Mapping the research on the application of artificial intelligence in cancer: a scientometric analysis

Background: Today, despite the progress of science in healthcare, cancer is still one of the main causes of death worldwide. Artificial intelligence (AI) has emerged as a technology to tackle some of the biggest challenges in cancer research and treatment, and researchers have completed numerous studies in this area. Therefore, the current study analyzed scientific research in the field of artificial intellige nce and cancer using scientometric tools.

Methods: This descriptive study utilized scientometrics techniques and focused on analyzing scientific publications related to using AI in cancer that were indexed in the Web of Science Core Collection (WoSCC) database. until April 23, 2023. To analyze the data, the Babblemetrix package was used in the R software.

Results: A total of 8098 related documents were retrieved, and the USA, China, and Germany had the most publications. The words "Classification," "Cancer," and "Diagnosis" were the most important keywords of the authors in the scientific publications. Pathology and Diagnosis were the primary topics in the field of AI and cancer. Moreover, Cancer, Survival, and Computer-aided detection have received more attention from researchers in recent years.

Conclusion: The findings of the study suggest that AI has enormous potential to revolutionize cancer research and treatment, and pave the way for more effective and personalized therapies. The results of this study can be useful for research policy-makers and researchers to determine the priorities and research decisions in this field.

Keywords: Artificial Intelligence, Cancer, Scientific publications, Scientometric.

Background

Cancer is a complex and heterogeneous disease that poses significant challenges to researchers, clinicians, and patients. Despite advances in treatment, cancer remains one of the leading causes of mortality worldwide (1). In recent years, due to the advancement of information technology, there has been a significant improvement in the process of diagnosing cancer (2). Accordingly, the high potential of artificial intelligence technology can be an effective help in this field (3). Artificial intelligence (AI) is a research field where computers are used to imitate human intelligence (4). Simply put, AI refers to a machine's capacity to learn and identify patterns and connections from sufficient examples and apply this knowledge efficiently to make decisions on unfamiliar data. AI is a broad concept that includes machine learning and deep learning. In general, machine learning falls under AI, and deep learning is a specific area within machine learning that concentrates on intricate artificial neural networks (5). AI has emerged as a promising technology for tackling some of the biggest challenges in cancer research and treatment (6). AI refers to technologies that enable machines to learn from data and make decisions based on patterns and algorithms (7).

In cancer research and treatment, AI can help analyze vast amounts of patient data such as medical images, genetic information, and electronic health records to identify new insights into the disease (8, 9). Overall, AI has the potential to transform cancer care, improving patient outcomes and reducing healthcare costs. In recent years, there has been a significant increase in research on AI in cancer, covering various topics such as imaging, genomics, and clinical decision support systems. Scientometric can play a crucial role in understanding the impact of AI on cancer research and patient outcomes.

Scientometric is the study of scientific output, including publications and citations, and their impact on the scientific community. By analyzing trends in scientific publications related to AI in cancer research, scientometric research can identify key areas of innovation and collaboration, as well as the most influential researchers and institutions in the field (10, 11). Therefore, scientometric studies have emerged to analyze the trends and patterns of AI research in cancer.

One such study by Zhang et al. (2022) analyzed the scientific publications related to AI in Breast Cancer research from 2000 to 2021, using the Web of Science database. They found that the number of publications had increased rapidly in recent years. The top countries in terms of publications were the United States and China. Mem Sloan Kettering Canc Ctr, Radboud Univ Nijmegen, Peking Univ, Sichuan Univ, ScreenPoint Med BV, Lund Univ, Duke Univ, Univ Chicago, Harvard Med Sch, and Univ Texas MD Anderson Canc Ctr were the leading institutions in the field of AI in breast cancer. AI, breast cancer and classification, and mammography were the leading keywords. A total of five primary clusters were found within the network of fifty topics, including radiology features, lymph node diagnosis and model, pathological tissue and image, dataset classification and machine learning, gene expression, and survival (12).

Another study by Shen et al. (2022) analyzed the scientific literature on AI and prostate cancer over 22 years, using the Web of Science database. They identified three cluster research topics, including “Diagnosis and Prediction AI-related study”, “Non-surgery AI-related study”, and “Surgery AI-related study” (13). In this field, Other scientometrics studies have been conducted, including artificial intelligence-based tumor pathology (14), lung cancer (6), and cancer pain (15), which shows the importance of research in these fields.

Therefore, the study aimed to provide mapping scientific publications, and mapping scientific collaborations related to this topic. Ultimately, the goal is to inform and guide researchers, practitioners, policymakers, and stakeholders in making informed decisions and advancing to utilize of AI in cancer.

Methodology

This descriptive study utilized scientometrics techniques and focused on analyzing scientific publications related to using AI in cancer that were indexed in the Web of Science Core Collection (WoSCC) database. The Web of Science (WoS) is globally recognized as the premier citation indexing database for its credibility and extensive usage across academic fields. Since its inception in 1900, the Web of Science has established itself as the foremost citation database globally, renowned for its prestige, widespread usage, and longevity. In comparison to other databases, it offers unparalleled cited reference indexing and provides a vast array of valuable and comprehensive documents for download across numerous scientific disciplines (16).

