

Using temporal heatmaps to identify worthwhile articles on immune checkpoint blockade for melanoma (ICBM) in Mainland China, Hong Kong, and Taiwan since 2000

A bibliometric analysis

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Abstract

Background: Melanoma is a life-threatening form of skin cancer. Due to its remarkable effectiveness, the immune checkpoint blockade is widely used to treat melanoma (ICBM). No research has been conducted on ICBM for identifying the most readable articles. A bibliometric analysis of 100 top-cited ICBM (T100ICBM) in recent decades is required to highlight articles worth reading.

Methods: Based on the Web of Science Core Collection, we summarized the articles on ICBM published in each year from 2000 to 2022, with first authors from Mainland China, Hong Kong, and Taiwan (CHT). Using the CJAL score, data extraction and visualization of the distribution of ICBM publications were conducted on 2718, and 100 top-cited articles, respectively. We used the temporal heatmap to identify the most readable articles. Four descriptive, diagnostic, predictive, and prescriptive analytics (called DDPP model) were applied to describe the features of T100ICBM articles. The absolute advantage coefficient was used to determine the dominance extent of the most influential region, institute, department, and author.

Results: A total of 2718 publications was included after removing first or corresponding authors who were not affiliated with CHT. Publications by year showed a sharp increase from 2014 onward and either peaked in 2022 or have not yet peaked. It was evident that there was a large difference between the number of publications in provinces/metropolitan cities/regions on CHT. Beijing, Sichuan University, Oncology, and Guo Jun from Beijing are the most prolific and influential region, institute, department, and author. When comparing research achievements to the next productive authors based on the CJAL score, only Dr Jun has a medium effect of dominance ($=0.60$). On the basis of their consecutive growth in citations over the past 4 years, 20 T100ICBM articles were recommended for readers.

Conclusion: The field of ICBM is growing rapidly, and Beijing and Sichuan University are taking the lead in CHT. Furthermore, the study provides references for worth-reading articles using the temporal heatmap. Future research hot spots may focus on these 4 themes of immunotherapy, melanoma, metastatic melanoma, regulatory T cells, cells, and activation, which may pave the way for additional study.

Abbreviations: AAC = absolute advantage coefficient, CC = correlation coefficient, CHT = mainland China, Hong Kong, or Taiwan, IP = inflection point, ICBM = immune checkpoint blockade for melanoma, RA = research achievement, RIDA = region, institute, depart, and author, TBG = temporal bar graph, THM = temporal heatmap, VBA = visual basic for application.

Keywords: advantage coefficient, CJAL score, immune checkpoint blockade, melanoma, research trends, temporal heatmap, web of science

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The datasets generated during and/or analyzed during the current study are publicly available.

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Key points

We included 4 visualizations to explore the characteristics of publications on ICBM, particularly using the temporal heatmap to highlight articles worth reading.

Using the Pearson correlation coefficient on citations over the last 4 years, the most readable articles were identified, which has never been mentioned in the literature before.

In the radar diagram, the Yk-index, and the CJAL score are calculated based on the publications of the first and corresponding authors, which is an easy and effective way to represent the research achievements for countries/regions, institutes, departments, and authors.

1. Introduction

While the frequency of melanoma has increased over the past decade, advanced melanoma has become less lethal. Nevertheless, melanoma remains one of the deadliest forms of skin cancer.^[1] There has been a rapid increase in melanoma cases worldwide. In 2015, there were more than 350,000 new melanomas^[2]; in addition, the rate of new melanomas has steadily increased over the past 20 years. Immune checkpoint blockade is widely used to treat melanomas (ICBMs), especially those with negative regulators, such as T-lymphocyte associated protein-4 (CTLA-4), programmed death receptor 1 (PD-1), and its ligand (PD-L1). Clinical trials are often conducted on ICBMs. This remarkable efficacy of ICBMs can be attributed to the biological characteristics of the disease.^[3]

In many studies, melanoma has been observed to progress and to occur at a higher rate in immunosuppressed individuals, which supports the efficacy of immunotherapy.^[4,5] Additionally, melanoma is always associated with a substantial tumor mutation burden,^[6] which may lead to a stronger immune response. Due to these biological and clinical characteristics, ICBMs have been thoroughly researched over the past 2 decades and have gradually become a major area of research.

1.1. Bibliometric analysis for a better understanding of article characteristics

A bibliometric analysis is a quantitative approach to evaluating research performance that uses methods such as co-occurrence analysis and citation analysis.^[7-9] The main purpose of bibliometrics is to measure the impact or influence of research articles. A bibliometric method is used to estimate the amount of influence or impact that a particular research article may have on future research, and it is especially useful when the topic is becoming increasingly intriguing over time. The ICBM, however, has not been analyzed bibliometrically. A comprehensive bibliometric analysis covering recent decades to examine research trends and public interest in ICBM is needed.

1.2. ICBM articles authored by Chinese professionals

In general, dermatology physicians practice medical services in hospitals to treat skin diseases.^[10] They may also work for quality of care in patients such as those in cancer treatments. As of July 1, 2022, more than 14 articles are indexed in the PubMed database with “dermatology physicians” in Title.^[11] Of these, no such articles were written by authors from mainland China, Hong Kong, or Taiwan (CHT).

Over the past 20 years, China role in the international community has significantly expanded. The same trend can be observed in scientific publications.^[12] Numerous articles comparing publications in CHT^[13-15] were mentioned. However, the

characteristics of research from dermatology physicians among Chinese individuals in the CHT remain unknown, particularly on the ICBM topic.

1.3. About the worth-reading articles

During the 1970s, a paper that had been cited 80 or more times was regarded as being “highly cited” in mathematics.^[16] Garfield also reported that highly cited articles with 100 or more citations were generally classified under clinical or general medical journals.^[17] Most classics in a given field are still highly cited.^[18] A paper that is highly cited can serve as an indicator of “world-class” research.^[19]

Publications in PubMed contain more than 357 articles mentioning 100 keywords and cited in Title,^[20] such as hemodialysis,^[21] pemphigus vulgaris,^[22] cervical cancer radiotherapy,^[23] and oral lichen planus.^[24] None of them were found on the topic of articles worth reading. That is, the most important and noteworthy articles based on the citation trend (rather than the number of total citations alone) have not been mentioned in the literature to date. Articles with an increase in citations in recent years should be taken into account based on 100 top-cited articles.

1.4. Four analytics in bibliographical studies

A number of bibliographical studies indicate that the number of publications has increased rapidly in recent years.^[25,26] In general, 4 types of analytics (called DDPP model in this study) are frequently applied to bibliometrics, including; Descriptive (e.g., rankings of research achievements [RAs] for authors, which answers the question of what happened?); Diagnostic (e.g., classification of themes, keywords, or author collaborations, which answers the question of why did this happen?); Predictive (e.g., using weighted keyword mean citations to predict article citations^[27-30]), and; Prescriptive (e.g., with heatmaps to highlight the roadmap for the future, which answers the question of what should we do next?) facets.^[31]

The 4 analytics can be used in conjunction to; Complete a picture of the story by describing the data in bibliometrics; Investigate why those patterns (or classifications) have occurred, and; Make informed predictions about whether the trends will continue. With prescriptive analytics, readers are provided with actionable recommendations for the future.^[30]

To determine whether the worthwhile articles on ICBM can be illustrated with prescriptive analytics, it is necessary to verify their validity using heatmaps.

