

Visual Mapping and Future Direction of Marine Products Supplementary and Chemotherapy in The Treatment of Breast Cancer. A Bibliometric

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ABSTRACT

Marine products have gained attention for their potential benefits in the treatment of breast cancer, offering an alternative or supplementary approach to traditional therapies. While they are not intended to replace established medical treatments like chemotherapy or surgery, marine natural products have shown promise in providing symptom relief, enhancing the quality of life, and potentially improving treatment success for breast cancer patients. Studies have explored the use of marine products in conjunction with chemotherapy for their palliative care benefits and as adjuvants to conventional therapies. Marine-derived compounds have been investigated for their anticancer properties, including apoptosis induction, anti-proliferative effects, and modulation of signaling pathways involved in breast cancer progression. These natural products offer a complementary avenue for managing breast cancer, potentially enhancing treatment outcomes, and addressing therapeutic challenges. The utilization of marine products in breast cancer therapy dates back to ancient times when various cultures recognized the therapeutic benefits of plants, herbs, and marine resources. The purpose of this study is to visually map and guide future research on supplementary marine products and chemotherapy in breast cancer based on bibliometric analysis.

Keywords: Marine products, Chemotherapy, Breast cancer, Anticancer, Visual mapping, Bibliometric.

INTRODUCTION

Marine products have gained attention for their potential benefits in the treatment of breast cancer, offering an alternative or supplementary approach to traditional therapies. While they are not intended to replace established medical treatments like chemotherapy or surgery, marine natural products have shown promise in providing symptom relief, enhancing the quality of life, and potentially improving treatment success for breast cancer patients. Studies have explored the use of marine products in conjunction with chemotherapy for their palliative care benefits and as adjuvants to conventional therapies. Marine-derived compounds have been investigated for their anticancer properties, including apoptosis induction, anti-proliferative effects, and modulation of signaling pathways involved in breast cancer progression. These natural products offer a complementary avenue for managing breast cancer, potentially enhancing treatment outcomes, and addressing therapeutic challenges. The utilization of marine products in breast cancer therapy dates back to ancient times when various cultures recognized the therapeutic benefits of plants, herbs, and marine resources. The purpose of this study is to visually map and guide future research on supplementary marine products and chemotherapy in breast cancer based on bibliometric analysis.

MATERIALS AND METHODS

Data collection

The data used in this study were retrieved and downloaded from Scopus on April 03, 2024. We used the following search formula: #breast cancer OR breast tumor# AND marine product

OR chemotherapy. After removing the literature irrelevant to the study, we observed 341 papers (with no duplicates). The retrieved documents were saved in a CSV format.

Data analysis

The bibliometric data analysis used all CSV files. Afterward, we visualized those data analyses using VOSviewer software. VOSviewer was used to visualize the co-authorship network of countries/institutions, co-citation analysis of sources, and co-occurrence of keywords. Hence, we generate publication maps, country maps, author maps, or journal maps based on keyword maps by VOSviewer.

RESULTS

A total of 341 documents related to marine products supplementary and chemotherapy in the treatment of breast cancer were retrieved; this includes 225 articles, 100 reviews, three short surveys, three conference papers, four editorials, 1 note, three book chapters, one erratum and one retracted (Table 1).

Table 1. The primary search results by document type.

Document Type	Records
Article	225
Review	100
Short survey	3
Conference paper	3
Editorial	4
Note	1
Book chapter	3
Erratum	1
Retracted	1
Total	341

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Six thousand eight hundred eighty-seven citations have been recorded for all publications, with the highest citation in 2010, with the number 1,415 (Figure 1).

This line graph represents the Annual Citation Index from 1996 to 2014. The vertical axis indicates the number of citations, while the horizontal axis represents the years. Steady Growth (1996-2009): The graph shows a generally steady increase in citations from 1996 (443 citations) to 2009 (605 citations) with some fluctuations. Peak in 2010: There was a significant spike in 2010, with citations reaching 1,415, indicating a possible publication or event that drew considerable academic attention. Drop and Recovery (2010-2014): After the peak in 2010, there was a sharp decline in 2010 to 516 citations. The index then shows a recovery, reaching 1,350 citations in 2014.