Many studies have utilized this database for conducting scientometric and bibliometric analyses (17, 18).

The search strategy was conducted using the Mesh keywords on 23 April 2023. The search strategy is as follows.

1)

TS=("Artificial Intelligence") OR TS=("Computational Intelligence") OR TS=("Machine Intelligence") OR TS=("Computer Reasoning") OR TS=("Computer Vision Systems") OR TS=("Computer Vision System")

2)

((TS=("Knowledge Acquisition") OR TS=("Computational Intelligence") OR TS=("Knowledge Representation") OR TS=("Knowledge Representations") OR TS=(AI)) AND WC=(Computer Science, Artificial Intelligence))

3)

TS=(Tumor) OR TS=(Neoplasm) OR TS=(Tumors) OR TS=(Neoplasia) OR TS=(Neoplasias) OR TS=(Cancer) OR TS=(Cancers) OR TS=(Malignant Neoplasm) OR TS=(Malignancy) OR TS=(Malignancies) OR TS=("Malignant Neoplasms") OR TS=("Benign Neoplasms") OR TS=("Benign Neoplasm")

4)

(#1 OR #2) AND #3

To analyze the collected data, the researchers employed Biblioshiny, a graphical interface tool based on the Bibliometrix package in R programming language. This tool allowed for visualizing information related to scientific productions and publications in various categories such as nations and regions, journals, authors, articles, keywords, and research institutes (19-21). Additionally, the researchers used Keywords Plus to draw conceptual maps in each publication and generate thematic maps. It is worth noting that Keywords Plus is associated with Thomson Reuters editorial experts who utilize a semi-automated algorithm to capture an article's content with greater depth and variety (22). Overall, the study was structured into three main parts: data collection, data analysis and visualization, and interpretation.

Results

According to data extracted from the WoSCC database, there were a total of 8098 scientific publications related to AI in Cancer. Figure (1) demonstrates the yearly pattern of these publications ranging from 1983 up until April 23th, 2023.

According to the data in Figure 1, the scientific publications on AI in cancer have grown a lot in recent years and since 2017, and it is shown that the most significant number of articles were published in 2021. Furthermore, it is noteworthy that the analyzed scientific publications in 2022 were until 23 April 2023.

Figure 2 demonstrates ten of the most important sources of scientific publications of AI in the cancer subject area and indicates that the Cancers, Frontiers in Oncology, and Diagnostics journals with 267, 232, and 163 documents, respectively, have the highest amount of scientific publications in this scientific field.

Figure 3 shows the distribution map of the amount of publications of AI in cancer in the world, according to this, the countries of the USA, China, and Germany have the highest amount of publications.

Moreover, Figure (4) shows the scientific collaboration of participating countries in the AI in cancer.

Figure 5 indicates the word cloud of 1000 most important keywords of scientific publications in the AI in cancer subject area, which suggests that the words "Classification," "Cancer," and "Diagnosis" are the most important keywords of scientific publications on AI in cancer.

Figure 6 indicates the strategic diagram of the thematic map to demonstrate the significance and development of research topics. Moreover, it shows the thematic map based on density (y-axis) and centrality (x-axis). The centrality measures the importance of the selected theme, and density measures the development of the chosen theme.

In Figure 6, the upper-right quadrant shows the motor themes. They are characterized by both high centrality and density. "Cancer," "classification," and "diagnosis" are the more developed and essential in AI in cancer subject area. In the upper left quadrant, the niche themes are observed, which are peripheral and specific topics for the research field. "Computer-aided detection," "Collorectal-cancer," "Colonoscopy", "melanoma," "Algorithms," and "Skin-cancer" are in this quadrant. The basic themes are demonstrated in the lower right quadrant. These are basic, general, and transversal themes in the research field. "System," "Risk," and "Validation" and "Survival," "Radiomics," "Lung-cancer" keywords are basic themes in the AI in the cancer subject area. Finally, there are emerging, or declining themes in the lower left quadrant. "Identification," "Expression," and "Therapy" are in this quadrant.

Moreover, Figure 7 demonstrates the thematic evolution trends in the scientific publications of the AI in cancer subject area over time in five time periods 1983-1995, 1996-2000, 2001-2010, 2011-2021, and 2022-2023.

Figure 7 demonstrates the growth and evolution of topics in the fields of AI and cancer. The data presented in Figure 7 indicates that Pathology and Diagnosis were the primary topics in the field of AI and cancer. Moreover, Cancer, Survival, and Computer-aided detection have received more attention from researchers in recent years.

Discussion and conclusion

The study has revealed scientific output and research related to artificial intelligence in cancer. Specifically, since 2017, the field has experienced considerable growth, underscoring its significance among researchers in recent times. Most of the scientific publications in this realm have surfaced in medical journals, especially those pertaining to cancer, as well as computer journals, signaling the interdisciplinary nature of artificial intelligence in cancer. Furthermore, the importance of the artificial intelligence field in cancer has been demonstrated among researchers in various scientific fields. In general, past studies have also shown that the growth of research in the field of AI and medicine has increased significantly in recent years (11, 21, 24). Also, in this field, Shen et al. 2022 have shown that scientific productions in the field of artificial intelligence-based tumor pathology have been increasing and most publications have been from 2016 onwards (14).

