviations: PSY, publication starting year.





# **3.5 PROMINENT INSTITUTIONS**

The organizations with the most extensive research contributions to oral cancer are depicted in Figure 6. A total of 160 organizations have contributed to publications in this area. The figure below provides information about the top 10 universities, their total publications, and the corresponding percentages. The leading university, Ministry of Education China, has produced 71 publications (2.86% of the total). Following at a distance is the National Taiwan University and China Medical University with 41 publications (1.65%), Chinese Academy of Sciences with 36 publications (1.45%), Sichuan University and Chang-Gung Memorial Hospital with 29 publications (1.17%), and subsequently, in order, National University of Singapore, University of Texas MD Anderson Cancer Center, The University of Texas at Austin, and Wuhan University, each with 27 publications (1.09%). This data collectively highlights the significant contributions of various organizations to the research landscape of oral cancer.



Fig. 6 Highly productive organizations in oral cancer research

# 3.6 RESEARCH AREA

Oral cancer manifests in the world, captivating the attention of researchers who delve into its progression, underlying causes, and associated concerns. Table 6 showcases the primary domains investigated in oral cancer research, with a focus on 1868 research articles published in the field of Engineering by diverse authors. Engineering takes the lead, followed at a distance by Computer Science with 1117 articles (12.9%), Biochemistry, Genetics, and Molecular Biology with 1056 articles (12.2%), Chemical Engineering with 1006 articles (11.7%), Material Science with 914 articles (10.6%), Chemistry with 741 articles (8.6%), Medicine with 594 articles (6.9%), Physics and Astronomy with 443 articles (5.1%), Pharmacology, Toxicology, and Pharmaceutics with 216 articles (2.5%), and Mathematics with 209 articles (2.4%). The same research approach has been previously utilized in References 44 and 69.

Table 6: Top 10 research areas in oral cancer		
Research areas	TP	% (TP)
Engineering	1868	21.6%
Computer science	1117	12.9%
Biochemistry, Genetics and Molecular Biology	1056	12.2%
Chemical Engineering	1006	11.7%
Material Science	914	10.6%
Chemistry	741	8.6%
Medicine	594	6.9%
Physics and Astronomy	443	5.1%
Pharmacology, Toxicology and Pharmaceutics	216	2.5%
Mathematics	209	2.4%

Abbreviation: TP, total publication.

# 3.7 KEYWORD ANALYSIS

Keyword mining is the extraction and identification of important keywords from text to reveal patterns and concepts. It's used in fields like information retrieval and text analysis to understand the main themes in documents. Numerous research studies have explored the utilization of author keywords as a metric to gauge the progression of topics [45], [48],[49]. Author keywords essentially distil and condense the paper's content. In Table 7, you will find a compilation of the top words that authors frequently employ as keywords. Moreover, the most commonly utilized term in paper titles and abstracts. Particularly exceptional keywords can captivate the attention of researchers in specific fields [21]. Validation of the same research design is evident in References [32], [45], [47]. Drawing inspiration from prior works, we have employed the same research methodology for our bibliometric analysis.

A closer examination of Table 7 reveals that words like "Human," "Article", "Diseases", "Male", "female" and so on highlight the prominence of the titles of the paper, their abstract, and most commonly employed keywords. These recurring terms offer insights into the distinctive characteristics of certain fields and platforms. These high-frequency terms reflect the characteristics of research areas, with the exploration of individual differences' mechanisms emerging as notable research subjects within theory-oriented oral cancer studies in the previous timeframe.

	rable /: The most frequently	used words in the author's keywords, paper lives a	nd adstract
Words	Occurrences	Words	Occurrences
Human	1283	Human Cell	389
Article	1032	Apoptosis	382
Diseases	861	Oral Cancer	355
Male	647	Tumors	343
Female	623	Cell Line Tumor	314
Nonhuman	592	Animal Model	310
Animals	535	Squamous Cell Carcinoma	306
Metabolism	488	Diagnosis	257
Mouth Neoplasms	467	Mouth Squamous Cell Carcinoma	210
Pathology	456	Cell Survival	204
Cell Proliferation	429	Gene Expression	147
Mouth Tumor	393	Oral Squamous Cell Carcinomata	124

Table 7: The most frequently used words in the author's keywords, paper titles and abstract