This bar graph represents the number of publications per year from 1978 to 2024. The vertical axis indicates the number of publications,

while the horizontal axis represents the years. Early Years (1978-1999): There are sporadic publications with generally low numbers, mainly between 0 to 3 publications per year. Gradual Increase (2000-2009): Starting from the early 2000s, there is a gradual increase in the number of publications, reaching up to 10 by 2009. Significant Growth (2010-2022): From 2010 onward, there is a noticeable increase in publications, peaking at 35 in 2022. This period shows a consistent growth trend, indicating rising research activity or interest in the field. Recent Decline (2023-2024): There is a decline in publications in 2023 and a sharp drop in 2024, suggesting a possible reduction in research output or a shift in focus. We used searching range from 1978 to 2024. However, the first relevant result was from 1978 (Figure 3 and Table 2).

Understanding the evolution of research output over the years is crucial for academics, institutions, and policymakers. This analysis delves into the number of academic publications from 1978 to 2018, highlighting significant trends and patterns that can inform future research strategies.

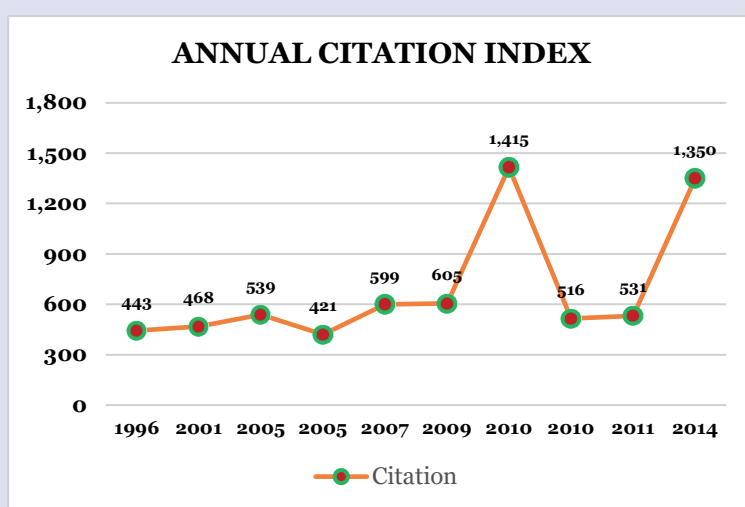


Figure 1. Annual citation trends. The x-axis indicates the year, and the y-axis is the citation frequency.

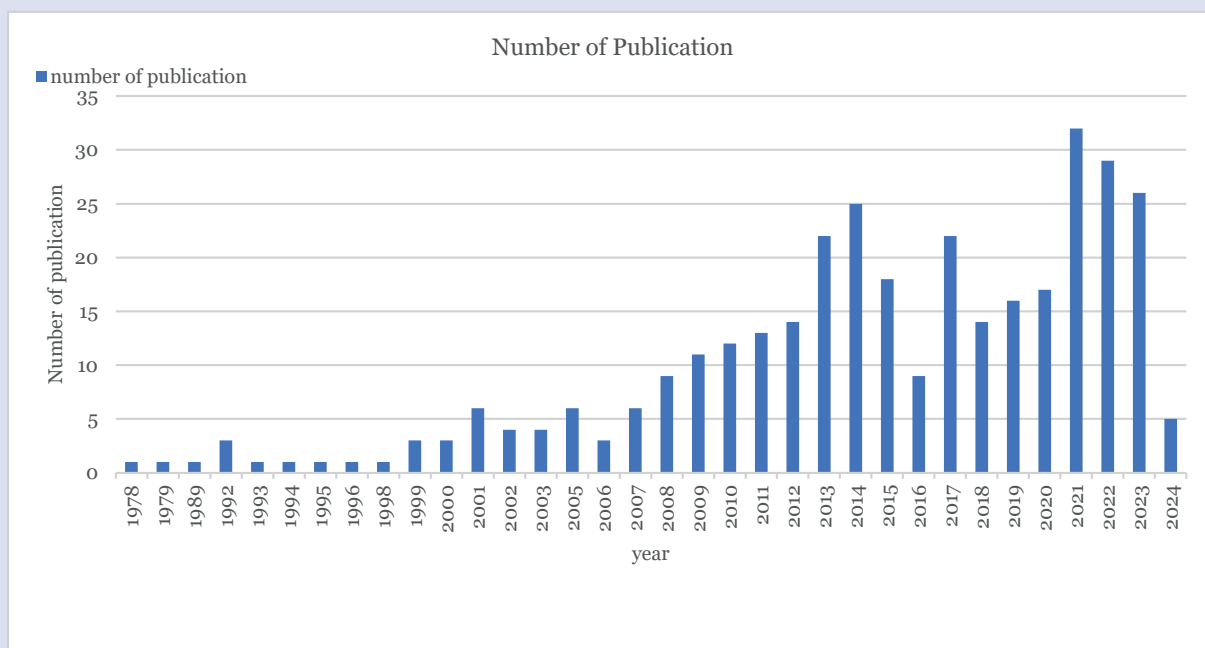


Figure 2. The annual publication X-axis indicates the year of publication. The Y-axis shows the number of publications.