The results of the thematic map have shown the existing topics in scientific publications on the AI in cancer subject area. Accordingly, the topics “Cancer," "classification," and "diagnosis" are the more developed and essential in AI in the cancer subject area. “Computer-aided detection,” “Collorectal-cancer,” “Colonoscopy”, “melanoma,” “Algorithms,” and “Skin-cancer” are peripheral and specific topics. Moreover, the topics "System," "Risk," and "Validation" and "Survival," "Radiomics," "Lung-cancer" keywords are basic themes in the AI in cancer subject area. In addition, "Identification," "Expression," and "Therapy" are emerging, or declining themes. Cancer classification involves identifying the type and stage of cancer, as well as determining its molecular and genetic characteristics. This information is critical for developing personalized treatment plans for patients. AI can help with this task by analyzing large datasets and detecting patterns that are not easily discernible by humans. For example, machine learning algorithms can be trained to recognize specific biomarkers or genetic mutations associated with certain types of cancer (24-27). While cancer classification and diagnosis are certainly important areas of focus for AI in cancer research and treatment, there are also more specific topics that can benefit from computer-aided detection and algorithms. One such topic is colorectal cancer and colonoscopy. Colonoscopy is the most effective method for detecting and preventing colorectal cancer, but it relies on visual inspection by a clinician, which can be time-consuming and subject to human error (28). Computer-aided detection (CAD) systems can assist with this task by analyzing colonoscopy images and identifying potentially cancerous lesions (29). Similarly, AI can also aid in the detection of skin cancer, particularly melanoma. Melanoma is a particularly dangerous form of skin cancer that can spread quickly if not caught early. Dermatologists can use CAD systems to analyze images of suspicious moles and lesions, flagging those that require further examination. These systems can also assist with tracking changes in mole appearance over time, helping to identify potential cases of melanoma before they become advanced (30).

Also, the results of the study demonstrated the use of AI in cancer research and treatment has generated a lot of interest in several basic themes, including systems, risk assessment, validation, and survival, radiomics, and lung cancer. These basic themes represent important areas of focus for AI in cancer research and treatment. By leveraging the power of AI, researchers and clinicians can improve our ability to detect and treat cancer, ultimately leading to better outcomes for patients.

In the field of AI in cancer research, the themes of "Identification," "Expression," and "Therapy" have played pivotal roles in advancing our understanding of the disease. However, these themes

are now experiencing a shift in prominence as other themes emerge as more relevant. For example, the theme of "Validation" has gained importance due to the need for rigorous validation of AI algorithms used in cancer diagnosis and treatment. Similarly, the theme of "Survival" is becoming increasingly important as researchers explore the use of AI in predicting patient outcomes and developing personalized treatments. The theme of "Radiomics" is also gaining traction, as researchers leverage machine learning algorithms to extract quantitative features from medical images and use them to predict treatment response (31). While the themes of "Identification," "Expression," and "Therapy" continue to be essential components of cancer research, their relative importance in the context of AI is evolving. As such, researchers must adapt their approaches and prioritize emerging themes to ensure that AI technology is effectively utilized to improve cancer diagnosis and treatment. Overall, the findings of the study suggest that AI has enormous potential to revolutionize cancer research and treatments and pave the way for more effective and personalized therapies.

Future investigations should delve into diverse cancer types and their associated scientific subdisciplines. By broadening the scope of inquiry, a more comprehensive understanding of cancer and its complexities can be attained. One of the limitations of this study is focusing on the publications of a scientific database, which may have ignored the scientific publications indexed in other scientific databases. Nevertheless, given the selection of the Web of Science (WOS), renowned for its inclusion of significant and credible publications, this limitation is partially mitigated.

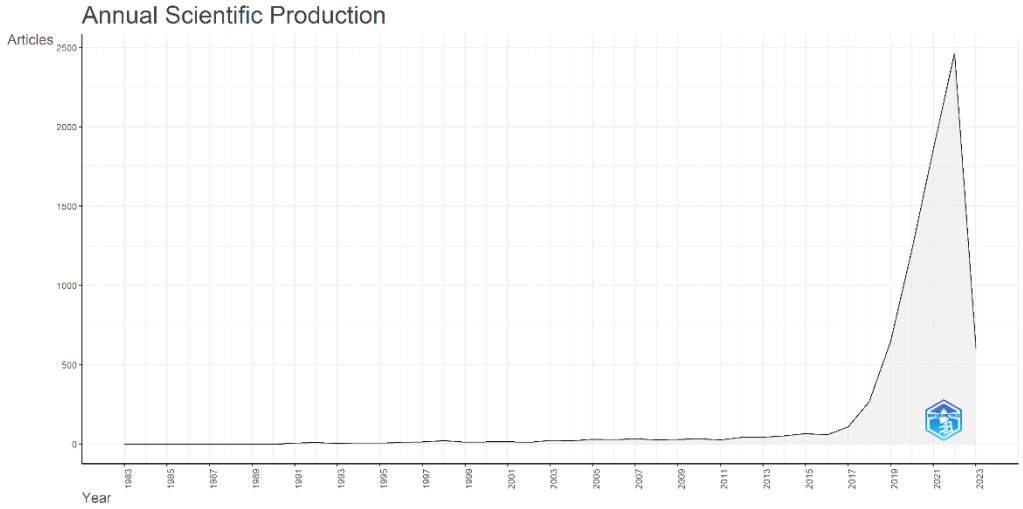

Figure 1: The yearly pattern of these publications ranging from 1983 up until April 23th, 2023.