1.5. Aims of this study

There has been a need for a comprehensive bibliometric analysis of ICBM research to; Identify the characteristics of publications and; Identify articles worth reading. The aim of this study was to verify the validity of a temporal heatmap (THM) that could be used to highlight articles worthy of reading based on 100 of the most highly cited ICBMs (T100ICBM).

2. Methods

2.1. Data sources

We searched the keywords (immune checkpoint inhibitors in melanoma constrained on; Articles and review articles and; First or corresponding authors from CHT since 2000) in Web of Science core collection. A total of 2718 articles with citations in each year were extracted and matched to those in PubMed with the PMID (i.e., PubMed identity number). The T100ICBM articles in WoS were compiled; see the data in Supplemental Digital Content 1, Supplemental Digital

Content, <http://links.lww.com/MD/I407> and the search strategy in Supplemental Digital Content 2, Supplemental Digital Content, <http://links.lww.com/MD/I408>.

As this study did not involve the examination or treatment of patients or review of patient records, it was exempt from review and approval by our research ethics committee.

2.2. Four analytics applied to this study

2.2.1. Descriptive analytics in 2718 articles. A bar chart was drawn to illustrate the publication trend of articles in ICBMs. A choropleth map,^[32] a 4-quadrant radar plot,^[33] and a pyramid plot in $R^{[25]}$ were used to visualize the productive entities in articles.

The absolute advantage coefficient (AAC) (see Eqs. 1–3)^[28,34–36] was applied to evaluate the dominance extent for the most influential region, institute, depart, and author (RIDA) in CJAL scores.

$$AAC = (R_{12}/R_{23}) / (1 + (R_{12}/R_{23})), \tag{1}$$

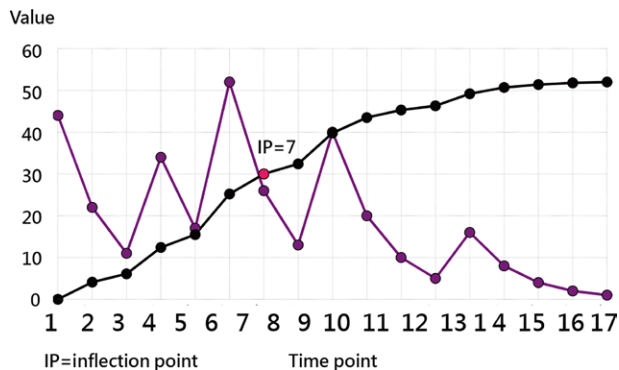


Figure 1. The IP is shown on an ogive curve using the Newton–Raphson iteration method (NRIM). IP = inflection point.

$$R_{12} = A1/A2, \tag{2}$$

$$R_{23} = A2/A3, \tag{3}$$

where the AAC ratio is determined by the 3 consecutive numbers of values (e.g., top 3 CJAL scores in descending order denoted by A1, A2, and A3 in Eqs 2 and 3). The ACC ranged from 0 to 1.0, representing the strength of dominance for the top member when compared to the next 2 members. Through the computation of AAC, the dominance strength in a variable (i.e., country, journal, or category) can be measured and judged by the effect size, with criteria of <0.5, between 0.5 and 0.7, and not less than 0.7 as the small, medium, and large effect sizes, respectively.^[28]

2.2.2. Diagnostic analytics in T100ICBM articles. In addition, a 4-quadrant radar plot^[33] was applied to visualize the influential entities in T100ICBMs using the CJAL score^[33] (based on the CJA score^[37] and the L-index^[38]). The Y-index^[39,40] was applied to locate their coordinates on the radar plot. Four visual representations were used to conduct the diagnostic analytics, including; A network chart,^[41,42] A chord diagram,^[43] A Sankey diagram,^[28] and; An impact beam plot^[44]; See the way to draw these visualizations in Supplemental Digital Content 2, Supplemental Digital Content, <http://links.lww.com/MD/I408>.

By using cword analysis based on social network analysis,^[41,42] cword analysis was performed to extract the chief keywords in clusters as themes (or leaders) represented by Keywords Plus that were retrieved from the Web of Science core collection. Next, the themes represented by the chief keywords in clusters were assigned to T100ICBM using Equation 4.^[45]

$$Theme\# = At[\max_{0 \leq x \leq 1} \sum_{i=1}^L \sum_{j=1}^n (m = m + 1)], \tag{4}$$

where L is the number of keywords in article I. n is the number of keywords denoted by keyword k belonging to the theme defined in cword analysis.^[41,42] Accordingly, theme# is redirected to the maximal number of keywords (= m) involved in

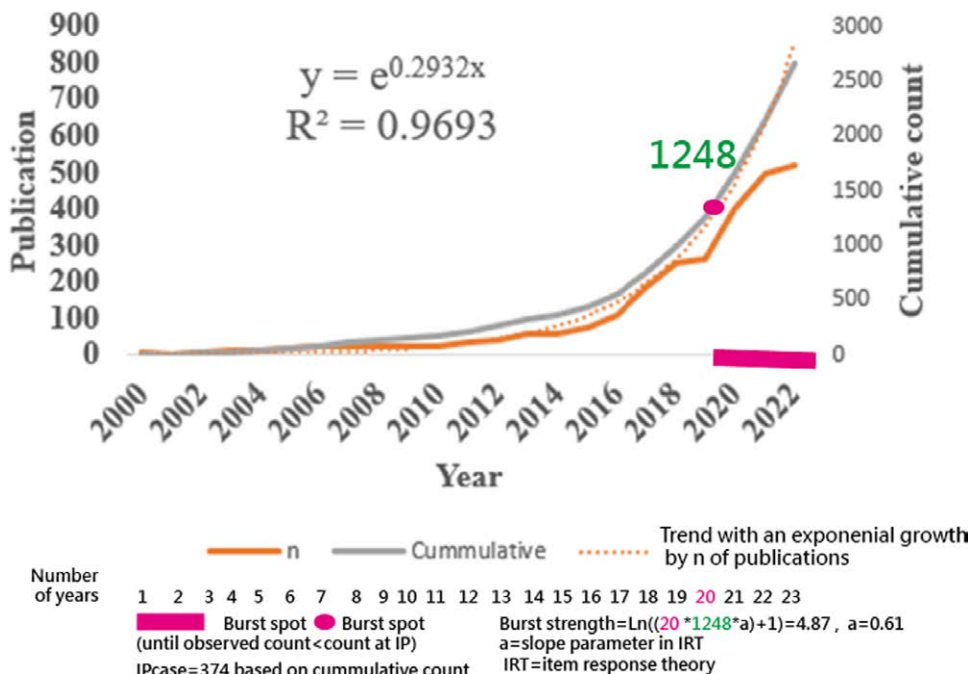


Figure 2. Trend analysis of the 2718 articles with the inflection plot and burst spots since 2000.

theme # via equation 4. The top 5 keywords in each cluster were displayed on a chord diagram.^[43]

2.2.3. Predictive analytics in T100ICBM articles. The number of connections for a specific Keyword plus was computed based on an equal weight in an article.^[27-30] The weighted mean citation for each term was applied to predict article citations based on the correlation coefficient (CC) in determining the predictive power related to original article citations. The CC *t* value was calculated using the following formula ($=CC \cdot x$)^[27-30] A prediction equation was produced through simple regression analysis using MedCalc statistical software, version 9.5.0.0 (MedCalc, New York, NY). A scatter plot was used to display the relationship between weighted mean citations and article citations in T100ICBM articles.