- *Historical Overview of Research Publications (1978-2018)*

Academic publications serve as a barometer for scientific and scholarly progress. The data spanning four decades reveals notable fluctuations and growth in the volume of research output.

- *The Early Years: Limited Output (1978-1999)*

The number of publications from 1978 to the late 1990s remained relatively low. The first recorded year, 1978, saw just one publication, a number that did not change until 1989. The following years, 1992 and 1993, showed a slight increase, with three and one publication, respectively. The number of publications stayed minimal, fluctuating between one and three annually until the end of the 20th century.

- *Turn of the Century: Gradual Increase (2000-2009)*

The early 2000s marked the beginning of a steady increase in academic publications. Two thousand records show three publications, which doubled to six by 2001. This growth trend continued, albeit slowly, throughout the decade. By 2009, the number of publications had risen to 11, indicating a growing emphasis on research and academic output.

- *A Surge in Research Output: The 2010s*

The 2010s witnessed a dramatic surge in the number of academic publications. Starting with 12 records in 2010, the number of publications climbed each year, reaching 25 by 2014. This trend, however, saw a slight dip in 2015, with 18 publications. The subsequent years demonstrated fluctuations but maintained higher outputs than previous decades, with notable peaks in 2013 and 2017, with 22 publications.

- *Top 10 Journals by Volume*

This table presents the top 10 journals ranked by the volume of publications. The data highlights the number of records or articles published by each journal. Here is a breakdown and interpretation of the data (Table 3):

1. **Marine Drugs** leads with a significant margin, publishing 55 records. This indicates its intense focus and substantial contributions to its field.
2. **Molecules** follows with 12 records, demonstrating a lower, yet still substantial, publication volume.

Table 2. The year and the number of publications.

Year	Records	Year	Records	Year	Records	Year	Records
1978	1	1996	1	2005	6	2012	14
1979	1	1998	1	2006	4	2013	22
1989	1	1999	3	2007	6	2014	25
1992	3	2000	3	2008	9	2015	18
1993	1	2001	6	2009	11	2016	9
1994	1	2002	4	2010	12	2017	22
1995	1	2003	4	2011	13	2018	14

Table 3. Top 10 journals by volume.

Journals	Records
Marine Drugs	55
Molecules	12
Journal of Natural Products	9
Bioorganic and Medicinal Chemistry Letters	8
Journal of Medicinal Chemistry	6
Investigational New Drugs	6
International Journal of Molecular Sciences	6
European Journal of Medicinal Chemistry	5
Cancer Research	5
Biomolecules	5

Table 4. Ten most used keywords by occurrences.

Keyword	Occurrences
Human or humans	507
antineoplastic agent	230
Antineoplastic Agents	118
Female	194
article	183
breast cancer	164
antineoplastic activity	159
Apoptosis	139
Cell Proliferation	117
natural product	110

3. **Journal of Natural Products** and **Bioorganic and Medicinal Chemistry Letters** have 9 and 8 records, respectively, indicating their active roles in their respective research areas.
4. Three journals, **Journal of Medicinal Chemistry**, **Investigational New Drugs**, and **International Journal of Molecular Sciences**, each have published six records showing moderate research activity.
5. The bottom three journals in this list, **European Journal of Medicinal Chemistry**, **Cancer Research**, and **Biomolecules**, have 5 records each. While their publication volumes are lower, they still contribute significantly to their fields.

This table lists the top ten most frequently occurring keywords in research articles, providing insight into the predominant topics and areas of focus in the field. Humans or humans appear most frequently, with 507 occurrences highlighting the centrality of human-related research. Antineoplastic agents and Antineoplastic Agents combined for 348 occurrences, indicating a significant focus on cancer treatment research. Female and Breast cancer, with 194 and 164 occurrences, respectively, suggest a notable emphasis on gender-specific health issues, particularly breast cancer. An article with 183 occurrences likely reflects the inclusion of this keyword in the metadata of research articles. Antineoplastic activity, Apoptosis, Cell Proliferation, and Natural product indicate active areas of investigation in cancer biology and treatment mechanisms.