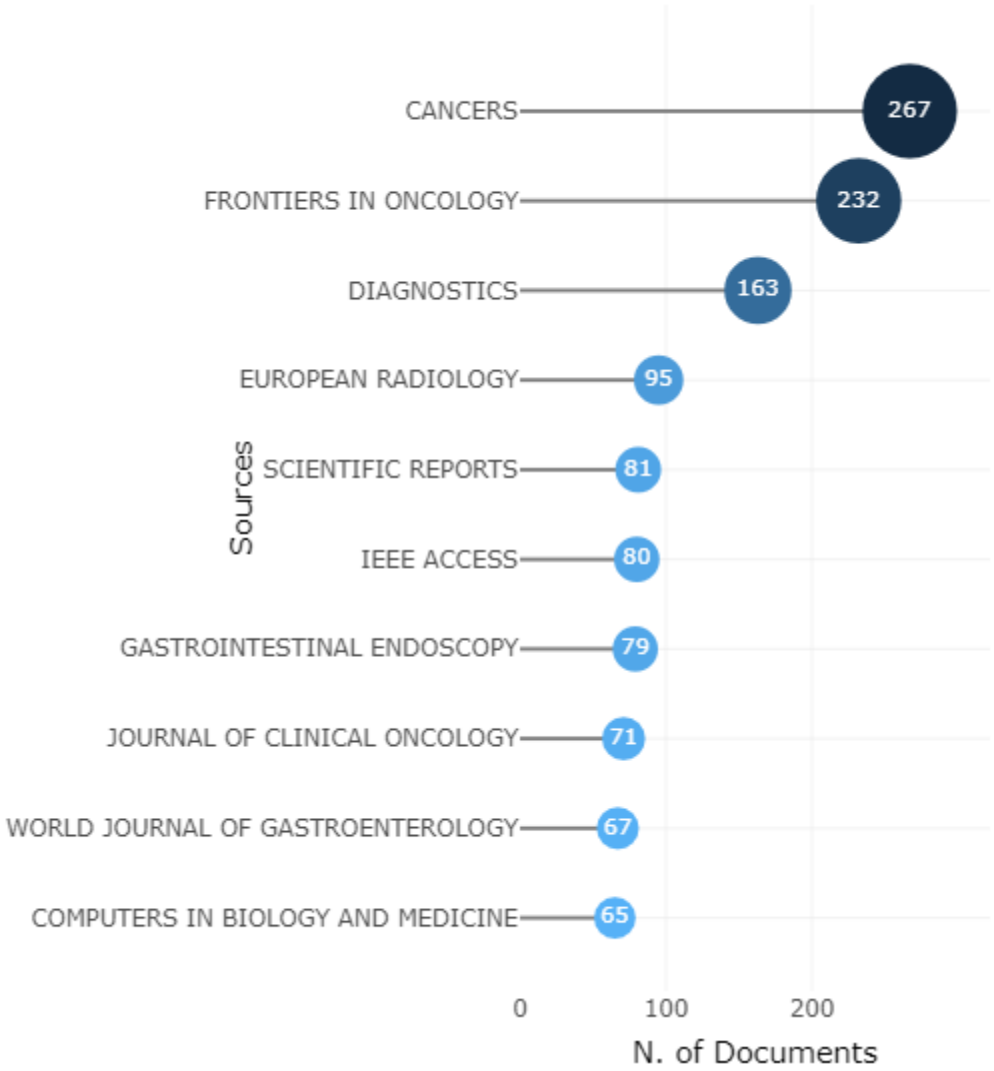

Figure 2: Ten of the most important sources of scientific publications of AI in the cancer subject area