# 3.8 EXPLORING RELATIONSHIPS WITH NET-MAP ANALYSIS

In the present analysis, it is demonstrated that a multitude of scholars utilize keyword extraction as a method to analyze the progression of the subject area. The utilization of the keyword abstraction was employed to comprehend the field's [50]. The VOSViewer software was used to create records that show how often keywords appear together. Co-occurrence refers to when two keywords are used in the same article. A spectrum of colours was applied to denote these keywords within the network. Clusters with similar items delineated shared topics. The most prominent node within each cluster was determined by the common keywords among clusters [51]. The variation in cluster colours signifies the insights gained from the study. Figure 7 showcases the interrelation of author-supplied keywords through an average network diagram created using VOSviewer. This research design has been previously adopted by scholars as referenced in [21], [45], [52], [53]. The minimum required keyword occurrences for inclusion in the diagram were set at 50. The analysis encompasses 205 keywords surpassing this threshold, organized into four clusters, with a total network strength of 24,040. Figure 8 illustrates the arrangement of keyword items across four main nodes—human, controlled study, nonhuman, and tumor.



Fig. 7 Net-Map overlay visualization of keyword co-occurrence Network



Fig. 8 Net-Map diagram of keyword network visualization

The most significant node in the cluster is 'human,' representing the key subject in the initial stages of investigating tumor detection among humans. Various experts in oral cancer research collaborated across different domains during the initial research phase. The overarching objective of oral cancer research is to mitigate the disease's impact by focusing on a combination of prevention, early detection, effective treatment, and improved patient support [10]. This effort is a vital component of initiatives aimed at advancing public health and well-being. The use of net-map analysis additionally

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presents the insights obtained during the early stage, which the researchers subsequently applied in the field of oral cancer prediction. A primary cluster featuring the key node 'human', evidenced by multiple words such as human, disease, non-human, animal, metabolism, and oral neoplasm, exhibits these associations. In this context, the presence of the word 'disease' underscores fears about increased mortality due to inadequate cancer detection.

Throughout history, oral cancer has had a significant impact on the global population. From ancient civilizations to the present day, this disease has posed a serious threat to human health. Its effects are evident in the physical and emotional pain experienced by individuals, families, and communities, as well as the strain it places on healthcare systems [54]. In earlier times, limited medical knowledge and access to advanced treatments often resulted in late-stage diagnoses and unfavourable outcomes for patients having cancer. The toll of the disease, which can impede speech, eating, and facial appearance, has caused widespread suffering [55]. Fortunately, advancements in medicine heightened awareness, and improved diagnostic and treatment choices have helped alleviate some of the challenges posed by oral cancer. Nevertheless, the historical suffering and loss associated with the disease act as a cue to the ongoing significance of early detection, prevention, and ongoing research aimed at minimizing its impact on people and societies around the world [56]. As the incidence of cancer has risen, researchers have concurrently introduced a variety of cancer detection models and applications. This is evidenced by the clustering of relevant terms in Figure 8, where keywords such as network, algorithm, node, and performance are prominent. The study of keyword trends in 'diagnosis' primarily revolves around areas like cancer detection models, medical imaging, diagnostic imaging, machine learning, and deep learning models. This trend has motivated researchers to amplify their efforts by integrating complex network analysis with oral cancer detection and prognosis prediction capabilities. A notable instance of this integration is the formulation of a model aimed at early detection and overall survival prediction in small-world systems, as explored in various studies.

Initial research into oral cancer predominantly involved the application of epidemic theory and network analysis, paving the way for subsequent multidisciplinary investigations. Following that, machine learning and deep learning methods were incorporated into different models for oral cancer detection to evaluate their efficacy [56]–[61]. As the researchers delved deeper into their analyses, they were motivated by the prospect of saving lives through their contributions. The network map served as a starting point, providing a glimpse into the potential future of oral cancer research. It served as a reminder that every breakthrough, every revelation, and every connection established had the power to reshape the narrative surrounding oral cancer—from one of devastation to one of optimism. Thus, armed with insights from the network map analysis, scientists embarked on a journey that fused knowledge, empathy, and innovation to overcome the silent adversary, oral cancer [18].