DISCUSSION

The bibliometric properties of 341 publications that met the inclusion criteria of the research study were analyzed in this study. It was found that there has been a growing trend, as in Figure 3.

This keyword occurrence visualization map is created using VOSviewer, which displays the relationships and co-occurrences of various keywords in a dataset. Keywords are grouped into clusters based on their co-occurrence patterns, indicating different research themes or topics. The map uses circles and lines to represent keywords and their connections.

- **Key Elements:**

Clusters: The map is divided into clusters, each represented by a different color. Each cluster groups related keywords frequently appearing in the same context or research papers.

Cluster 1 (Red): Includes keywords like "cytotoxicity," "apoptosis," "anticancer," and "marine natural product." This cluster seems to focus on the toxic effects of substances, mechanisms of cell death, and natural compounds with potential anticancer properties. **Cluster 2 (Green):** Contains keywords such as "breast cancer," "chemotherapy," "ovarian cancer," and "drug development." This cluster centers around cancer research and related therapeutic strategies, specifically

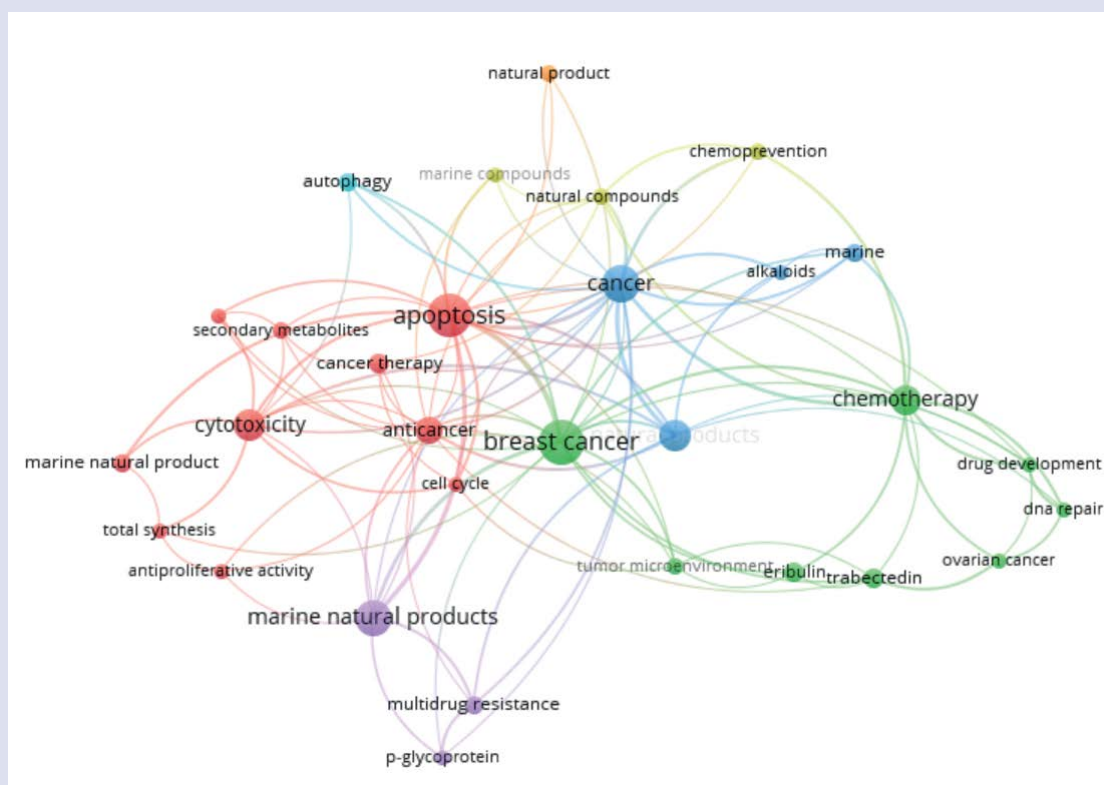


Figure 5. Network visualization of the keywords.