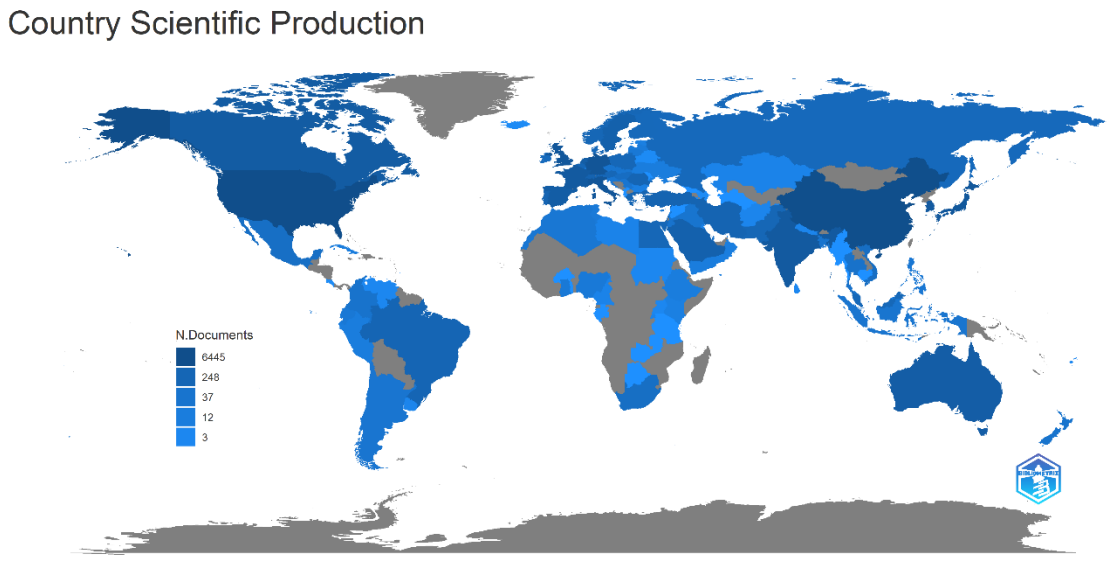

Figure 3: The distribution map of the amount of publications of AI in cancer in the world.

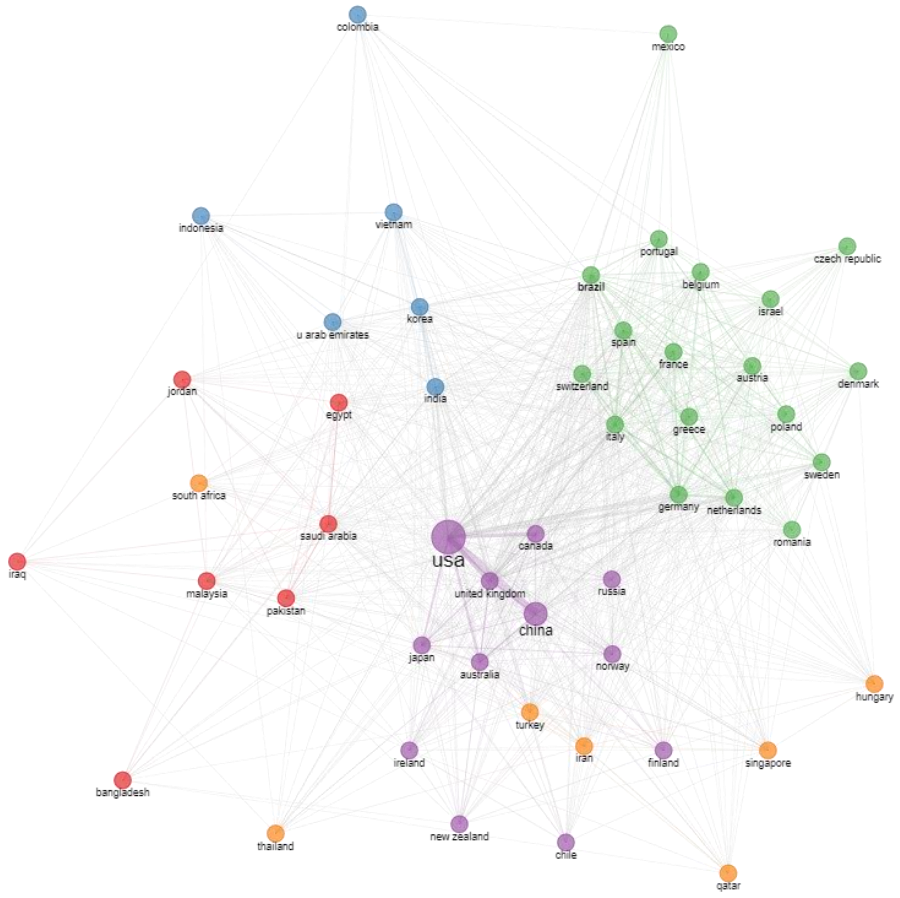

Figure 4: The scientific collaboration of participating countries in the AI in cancer.