2.2.4. Prescriptive analytics in T100ICBM articles.

2.2.4.1. The use of a temporal heatmap. The THM contains 4 dimensions, namely, articles on the row, years on the column, and color darked by article citation, and the burst point starts at the beginning of red font and ends at citations smaller than the count at the burst point (i.e., turning point mentioned in Introduction). With the THM, the most worth-reading articles with higher growing citation trends in T100ICBM articles were highlighted by the respective burst strength.

2.2.4.2. Temporal heatmap with signals of trend and burst spots. In the context of a heatmap, the intensity of data density is shown as a darker color in 2 dimensions (e.g., attributes and years in rows and columns as in a temporal bar graph [TBG]^[46,47]). We proposed a THM, which would display the citations by article over the years, incorporating additional burst spots, signals of trend,^[48,49] and values complementary to the traditional TBG.^[46,47]

The burst spot occurs at the inflection point (IP) of cumulative counts over time.^[48] The IP is derived from the item difficulty on a given ogive curve^[49] if the model item characteristic

curve (ICC) becomes the basis for generating a continuous function.^[50]

The IP is shown on an ogive curve using the Newton–Raphson iteration method (NRIM).^[49,51] By clicking on the following link, readers are invited to practice it.^[52] A series of numbers (represented by counts over time) is demonstrated and generated via the Collatz conjecture^[49,53]; see Figure 1.

The hot spot is extended from the IP to the next time points based on the counts that are not less than those from the IP. This burst strength is defined by the equation ($= \log (axcounts \text{ at IP})$),^[48,49] where *a* is the slope parameter in item response theory, the larger the steeper of the ogive curve.

The trend signals include 5 possible outcomes (e.g., ready to rise, increasing, slow down, declining, and stationarity). The definitions of these terms have been described in the study.^[34]

2.3. Creating dashboards on google maps

All graphs were drawn by author-made modules in Excel (Microsoft Corp). We created pages of HTML used for google maps. All relevant CJAL scores^[33] for each member can be linked to dashboards on google maps. The way to draw the visualization involved in this study is deposited in Supplemental Digital Content 2, Supplemental Digital Content, <http://links.lww.com/MD/I408>.

3. Results

3.1. Descriptive analytics in 2718 articles

A significant rise in ICBM publications is evident in Figure 2. Due to the end of data extraction until November 20, 2022, we can expect articles in 2022 to be higher than those in 2021. The burst strength is 4.87 ($= \ln (20 \times 1248 \times 0.61 + 1)$) located in 2019, where IP = 20, cumulative count in 2019 = 1248, and the slope parameter (i.e., the discrimination parameter denoted by *a* in item response theory) = 0.61.

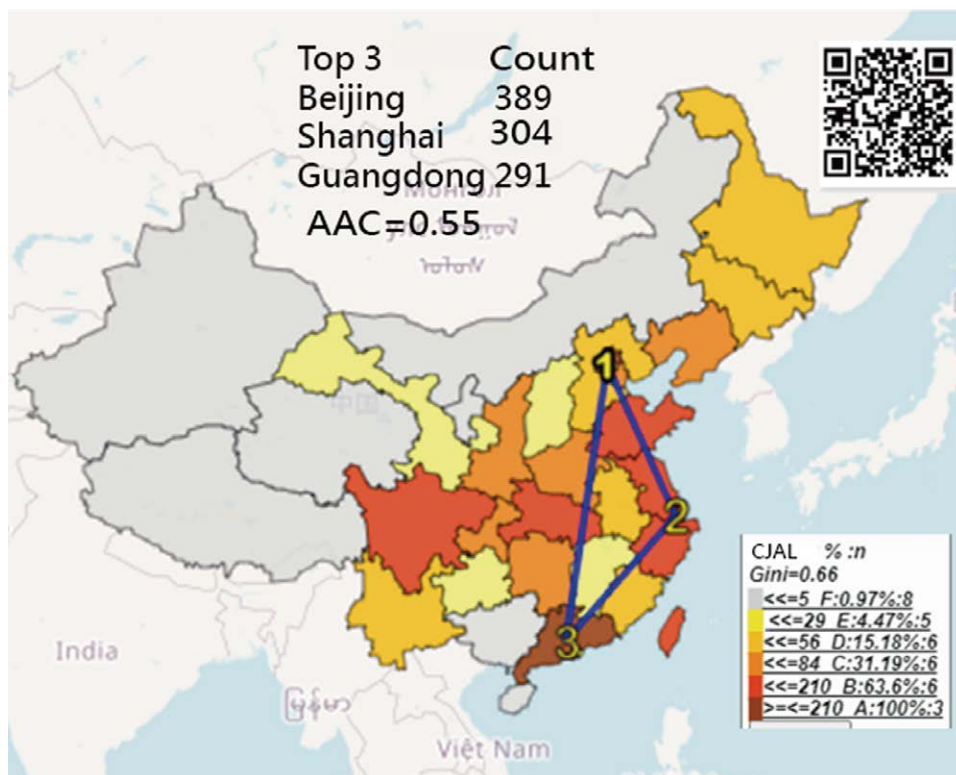


Figure 3. The most influential regions in Mainland China, Hong Kong, and Taiwan using CJAL scores shown on a choropleth map.

Figure 3 illustrates the geographical distribution of regions. Beijing (389), Shanghai (304), and Guangdong (291) are the 3 most prolific regions. Based on Equation 3, Beijing's AAC is 0.55. The most prolific and influential RIDAs are Beijing in regions, Sichuan University in institutes, Oncology in departments, and the author Guo Jun from Beijing. Based on the CJAL score, only Dr Jun has a medium effect of dominance (0.60); see Figure 4.

As shown in Figure 5, Front Oncol (122), Front Immunol (118), and Oncol Lett (49) are the most productive journals. Since 2000, 40 articles have been published in *Medicine (Baltimore)* with a mean citation of 12.8.

3.2. Diagnostic analytics in T100ICBM articles

In T100ICBM, 4 themes were identified using cword analysis, as shown in Figure 6, including immunotherapy, melanoma, metastatic melanoma, regulatory T cells, cells, and activation as key words in clusters. Figure 6 shows a chord diagram^[43] of the top 5 keywords in each cluster. The chord diagram enables us to understand which themes dominate the T100ICBM articles and their relationship through the color-coded curves.

The Sankey diagram in Figure 7 is another useful visual representation. The majority of the publications were published in 2018, melanoma under themes, oncology under subject categories, the journal of Hematol Oncol, Beijing, and the Huazhong University Science & Technology. There is a closer relationship

between the 2 adjacent members of the article entity when the curve is wider. A larger block indicates that there are more publications in T100ICBM.

Beijing, Huazhong University Science & Technology, Med Oncology departments, and the author Qian Chen from Jiangsu province are the most prolific and influential RIDAs in T100ICBM. Med Oncol has the highest AAC (0.55) based on the CJAL score, but with a medium dominance effect over the next members with higher CJAL scores; see Figure 8.

Figure 9 shows the T100ICBM articles with dots. There are 3 types of articles by theme, immunotherapy, melanoma, and others in red, green, and black. To access the articles in PubMed, readers are invited to scan the QR code in Figure 9 and click on a dot that interests them.

3.3. Predictive analytics in T100ICBM articles

To utilize the keyword weights to predict article citations, according to our results, keyword plus in WoS were evident in prediction power on the number of article citations (correlation coefficient = 0.97, $t = 36.54$), as shown in Figure 9. The regression equation is defined as article citation (y) = $-134.6364 + 1.8138 \times \text{Weight}(x)$ of the keyword plus. The slope coefficient presented statistical significance ($F = 1335.17, P < .0001$). As soon as the QR code in Figure 9 is scanned, the article appears instantly on PubMed when the bubble of interest is clicked.