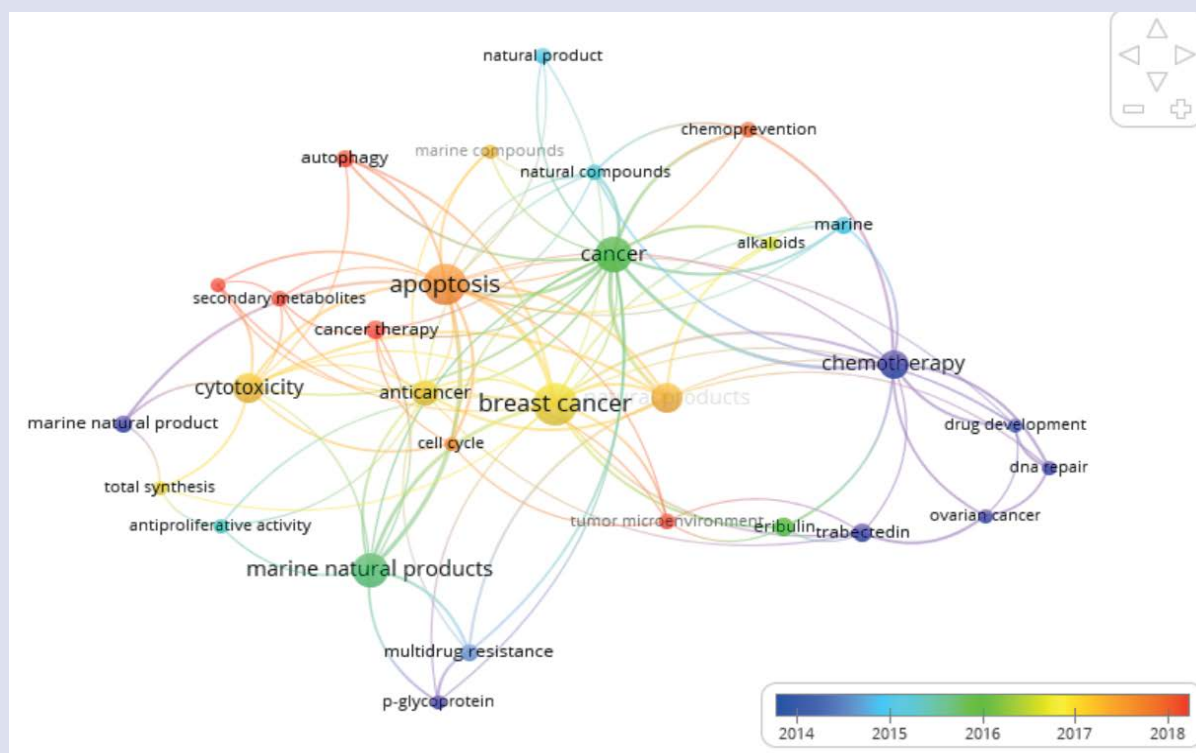


Figure 6. The visualization map of the keywords overlay by year.