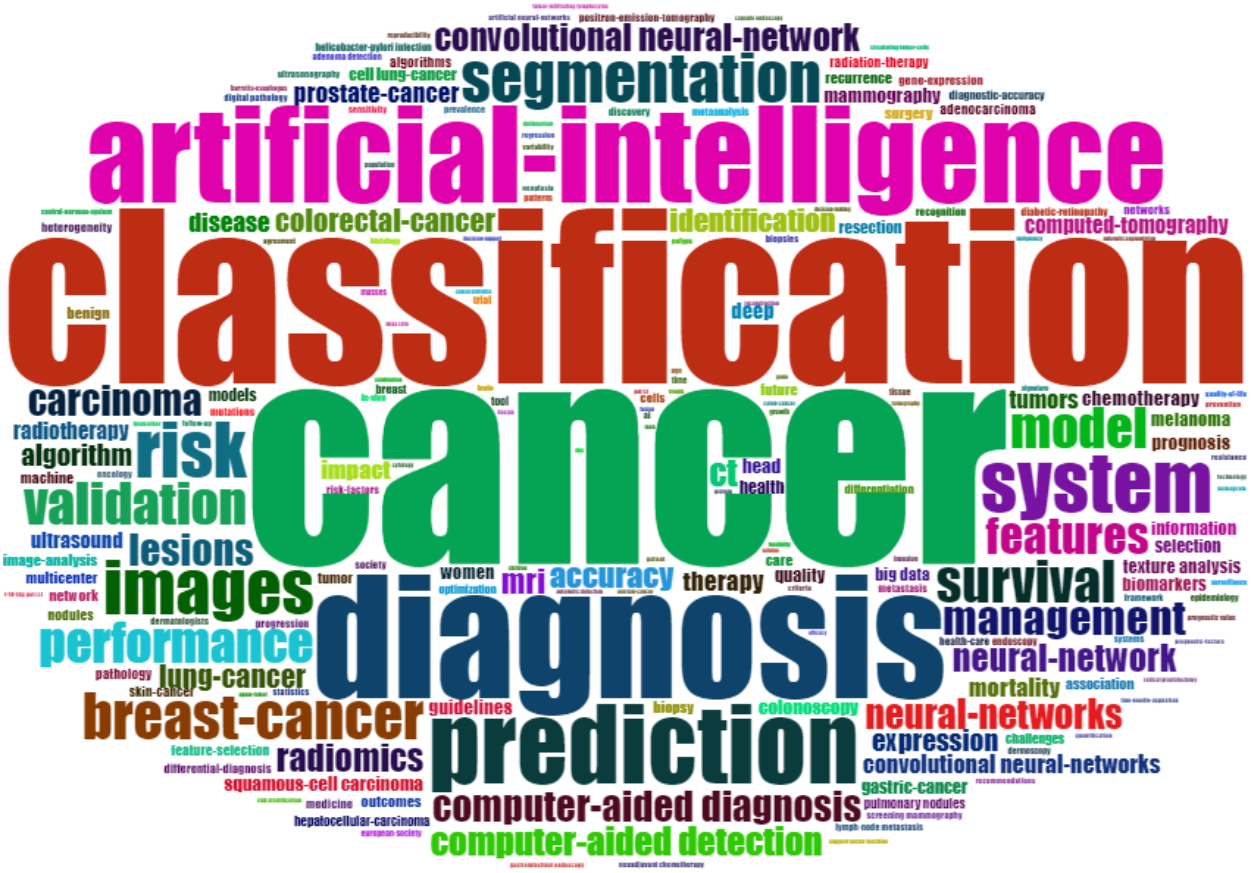

Figure 5: The word cloud of 1000 most important keywords of scientific publications in the AI in cancer subject area.