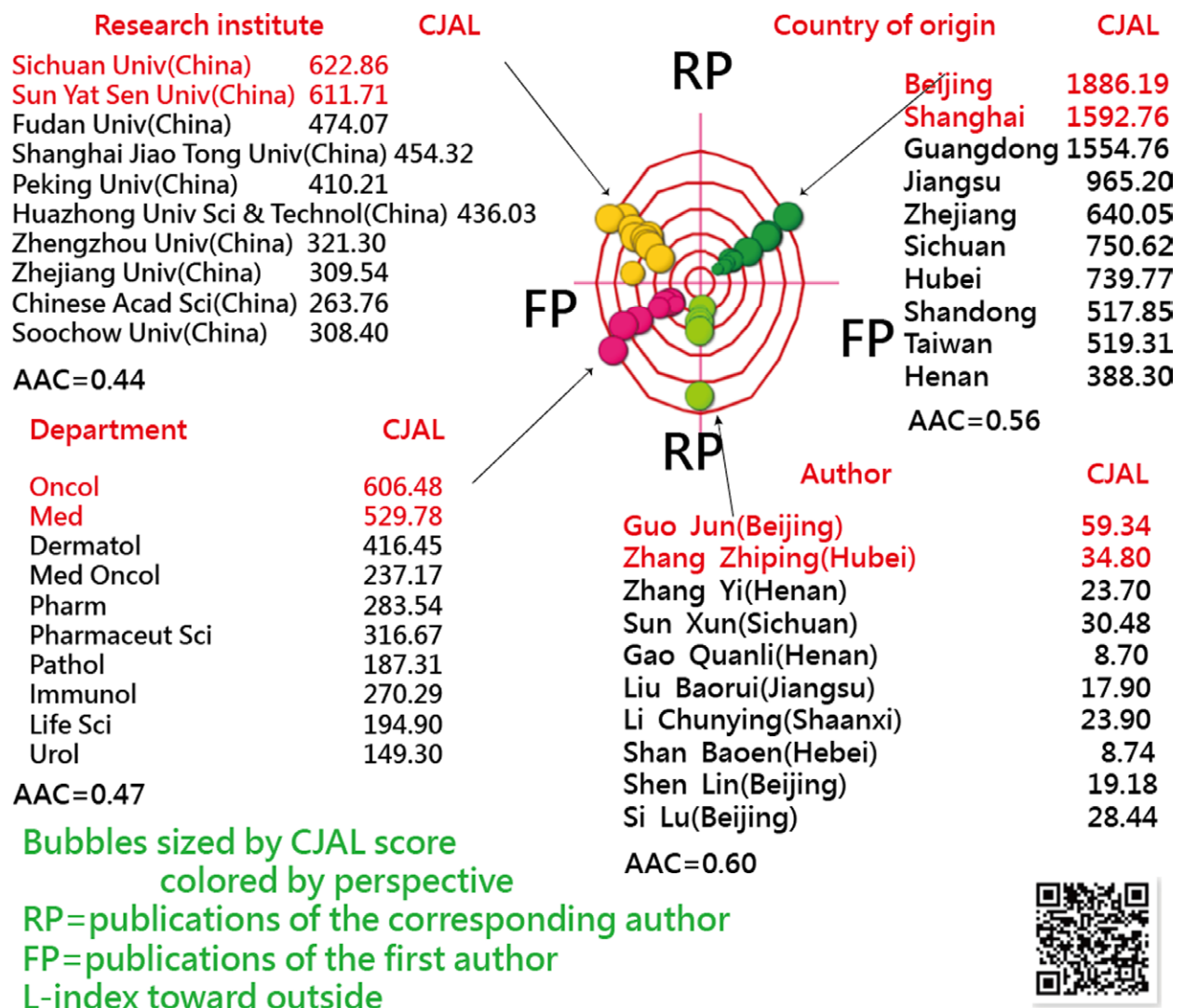


Figure 4. The productive entities in 2718 ICBM articles using a 4-quadrant radar plot. ICBM = immune checkpoint blockade for melanoma.

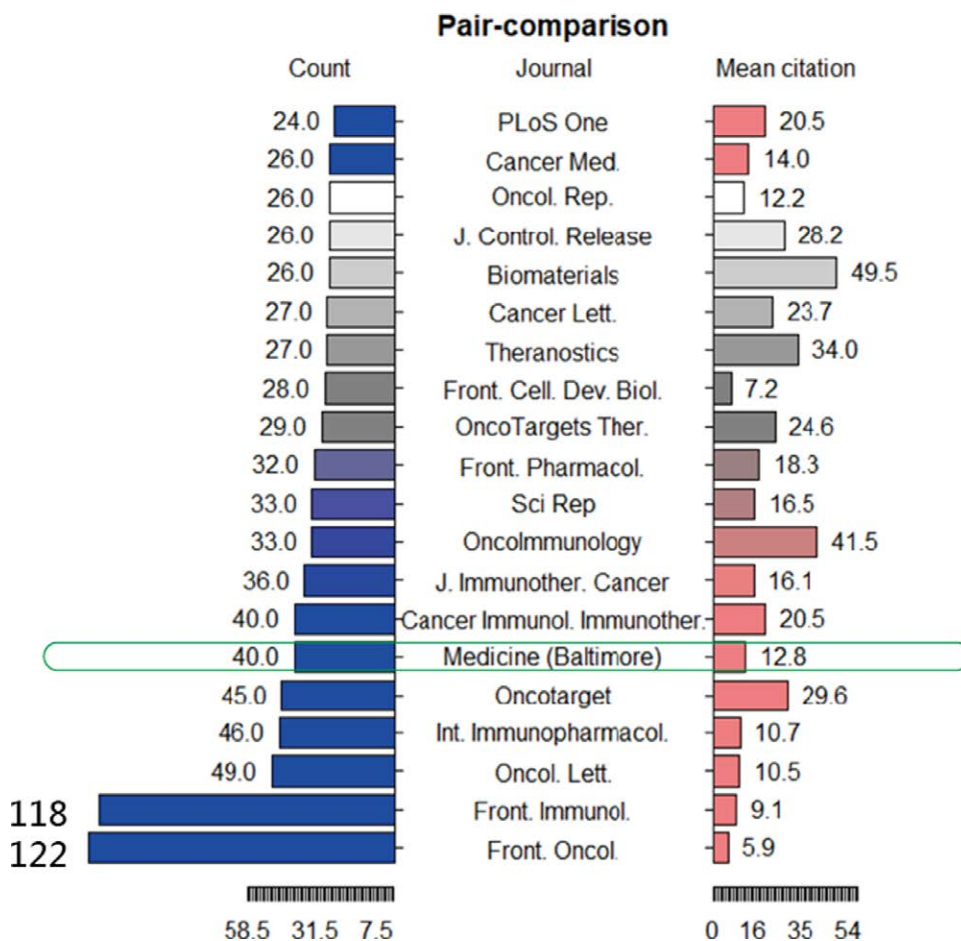


Figure 5. Top 20 journals in publications in comparison of articles and mean citations in T100ICBM using the pyramid plot. ICBM = immune checkpoint blockade for melanoma.

3.4. Prescriptive analytics in T100ICBM articles

Figure 11 illustrates twenty articles worthy of reading in T100ICBM. Citations have increased significantly over the last 4 years, particularly with stronger bursts and higher growth rates. In the THM (Fig. 11), there are 2 articles^[54,55] that will be abstracted in the Discussion section due to receiving the most citations. As a result, the study objective was accomplished: the validity of a THM that could be used to highlight articles that are worth reading in the T100ICBM papers, which is lacking in the traditional bibliometric analysis of 100 top-cited articles.