Figure 8 also illustrates that an increase in the number of models led researchers to conduct more experiments aimed at addressing oral cancer detection challenges. This insight is reflected in the cluster labelled 'controlled study.' This cluster encompasses key terms such as proliferation, metabolism, pathology, mouth neoplasm, and carcinoma. Researchers have explored various features, datasets, and techniques to tackle the complexities of early oral cancer detection. Furthermore, Figure 8 unveils a trend where the growth of research in oral cancer models is paralleled by an expanding presence in the field of chemistry, evident in the cluster associated with the keyword 'electron microscopy. This cluster includes keywords like biochemistry, drug carriers, oral bioavailability, mammals, and scanning electron microscopy. Chemistry's significance in oral cancer spans diverse areas, ranging from comprehending the disease at a molecular level to formulating effective treatments. This molecular understanding empowers medical professionals to engage in meaningful consultations with patients and peers on various healthcare inquiries [62].

Over time, there has been notable advancement in cancer research focusing on the oral region. The progression of research in cancer demonstrates a steady rise in the number of cases documented each year. For instance, studies indicate a yearly estimate of 1,958,310 individuals actively battling cancer. This translates to a daily increase of 5370 new cases [3]. The analysis of keywords mentioned above highlights the substantial enhancements achieved in the realm of oral cancer detection. Researchers employ diverse explanations to elucidate terminologies associated with the detection of oral cancer.

# 4. COMPARING THE PROPOSED STUDY WITH PREVIOUS RESEARCH

The outcomes of the proposed study demonstrate an amplified outcome in comparison to prior research efforts. This current study meticulously investigated and examined 2483 bibliometric records, a notable increase compared to the earlier study which analyzed 788 records [63], and a separate analysis of 663 records about bibliometric insights on oral cancer and its related terminologies [18]. Another point of distinction arises from the software employed for analysis. In this study, the analysis of data was conducted using the VOSviewer software. Unlike many prevalent tools for assessing bibliometric evaluation, the used software in this study offers an enhanced visual representation of the data. While navigating the interface of CiteSpace may seem a bit daunting, requiring a learning curve for new users, VOSviewer stands out by offering the visualization of network analysis of the bibliometric tools for data visualization are becoming increasingly relevant in facilitating decision-making processes and visualizing complex datasets within oral cancer research. Importantly, the current study introduces Net-Map analysis, an aspect absent in earlier research [18], [64]–[66]. Through Net-Map analysis, the study showcases the occurrence of keywords and the evolution of the domain by investigating a range of diverse keywords. This contributes significantly to the depth of insight provided by the study.

# 5. DISCUSSION

Oral cancer and its deadly effects affect the society. The inadequate ability to precisely forecast oral cancer and its survival motivates numerous researchers to examine the negative outcomes. The present study intends to conduct a bibliographic analysis of 2483 datasets, which collectively portray different facets of ongoing research. The data was sourced from the Scopus database. While the research initially progressed slowly, a notable exponential growth was observed from 2010 until 2024. This advancement was underpinned by collaborative efforts from 103 countries. Leading the pack was the USA, contributing the highest number of published articles, which garnered significant citations in related works. Publications from India and China also received periodic citations.

Several journals made substantial contributions in this realm. Particularly, the journal "International Journal of Molecular Sciences" emerged as the foremost publication with 470 articles and a total of 7856 citations in this field. A notable author, Wang Y, authored 51 publications with 904 citations. Among academic institutions, the Ministry of Education China System displayed the highest prolificacy in oral cancer research. Certainly, oral cancer might be more prevalent in certain countries mentioned earlier, underscoring the potential significance of prioritizing oral cancer research within institutional and governmental spheres (19).

The findings concerning publications, along with citations, significant authors, and various related aspects in the domain of oral cancer highlight the progress made in the field and underscore the contributions of various factors. Utilizing Net-Map visualization, users can identify the most frequently employed keywords in titles, abstracts, and documents, as well as relationships between them. Terms such as "human," "pathology," "disease," and "mouth neoplasms" have consistently dominated the discourse over time. The findings above indicate that the exploration of oral cancer is a recent focus, and the subject holds relevance for researchers. Furthermore, there remains ample opportunity for further investigation into oral cancer. Numerous techniques could be employed to enhance the reliability of cancer prediction models.