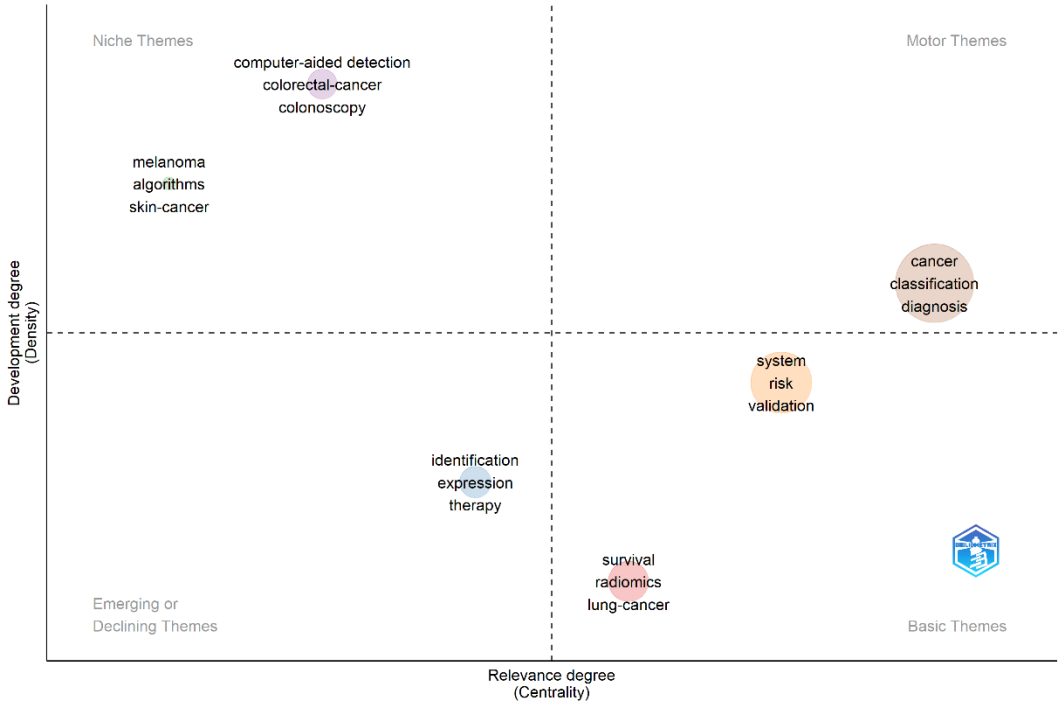

Figure 6: The strategic diagram of the thematic map

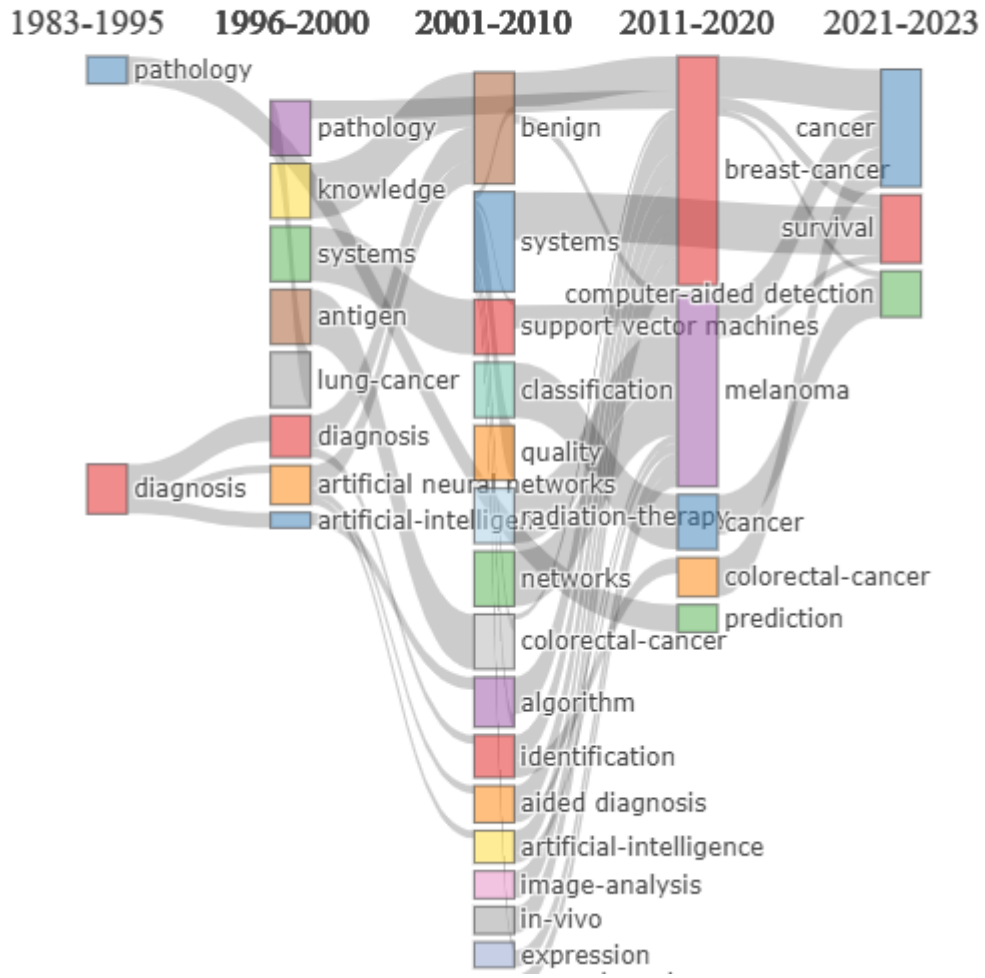

Figure 7: The thematical evolution trends in the scientific publications of the AI in cancer subject area over time in five time periods 1983-1995, 1996-2000, 2001-2010, 2011-2021, and 2022-2023.

References:

1. Mattiuzzi C, Lippi G. Current cancer epidemiology. Journal of epidemiology and global health. 2019;9(4):217.

2. Simmons CP, McMillan DC, McWilliams K, Sande TA, Fearon KC, Tuck S, Fallon MT, Laird BJ. Prognostic tools in patients with advanced cancer: a systematic review. Journal of pain and symptom management. 2017 May 1;53(5):962-70.

3. Huang S, Yang J, Fong S, Zhao Q. Artificial intelligence in cancer diagnosis and prognosis: Opportunities and challenges. Cancer letters. 2020; 471:61-71.

4. Xu Y, Liu X, Cao X, Huang C, Liu E, Qian S, Liu X, Wu Y, Dong F, Qiu CW, Qiu J. Artificial intelligence: A powerful paradigm for scientific research. The Innovation. 2021;2(4).

5. LeCun Y, Bengio Y, Hinton G. Deep learning. nature. 2015;521(7553):436-44.

6. Espinoza JL, Dong LT. Artificial intelligence tools for refining lung cancer screening. Journal of clinical medicine. 2020;9(12):3860.