3.5. Online dashboards shown on google maps

All the QR codes in Figures are linked to the dashboards if the QR code is scanned. Readers are suggested to examine the details about article information laid on google maps.

4. Discussion

Our analysis revealed that 2718 publications were included after removing first or corresponding authors who were not affiliated with CHT. As the number of publications increased from 2014 onward, they either peaked in 2022 or have not yet peaked. The number of publications on CHT varied greatly among provinces/metropolitan cities/regions. The most prolific and influential RIDAs are from Beijing, Sichuan University, Oncology, and Guo Jun from Beijing. When comparing RAs to the next productive author based on the CJAL score, only Dr Jun has a medium

effect of dominance (= 0.60). A total of twenty T100ICBM articles were recommended for readers based on their consecutive growth in citations over the past 4 years.

Accordingly, the study objective was accomplished: the validity of a THM that could be used to highlight articles that are worth reading in T100ICBM papers.

4.1. Additional information

Eyeball observations were used to determine that a peak in cumulative publications occurred in 2020 and a sharp decline occurred from 2014 to 2017 compared to the cumulative number of publications on ICBM.^[9] As opposed to using a mathematical model to calculate the inflection point as we did in this study on ICBM in CHT, Figure 2 shows a burst strength of 4.87 (= Ln (20 × 1248 × 0.61 + 1)) located in 2019, where IP = 20, cumulative count = 1248, and slope parameter = 0.61.

Although the most prolific regions are Beijing (389), Shanghai (304), and Guangdong (291) by publication, the number of citations per publication lagged far behind other countries on the ICBM topic.^[9]

By using the bibliometric method, we analyzed the chronological trends in the publications. Figure 2 shows that the number of ICBM publications was relatively small from 2000 to 2013, with a small, linear growth trend. In the CHT, the number of newly published papers remained under 100 from 2000 to 2013, with a rather small increase each year. The next period was from 2014 to 2018, during which the number of publications related to ICBM in CHT rapidly increased. Over 400 publications were published each year, but not 500, which is

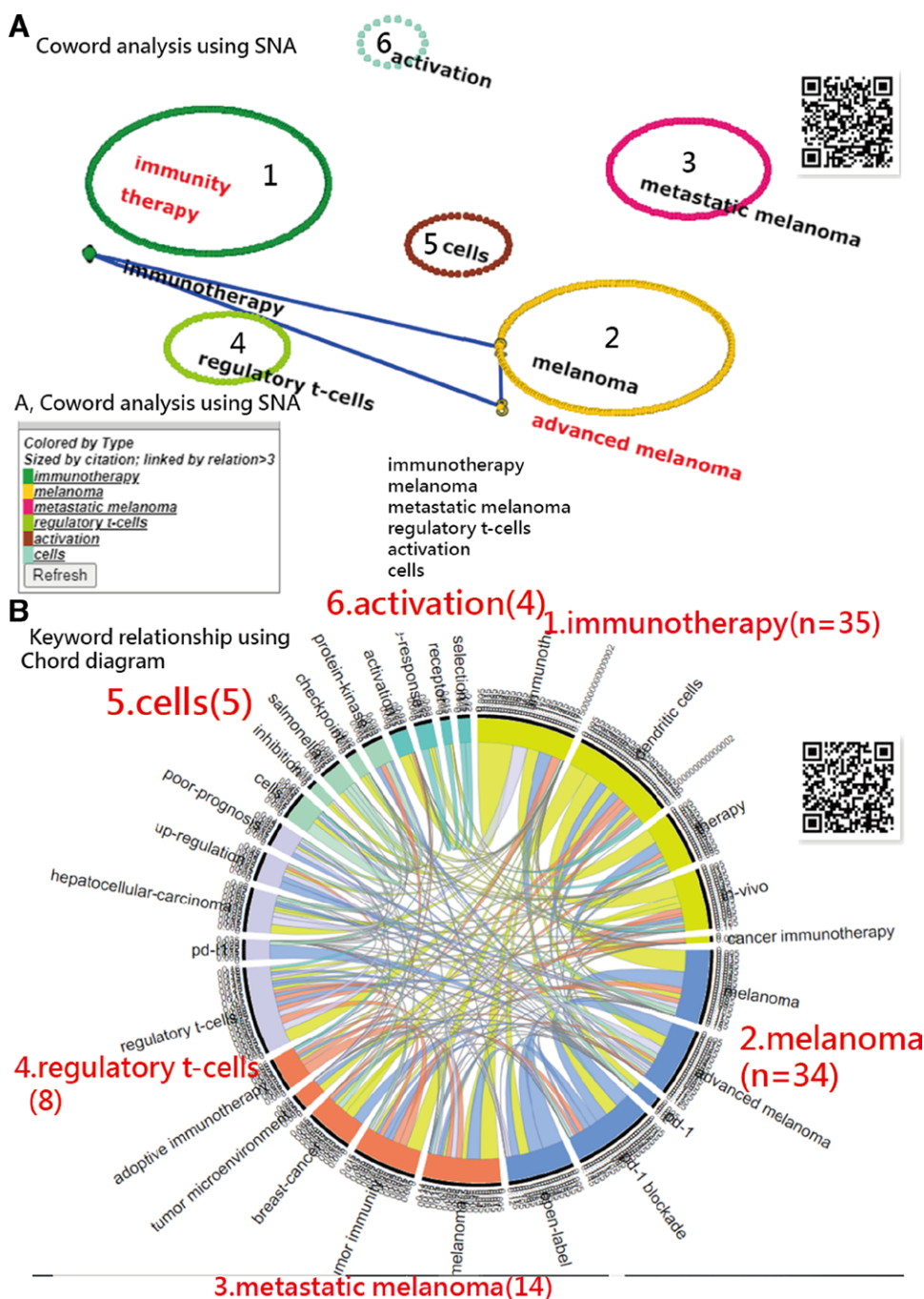


Figure 6. Six themes were classified using a network and a chord diagram to display.

consistent with previous research.^[9,56] In the third period, from 2019 to 2022, the number of publications increased to over 518, indicating the maturity of the theoretical aspects of the field.

In the past few years, the number of publications has increased, and the topic has gradually gained popularity. It was not until a breakthrough in cancer immunotherapy in 2013 that the number of publications per year reached 300. In 2014, the FDA approved anti-PD-1 antibodies (pembrolizumab and nivolumab) for advanced metastatic melanoma, and an anti-PD-L1 antibody (atezolizumab) was approved in 2016.^[9] Thousands of publications were published within a short period of time.^[57-60] We found, unsurprisingly, that the topic of ICBM has gradually become a research hotspot and that it is currently undergoing a period of major development. The theory developed rapidly during this period, and the number of papers

increased rapidly as well. Furthermore, the growth curve was sharp, and its gradient did not decrease during 2022. Over the next few years, we anticipate that this field will continue to develop in CHT.

A bibliometric analysis of ICBM articles conducted in 80 different countries and regions indicates that the United States published the majority of the documents in this field, followed by China,^[9] but the trend of citations indicates that China is becoming increasingly prolific, as demonstrated in this study.

For the most productive journals, considering the evidence for the total number of publications and IF (i.e., impact factor), the Journal of Front Oncology might be the most influential journal in the ICBM topic in CHT. Since 2000, 40 articles have been published in Medicine (Baltimore) with a mean citation of 12.8 (Fig. 5).