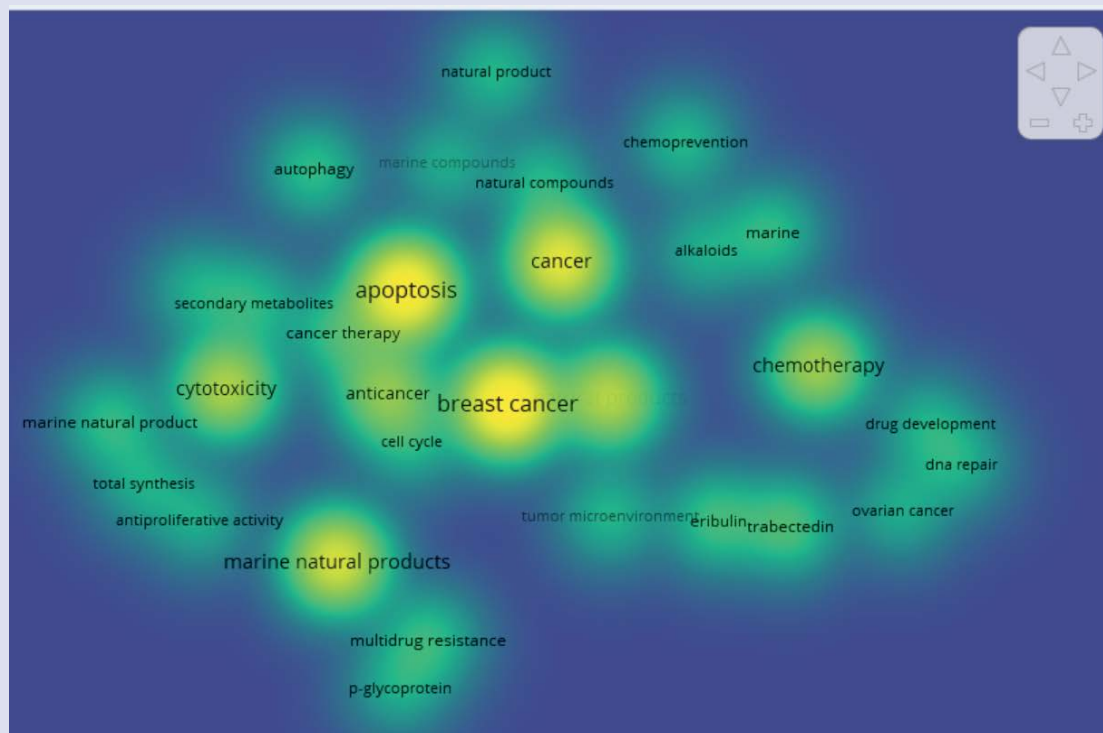


Figure 7. The visualization map of the density of keywords.

breast and ovarian cancers. Cluster 3 (Blue): Includes keywords like "cancer," "chemoprevention," and "natural compounds." This cluster likely focuses on cancer prevention and using natural compounds in cancer treatment. Cluster 4 (Yellow): Features keywords such as "natural product," "secondary metabolites," and "marine compounds." This cluster seems to focus on natural products and their derived compounds, particularly those from marine sources.

- **Keyword Connections:**

Lines between keywords represent their co-occurrences. Thicker lines indicate stronger relationships or more frequent co-occurrences, signifying a closer connection between those research areas.

- **Weights and Labels:**

The circles and the labels' font size indicate the frequency of keyword occurrences. Larger circles and labels correspond to keywords that appear more frequently in the dataset.

- **Density Visualization:**

The map also allows for density visualization, which helps identify dense areas of research activity by showing where keywords are heavily clustered together.

The visualization map generated by VOSviewer illustrates the network of scientific publications by different countries. Here is a breakdown of the key elements:

- **Nodes (Circles):**

Each circle represents a country involved in the publications. The size of each node indicates the number of documents (publications) from that country. Larger nodes signify a higher volume of publications.

- **Links (Lines):**

The lines connecting the nodes represent collaborative relationships between countries. The more frequent the collaboration, the thicker and more numerous the lines.

- **Clusters (Colors):**

Countries are grouped into clusters indicated by different colors. Clusters often signify a group of countries that frequently collaborate.

For example, the United States is a large blue node, indicating high publication volume and extensive collaboration. Nearby nodes like the United Kingdom, Canada, and Australia are also blue, showing high collaboration within this group.

- **Total Link Strength:**

At the bottom, the "Total link strength" quantifies the overall strength of the connections between countries.

- **Visualization Controls:**

On the right panel, there are options to adjust the visualization scale, weight by documents, and variation in size and line representation.

- **Analysis:**

The United States is the most prominent node, indicating it has the highest number of publications and collaborations. China, India, and the United Kingdom also have significant nodes, highlighting their major contributions to scientific literature. Collaboration networks reveal regional partnerships and international collaborations, with closely connected countries often having similar research interests or cooperative agreements. This visualization helps researchers and policymakers understand global research dynamics, identify key field players, and foster international cooperation.

The provided network visualization of keywords, created using VOSviewer, illustrates the relationships and co-occurrences of keywords from a set of documents. Here is an explanation of the key elements and insights derived from this visualization:

- **Nodes (Keywords):**

Each node represents a keyword used in the documents. The size of each node reflects the frequency of the keyword occurrence. Larger nodes indicate more frequently used keywords.

- **Links (Connections):**

Lines connecting nodes represent co-occurrences of keywords within the same documents. Thicker and more numerous lines indicate stronger and more frequent co-occurrence relationships.

- **Clusters (Colors):**

Nodes are grouped into clusters based on their co-occurrence patterns, indicated by different colors. Each color represents a group of keywords closely related to the literature.

For example, the green cluster is centered around "breast cancer," suggesting these keywords often appear together in breast cancer research.

- **Total Link Strength:**

The metric "Total link strength" quantifies the overall strength of the connections for a keyword, indicating how strongly it is related to other keywords.

Analysis of the Visualization:

- **Prominent Keywords:**

"Breast cancer" and "cancer" are among the most significant nodes, indicating they are widespread keywords in the dataset. "Chemotherapy" and "marine natural products" also appear as substantial nodes, showing their importance in research.