7. Jiang F, Jiang Y, Zhi H, Dong Y, Li H, Ma S, et al. Artificial intelligence in healthcare: past, present and future. Stroke and vascular neurology. 2017;2(4).
8. Bi WL, Hosny A, Schabath MB, Giger ML, Birkbak NJ, Mehrtash A, et al. Artificial intelligence in cancer imaging: clinical challenges and applications. CA: a cancer journal for clinicians. 2019;69(2):127-57.
9. Huang S, Yang J, Fong S, Zhao Q. Artificial intelligence in cancer diagnosis and prognosis: Opportunities and challenges. Cancer letters. 2020;471:61-71.
10. Singh AK, Naqvi SH, Ashraf T. Thematic Clusters of Artificial Intelligence in Lung Cancer: A Scientometric and Knowledge Network Analysis. International Journal of Medical Reviews and Case Reports. 2023;6(20):4-.
11. Tan XJ, Cheor WL, Lim LL, Ab Rahman KS, Bakrin IH. Artificial Intelligence (AI) in Breast Imaging: A Scientometric Umbrella Review. Diagnostics. 2022;12(12):3111.
12. Zhang Y, Yu C, Zhao F, Xu H, Zhu C, Li Y. Landscape of Artificial Intelligence in Breast Cancer (2000–2021): A Bibliometric Analysis. Frontiers in Bioscience-Landmark. 2022;27(8):224.
13. Shen Z, Wu H, Chen Z, Hu J, Pan J, Kong J, et al. The global research of artificial intelligence on prostate cancer: A 22-year bibliometric analysis. Frontiers in Oncology. 2022;12.
14. Shen Z, Hu J, Wu H, Chen Z, Wu W, Lin J, et al. Global research trends and foci of artificial intelligence-based tumor pathology: a scientometric study. Journal of Translational Medicine. 2022;20(1):409.
15. Huang L, Zhao Y, Xiang M. Knowledge Mapping of Acupuncture for Cancer Pain: A Scientometric Analysis (2000–2019). Journal of Pain Research. 2021;14:343-58.
16. Birkle C, Pendlebury DA, Schnell J, Adams J. Web of Science as a data source for research on scientific and scholarly activity. Quantitative Science Studies. 2020;1(1):363-76.
17. Danesh F, Dastani M, Ghorbani M. Retrospective and prospective approaches of coronavirus publications in the last half-century: a Latent Dirichlet allocation analysis. Library Hi Tech. 2021 Sep 13;39(3):855-72.
18. Danesh F, GhaviDel S, Piranfar V. Coronavirus: Discover the Structure of Global Knowledge, Hidden Patterns & Emerging Events. Journal of Advances in Medical and Biomedical Research. 2020 Sep 10;28(130):253-64.
19. Chen T, Gong X. Global Research Trend Analysis of Osmanthus fragrans Based on Bibliometrix. Mobile Information Systems. 2022;2022.
20. Aria M, Cuccurullo C. bibliometrix: An R-tool for comprehensive science mapping analysis. Journal of informetrics. 2017;11(4):959-75.
21. Mühl DD, de Oliveira L. A bibliometric and thematic approach to agriculture 4.0. Heliyon. 2022;8(5):e09369.
22. Della Corte V, Del Gaudio G, Sepe F, Sciarelli F. Sustainable tourism in the open innovation realm: A bibliometric analysis. Sustainability. 2019;11(21):6114.
23. Tian Z, Wang D, Sun X, Fan Y, Guan Y, Zhang N, et al. Current status and trends of artificial intelligence research on the four traditional Chinese medicine diagnostic methods: a scientometric study. Annals of Translational Medicine. 2023;11(3).
24. Jinlei L, Wenchao D, Nuo C, Wenjing L, Peirong Q, Hui Z, et al., editors. Knowledge Graph of Artificial Intelligence in Medicine: A Scientometric Analysis. 2022 7th IEEE International Conference on Data Science in Cyberspace (DSC); 2022: IEEE.
25. Huang S, Cai N, Pacheco PP, Narrandes S, Wang Y, Xu W. Applications of support vector machine (SVM) learning in cancer genomics. Cancer genomics & proteomics. 2018;15(1):41-51.
26. Jiang Y, Yang M, Wang S, Li X, Sun Y. Emerging role of deep learning- based artificial intelligence in tumor pathology. Cancer communications. 2020;40(4):154-66.
27. Echle A, Rindtorff NT, Brinker TJ, Luedde T, Pearson AT, Kather JN. Deep learning in cancer pathology: a new generation of clinical biomarkers. British Journal of Cancer. 2021;124(4):686-96.

28. Viscaino M, Bustos JT, Muñoz P, Cheein CA, Cheein FA. Artificial intelligence for the early detection of colorectal cancer: A comprehensive review of its advantages and misconceptions. World Journal of Gastroenterology. 2021;27(38):6399.
29. Min M, Su S, He W, Bi Y, Ma Z, Liu Y. Computer-aided diagnosis of colorectal polyps using linked color imaging colonoscopy to predict histology. Scientific reports. 2019;9(1):1-8.
30. Singh N, Gupta SK. Recent advancement in the early detection of melanoma using computerized tools: An image analysis perspective. Skin Research and Technology. 2019;25(2):129-41.
31. Bera K, Braman N, Gupta A, Velcheti V, Madabhushi A. Predicting cancer outcomes with radiomics and artificial intelligence in radiology. Nature Reviews Clinical Oncology. 2022;19(2):132-46.