Characteristics of productive entities in T100 articles

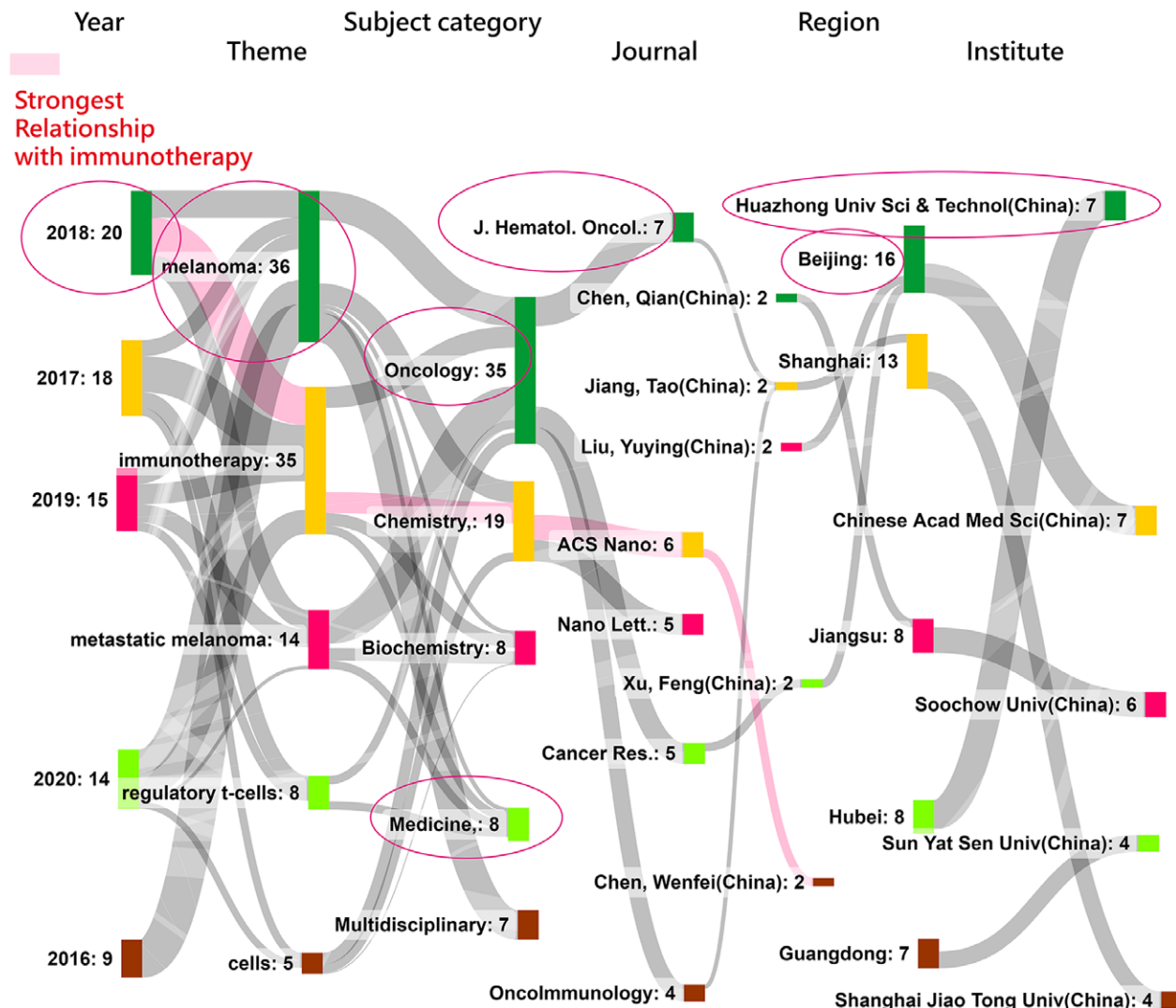


Figure 7. Relationship between the top five elements in entities shown on the Sankey diagram.

Four themes were found by analyzing keywords, including immunotherapy, melanoma, metastatic melanoma, regulatory T cells, cells, and activation, which may provide a basis for further research. As a result of a previous study,^[9] the focus of research gradually shifted from mechanisms to efficacy and adverse events. The theory was becoming mature, and its application was being explored, including the enhancement of its efficacy, the reduction of its adverse effects, and the extension of its use to other, more specific cancer types.^[61]

4.2. Two worth-reading articles with a higher growth rate of citations in T100ICBM

A study written by Yang et al^[54] and published in 2016 was the most noteworthy article. The article receiving 360 citations in the journal of *Nature* is entitled Potentiating the antitumor response of CD8 (+) T cells by modulating cholesterol metabolism. The authors addressed that mouse CD8 (+) T cells can be potentiated by inhibiting cholesterol esterification, which increases the plasma membrane cholesterol level and causes enhanced T-cell receptor clustering and signaling as well as more efficient formation of the immunological synapse. Furthermore, ACAT1-deficient CD8 (+) T cells were better than wild-type

CD8 (+) T cells at controlling melanoma growth and metastasis in mice. The ACAT1 inhibitor avasimibe was used to treat melanoma in mice and showed good antitumor effects.

The second article written by Zhang et al^[55] and published in 2020 was another noteworthy article and entitled The history and advances in cancer immunotherapy: understanding the characteristics of tumor-infiltrating immune cells and their therapeutic implications. The article was published in *Cell Mol Immunol*. The authors addressed that Single-cell RNA sequencing and mass cytometry are being used to study the immune infiltrates in the tumor microenvironment. This will provide insights into the functional diversities of tumor-infiltrating immune cells. This review focused on landmark studies and single-cell characterization of tumor-associated immune cells and summarized the phenotypic diversities of intratumoral immune cells and their connections with cancer immunotherapy.

4.3. Implications and changes

Top keywords with the strongest frequency bursts are frequently displayed on TBGs^[27,47,48] and timeline bar graphs in Cite Space.^[62-64] Of these, they do not contain such features as