- **Cluster Insights:**

The green cluster around "breast cancer" includes keywords like "chemotherapy," "DNA repair," and "ovarian cancer," indicating a focus on cancer treatment and genetic research. The red cluster with keywords such as "apoptosis" and "cytotoxicity" suggests a focus on cellular mechanisms and the effects of treatments at the cellular level. The blue cluster centers on "marine natural products," indicating a specialized research area focusing on marine-derived substances.

- **Interconnections:**

Keywords such as "cancer" act as bridges between multiple clusters, showing their broad relevance across different research themes. The connections between "marine natural products" and keywords like "antiproliferative activity" and "secondary metabolites" highlight interdisciplinary research combining natural products with pharmacological studies.

The overlay visualization map of keywords by year, created using VOSviewer, provides a temporal overview of research trends based on keyword occurrences. Here is a detailed explanation of the key features and insights:

- **Nodes (Keywords):** Each node represents a specific keyword used in the documents.

The size of the node indicates the frequency of occurrences of that keyword. Larger nodes signify more frequently used keywords.

- **Colors (Year of Publication):** The color of each node represents the average publication year of documents using that keyword.

The color gradient ranges from dark blue (indicating earlier years) to yellow (indicating more recent years), based on the provided legend (2014 to 2018).

- **Links (Connections):**

Lines between nodes represent the co-occurrence of keywords in the same documents. Thicker lines indicate stronger connections, i.e., keywords that frequently appear together.

Interpretation:

- **Temporal Trends:**

Keywords in dark blue are associated with older publications, while those in yellow represent more recent research. This color coding helps identify when particular research topics were prominent.

- **Emerging and Declining Topics:**

Keywords in yellow highlight emerging research areas that have gained attention in recent years. Keywords in blue or green reflect areas that were more actively researched in the past but might have seen a decline in recent years.

- **Research Evolution:**

The visualization shows how interest in specific keywords has evolved. For instance, the central position and larger size of "breast cancer" and "cancer" indicate these are consistently prominent topics. Their color can show shifts in focus over the years.

Example Insights:

- **Established Topics:**

"Apoptosis," "cytotoxicity," and "marine natural products" are shown in colors indicating earlier research focus, suggesting these topics were more prominent in previous years.

- **Recent Focus:**

Keywords like "chemotherapy," "drug development," and "DNA repair" are in lighter colors, indicating recent interest and newer research efforts in these areas.

The overlay visualization map is a powerful tool for understanding the temporal dynamics of research trends. It helps identify emerging topics, assess the evolution of established research areas, and guide future research directions by highlighting gaps and recent trends in the literature.

A keyword density visualization map is a graphical representation of the frequency and distribution of keywords within a body of literature. This map type helps identify high and low research activity areas based on keyword occurrences. Here is a detailed explanation:

- **Nodes (Keywords):** Each node represents a keyword.

The node's size is proportional to the frequency of that keyword's occurrence in the documents analyzed.

- **Color Gradients (Density):**

The color gradient on the map indicates the density of keyword occurrences. Areas with high keyword density (frequent co-occurrence of keywords) are typically shown in warmer colors such as red or yellow. Areas with low keyword density are shown in more excellent colors, such as blue or green.

- **Clusters:**

Keywords that frequently appear together form clusters, indicating related research topics or areas. Larger clusters represent significant research areas, while smaller clusters indicate more specialized or niche topics.

Interpretation:

- **Identifying Research Hotspots:**

Regions with warm colors (e.g., red) highlight research hotspots with a high concentration of related keywords, suggesting intensive research activity in those areas.

- Gaps in Research:

Cooler areas (e.g., blue) indicate gaps where less research activity is observed, potentially highlighting opportunities for further investigation.

- Trends and Relationships:

The proximity and connections between keywords can reveal how different research topics are interrelated. Keywords within the same cluster are closely related, showing common themes or subfields.

Example Insights:

- High-Density Areas:

Keywords like "breast cancer," "apoptosis," and "chemotherapy" might form a dense cluster, indicating a strong research focus in oncology.

- Emerging Topics:

Small but growing clusters might identify new or emerging research areas. A keyword density visualization map is a powerful tool for bibliometric analysis, providing insights into the structure and dynamics of research fields. It highlights well-established research areas and emerging trends, helping researchers and policymakers make informed decisions about future research directions. The benefits and potential of acupuncture for several diseases in pediatric patients are promising, and no adverse side effects have been reported.