# 6. CONCLUSIONS, LIMITATIONS, AND FUTURE RESEARCH

There is still more work to be done to prevent the losses imposed by the deadly oral cancer disease, such as losses related to Physical, personal, and financial situations. This study outlines the research trends observed during the last decade. Utilizing the software named VOSviewer, a thorough bibliometric analysis was performed on a dataset comprising 2483 records extracted from a database spanning the period from 1998 to 2024. This analysis included an examination of year-wise published and cited trends, highlighting the most prolific countries and institutions, analysis of source journals, recognition of primary contributing authors, and examination of keyword frequency. In conclusion, this study offers comprehensive insights into the queries outlined in the first section.

Over the years, there has been a steady rise in the annual volume of articles centred around oral cancer. The United States stands out as the foremost contributor in terms of published papers, thereby playing a pivotal role in advancing research related to oral cancer. The study sheds light on various countries, journals, authors, and organizations, thereby offering valuable insights to researchers. Notably, the field of computer science emerges as a highly prolific field for its extensive publications and ongoing research , particularly in areas like *neutrosophic theory in bioinformatics and medical analytics*. There has been a gradual emergence of significant themes in oral cancer detection over time following the evolution of relevant theories, methodologies, applied tools and techniques. The terminology employed in this context serves as a valuable resource for research scholars, aiding their comprehension of oral cancer detection and prediction concepts, and ultimately facilitating further advancements in this domain.

The outcomes discussed within the analysis are subject to several limitations. Firstly, the data compilation is drawn exclusively from Scopus, potentially overlooking numerous studies on oral cancer detection published in other journals that aren't included in Scopus. Secondly, the study has considered probable keywords and relevant research domains for oral cancer detection, but there remains a chance of inadvertently excluding associated keywords, introducing the potential for sampling errors in the gathered oral cancer publications. Thirdly, the study employs keywords that can sometimes lead to overlapping explanations and approaches when defining oral cancer. Fourthly, the present study offers a snapshot of currently accessible data concerning oral cancer. However, given the ongoing evolution of research within this domain, the information concerning diverse publications, significant research outcomes, author contributions, prominent journals, institutions, and countries may undergo modifications as time progresses.

In order to enhance the comprehensive understanding of this field, future bibliometric analyses could encompass a wider array of journals and databases like PubMed, Google Scholar, WOS, ScienceDirect etc. Additionally, refining results could be achieved through comparative examinations of diverse terms like "oral" and "survival," "survival time" and "oral cancer framework," with separate analyses conducted for each term. Existing literature demonstrates that the methods and materials used predominantly pertain to cancer presence detection, cancer categorization, and the evaluation of machine learning techniques [5]. Thus, the strategic placement of oral cancer within these efforts becomes crucial for its diagnosis. Interestingly, this particular aspect has been overlooked by some scholars, despite its utmost significance for predicting and treating cancer patients. Hence, forthcoming research endeavours could focus on the application of a variety of machine-learning methods tailored to the comprehensive analysis of distinct stages in the progression of oral cancer. These could incorporate *neutrosophic theory for machine learning and deep learning* [67]. Further research might also explore the analysis of co-citations for terms that lie outside the scope of this study. Scholars could also utilize structural indicators as tools for revealing the interconnections existing among authors, their publications, countries, institutions, and journals.

Analysis of the current research provides valuable assistance to scholars in several ways. This bibliometric investigation enables researchers to identify the most commonly utilized keywords for esteemed authors, articles, journals, and countries, along with various other pertinent aspects within this domain. The utilization of Net-Map analysis aids scholars in comprehending the past, present, and prospective evolution of oral cancer detection, which may benefit from *applications of neutrosophic theory in large-scale healthcare data*.

# LIMITATION AND PROSPECT

The research was grounded in utilizing Scopus-indexed publications to ensure the acquisition of dependable and impartial outcomes. Nevertheless, due to the constraint of solely considering English-language research and the dynamic nature of the Scopus database with continuous updates, minor disparities between our findings and the current results could arise. To attain more all-encompassing findings, future investigations could contemplate incorporating various databases such as Medline, Google Scholar, or Web of Science for a more thorough analysis.

#### **DECLARATION OF POTENTIAL CONFLICTS**

The authors have no conflicts of interest to disclose.

# AVAILABILITY OF RESEARCH DATA

The data for this bibliometric analysis was sourced from the Scopus database spanning the years 1998 to 2024.

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