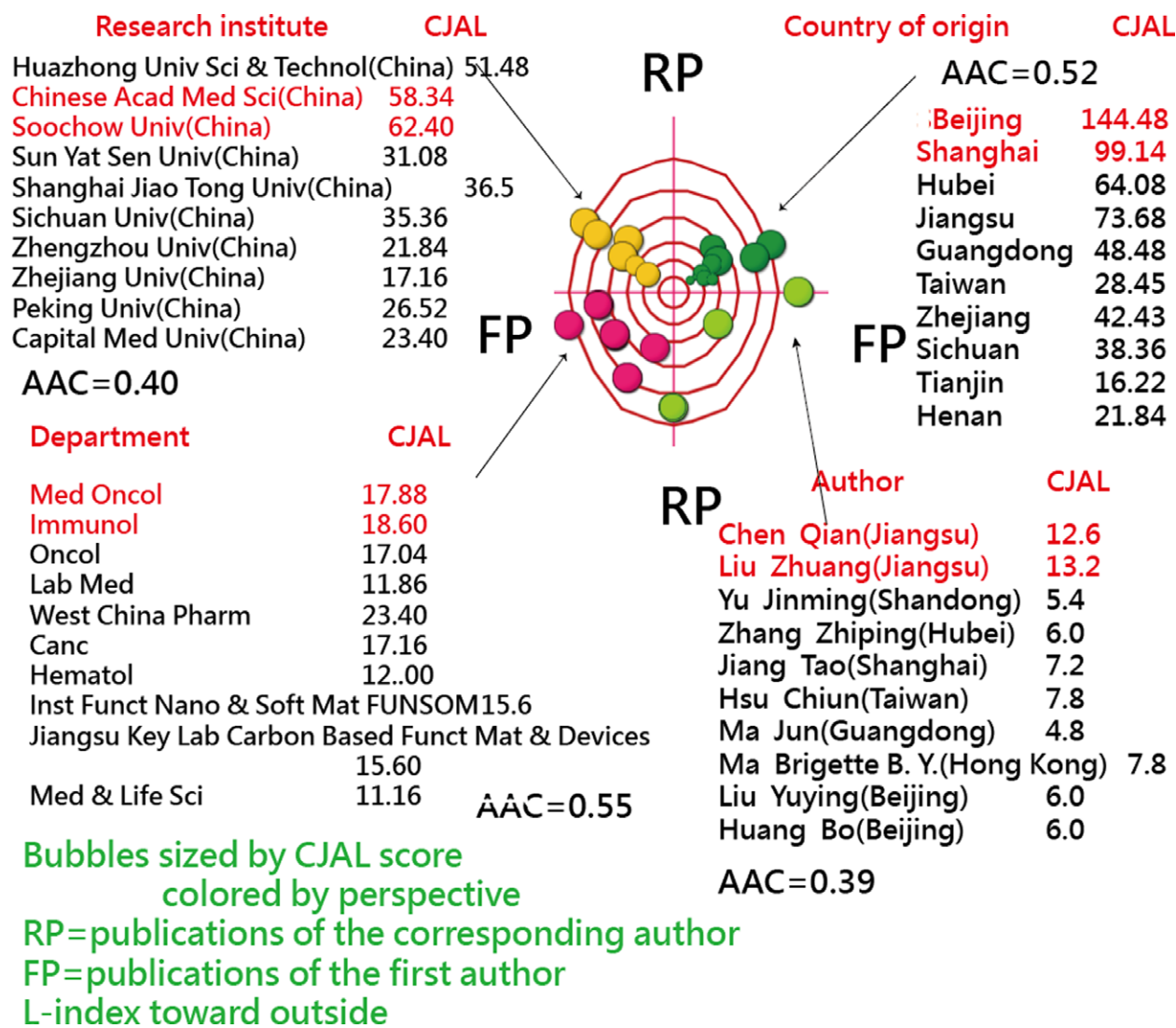


Figure 8. The productive and influential entities in T100ICBM shown on a 4-quadrant radar plot. ICBM = immune checkpoint blockade for melanoma.

values displayed on the heatmap and citation trend over the past years as we did on the THM in Figure 11: A strong frequency burst indicates that a variable has undergone a great change in a short period of time, and the red fonts indicate the durations of the bursts (or, described by authors on the timeline bar graph that the red bars represent frequently cited periods and the green bars represent infrequently cited periods^[65] in Cite Space^[62-64]).

The top 10 most highly cited documents on ICBM were listed in a previous study,^[9] such as an article published in *the New England Journal of Medicine* titled “Improved survival with ipilimumab in patients with metastatic melanoma” ranked first, with 10,310 total citations up to November 29, 2022, since 2010.^[66] Nonetheless, if the citation trend was observed using the Newton–Raphson Iteration Method (NRIM)^[49,51] and the link,^[52] the statistics include; A burst strength of 4.68 (=Ln(6×5817×0.32+1)) located in 2018, where IP = 6, cumulative count = 5817, slope parameter = 0.32, and growth type = ready to decline with a trend-0.83. = It is thus necessary to present articles worth reading for readers using the temporal heatmap of prescriptive analytics in the future.

The study has several distinctive features. First, the enhanced TBG was developed and demonstrated, particularly for any time-series data using the temporal heatmap. Document of

how to draw the heatmap in Supplemental Digital Content 2, Supplemental Digital Content, <http://links.lww.com/MD/I408>.

Second, a number of bibliographical studies have applied visualizations to descriptive and diagnostic analytics. Few such studies have been conducted in predictive analytics, and even fewer have been conducted in prescriptive analytics. An article with many Tables and graphs (e.g., 1 with 15 tables and 27 figures in an article^[67]) without descriptive and diagnostic analytics to explore the knowledge of interest and noninterest to the audience is inappropriate. The DDPP model proposed in this study can be applied and cited in the future bibliographical studies if our methods used in this study are followed (see Supplemental Digital Content 2, Supplemental Digital Content, <http://links.lww.com/MD/I408>).

Third, combining the Y-index and CJAL scores on a radar plot is an innovative, modern method for comparing RAs between countries, regions, institutes, departments, and authors. A bird eye view of the Sankey diagram with publication years, journals, subject categories, and themes has been demonstrated in studies^[28,68-71] and deserves to be incorporated into future bibliometric analyses.

Moreover, Cite Space^[62-64] was used to group and label article themes. There are, however, no such methods for assigning themes to articles using Equation 4.^[45] Human classification of themes assigned to articles^[72] is a laborious and time-consuming process.

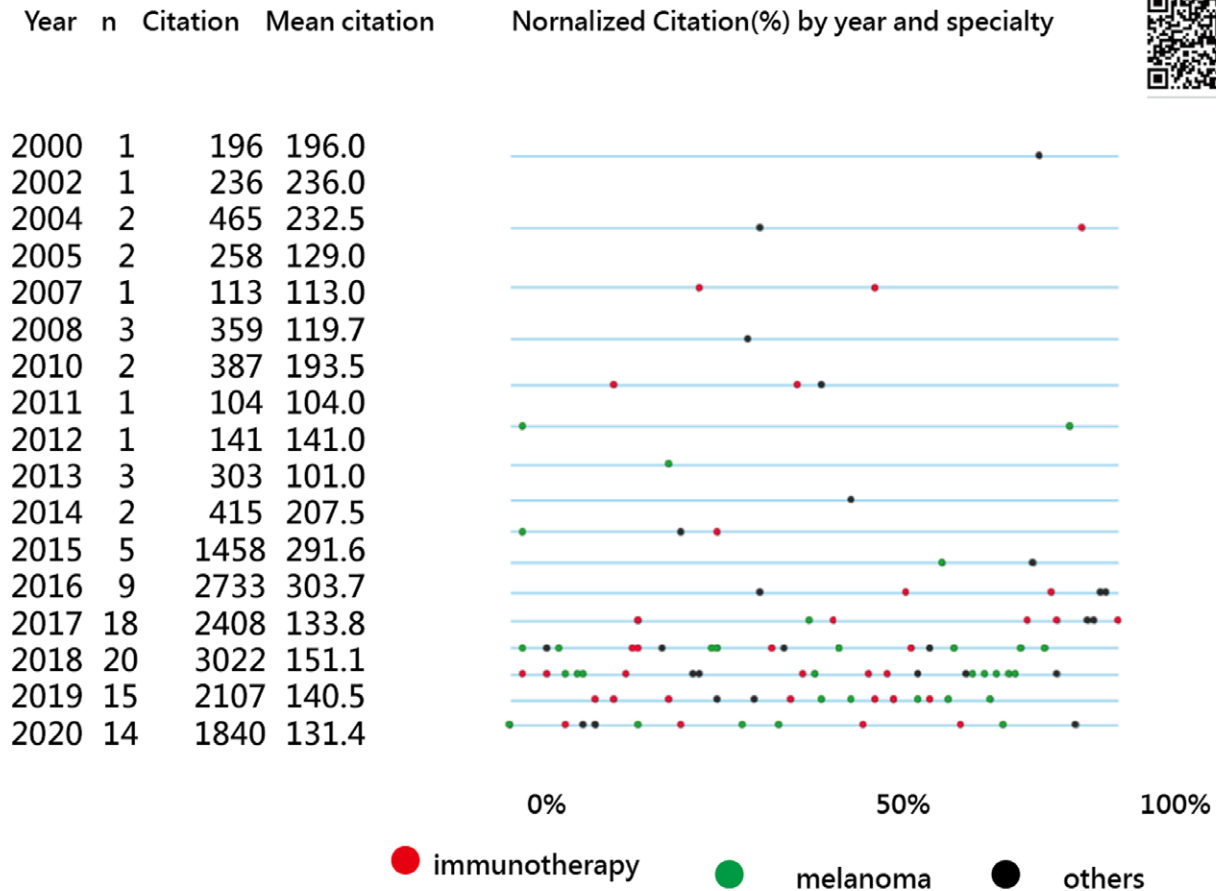
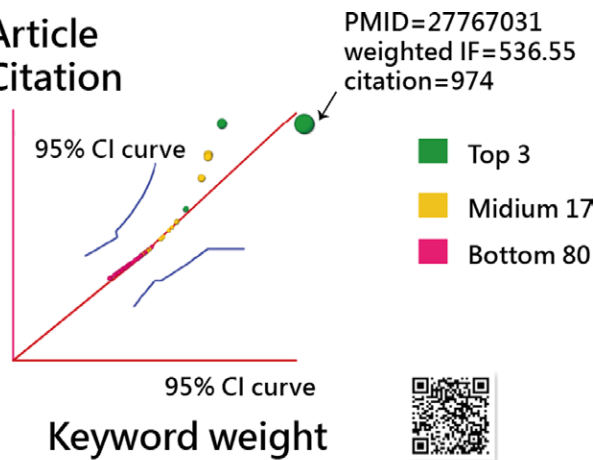


Figure 9. The major types of T100ICBM shown on the IBP. IBP = impact beam plot, ICBM = immune checkpoint blockade for melanoma.

Article Citation



$$y = -134.6364 + 1.8138 \times \text{Weight}(x) \text{ of Keyword}$$

CC=0.97, t=36.54, df=98

Figure 10. Using the weighted keyword mean citations to predict original article citations.

4.4. Limitations and suggestions

There are a number of issues that must be addressed in detail in further research. As a first concern, only articles pertaining to ICBM research in CHT are included. It is recommended that future studies on ICBM in the US use the CJAL score and the THM due to the dominance of the US in this ICBM research field.^[9]

The second point is that although the Y-index^[39,40] and the CJAL score^[33] have been considered to be fair measures of RA contributions, it is assumed that the co-first authors contribute equally to the articles. If authorship does not follow the rule as designed using the author weighted scheme,^[42,73-75] the results regarding the authors who contributed the most to articles will be biased.

Third, it takes some time to draw the THM. The advancement in hardware has made this task trivial with a dedicated software program, equally easy and quick, as demonstrated in Supplemental Digital Content 2, Supplemental Digital Content, <http://links.lww.com/MD/I408>.

Fourth, it was proposed in this study to apply predictive and prescriptive analytics to future bibliometrics, which need to take into account other possible tools that should be developed for use in the future.

Fifth, according to Figure 2, only regions with higher CJAL scores are compared. Readers may also be interested in the list of regions with the Y-index^[39,40] shown on the radar plot. Using the 4-quadrant radar plot^[33] to display the productive regions should be involved in a future study (see how to draw the radar plot in Appendix 2).

Sixth, it is possible that there are some biases because there are different authors with the same name or abbreviation who are affiliated with different institutions. Authors are limited to a region to prevent identical names across regions, but the results of RA comparison would be influenced by authors with the same name or abbreviation in the same region.

Finally, although the THM is considered useful and applicable, some basic R expertise is required to draw them effectively in R for use in the future.

Temporal heatmap

Author	Citation	Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Type	BS	Growth	PMID
Chen, Qi(Zhejiang)	89	2020	0	0	0	0	0	0	0	13	30	46	1	3.11	1.00	32108390
Xu, Feng(Liaoning)	146	2018	0	0	0	0	0	7	17	26	42	53	1	3.26	0.99	29843754
Liu, Li(Guangdong)	111	2019	0	0	0	0	0	0	0	13	41	57	1	3.12	0.99	31515453
Li, Xiaolei(Jiangsu)	167	2018	0	0	0	0	0	8	26	38	44	51	1	3.34	0.99	29482595
Jiang, Yongshuai(Shanghai)	141	2019	0	0	0	0	0	0	2	16	43	79	1	3.15	0.98	30888929
Yang, Wei(Shanghai)	360	2016	0	0	0	18	38	45	31	60	78	90	1	3.28	0.98	26982734
Duan, Fei(Hebei)	101	2017	0	0	0	0	3	12	16	20	24	25	1	2.77	0.97	28107662
Kwok, Gerry(Hong Kong)	129	2016	0	0	0	0	4	6	16	20	38	45	1	2.76	0.97	27398650
Zhang, Yu-Xue(Anhui)	97	2019	0	0	0	0	0	0	11	24	28	34	1	2.74	0.97	30943039
Zhou, Xiaoxiang(Beijing)	101	2020	0	0	0	0	0	0	0	11	42	48	1	3.26	0.97	32306958
Bai, Rilan(Jilin)	123	2020	0	0	0	0	0	0	0	4	48	71	1	3.16	0.96	32864131
Hu, Xueting(Beijing)	96	2020	0	0	0	0	0	0	0	10	41	45	1	3.13	0.96	32094452
Zhang, Yuanyuan(Beijing)	306	2020	0	0	0	0	0	0	0	4	112	190	1	3.55	0.95	32612154
Zhang, Zhen(Henan)	112	2020	0	0	0	0	0	0	0	21	45	46	1	3.22	0.95	32117960
Xu, Jun(Jiangsu)	145	2020	0	0	0	0	0	0	0	1	55	89	1	3.21	0.95	33139933
Xia, Yuqiong(Shaanxi)	188	2020	0	0	0	0	0	0	0	1	68	117	1	3.32	0.95	32856350
Wang, Yingying(Guangdong)	96	2020	0	0	0	0	0	0	0	1	39	56	1	3.06	0.95	32746880
Shi, Wei-Ye(Beijing)	101	2016	0	0	0	0	8	9	17	20	24	24	1	2.8	0.95	27735841
Chen, Qian(Jiangsu)	125	2019	0	0	0	0	8	9	17	20	24	24	1	2.77	0.95	31589233
Li, Xin(Shanghai)	96	2019	0	0	0	0	0	0	1	15	40	40	1	3.19	0.95	31616443

■ : increasing trend; BS: burst strength; Burst spot: red font; Burst point: at the beginning of numbers in red font; Number: citations observed over the years; Growth: correlation coefficient between citations and the corresponding series of years over the last 4 years; PMID: PubMed unique identifier; Author: 1st author of the article

Figure 11. Articles worth reading using the temporal heatmap to display.

5. Conclusion

With our bibliometric analysis using the THM, researchers would be able to gain a better understanding of the trends and articles worth reading in the ICBB field. At the beginning of this century, the number of publications in CHT was quite small, without obvious research trends, but has grown steadily in the past 4 years. Over the past 2 decades, Beijing, Shanghai, and Guangdong have been the most prolific regions in China. A total of 20 T100ICBM articles were recommended for readers based on their consecutive growth in citations over the last 4 years. In summary, ICB for melanoma is an important, fast-growing, and high-profile topic that will benefit from increased research. In future bibliographies, it is recommended to use the THM that can be used to highlight articles that are worth reading based on the DDPP model proposed in this study.

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