Discussion:

- Fluctuations in Data:

There are notable fluctuations, particularly in the dual data points for 2005 and 2010, which may need verification. Trend Analysis: Overall, the trend indicates a positive growth in citation indices, peaking significantly in 2010 and 2014.

- Potential Data Issue:

The repeated years (2005 and 2010) suggest there may be a need to check the data source for accuracy. Trend Analysis: Overall, there is a clear upward trend in the number of publications over the years, with notable peaks and troughs.

- Data Consistency:

The graph effectively shows the trend, but the sudden drop in 2024 may require further investigation or context to understand the cause.

Analyzing the Growth Patterns

The data showcases a clear upward trajectory in research publications from 1978 to 2018. Several factors could contribute to this trend, including advancements in technology, increased funding for research, and a growing number of academic institutions worldwide.

This visualization helps in understanding the structure and relationships within a research field. It reveals critical areas of focus, prominent research topics, and how different themes are interconnected. For instance, the strong connections between "breast cancer" and "chemotherapy" highlight significant research activity in cancer treatment strategies. Such maps are useful for identifying research trends, gaps, and potential areas for further investigation. They provide a comprehensive overview of the landscape of a particular field, aiding researchers in navigating the vast amount of information efficiently.

This distribution can indicate journal scope, research funding, and the number of submissions received. The use of natural products has numerous strengths that make it an ideal solution to contribute to fighting the global health problem of breast cancer. One advantage is the knowledge and experience of thousands of traditional medicines

in discovering and employing bioactive natural products or their combinations. Furthermore, those treatments are often less expensive than current pharmaceutical developments, dependent on significant investments. Hence, adapting and combining natural products and remedies with modern medicine solutions can contribute to obtaining improved therapies with synergistic effects and a considerable cost reduction. Another advantage is that current treatments such as chemo- or radio-therapies focus on treating the tumor, leaving other healthy organs exposed to side effects. Natural products offer less detrimental treatments to the rest of the organs and tissues. Marine natural products have been investigated for their synergistic effects with chemotherapy, providing a complementary strategy to conventional treatments. By combining natural products with modern medicine solutions, researchers aim to develop improved therapies with enhanced efficacy and reduced adverse effects.^{1,2}

Marine natural products have gained attention for their potential benefits in the treatment of breast cancer, offering an alternative or supplementary approach to traditional therapies. While treatments like chemotherapy and surgery remain crucial in managing breast cancer, incorporating marine products into treatment has shown promise in providing symptom relief, enhancing the quality of life, and improving treatment success.³

Palliative care plays a significant role in the treatment of advanced breast cancer patients, offering relief from physical manifestations of the disease and contributing to a higher quality of life. Endocrine adjuvant therapy, including hormonal therapy, remains a cornerstone in breast cancer treatment, emphasizing the importance of various treatment modalities in managing the disease.⁴

Studies have highlighted the clinical importance of palliative care for metastatic breast cancer patients, showcasing its role in improving quality of life, reducing depression rates, and potentially enhancing survival outcomes. Palliative care has been associated with facilitating less aggressive end-of-life care and maintaining or improving survival rates for patients with metastatic breast cancer.⁵ Furthermore, the integration of palliative care into standard breast cancer treatment programs has been shown to alleviate patients' suffering, emphasizing the importance of a holistic approach to breast cancer care that includes palliative interventions.⁶

In the realm of breast cancer treatment, the incorporation of marine products as supplementary agents to chemotherapy has attracted considerable attention. Marine natural products encompass a wide array of compounds that have exhibited the potential to augment the effectiveness of traditional treatments and enhance patient outcomes. Chemotherapy, notably agents like fluorouracil (5-FU), plays a pivotal role in breast cancer treatment and has significantly contributed to improving the prognosis of patients.⁷

The anti-breast cancer properties of marine products involve diverse mechanisms, including the downregulation of estrogen receptor-alpha expression, inhibition of tumor cell proliferation, migration, and angiogenesis, induction of apoptosis, and sensitization of tumor cells to radiotherapy and chemotherapy.⁷ Marine-based natural products have been investigated for their capacity to combat breast cancer resistance, focusing on mechanisms of resistance, recent clinical trials, and the therapeutic potential of marine-derived compounds.²

Secondary metabolites derived from marine sponges have demonstrated intriguing chemopreventive and chemotherapeutic characteristics, underscoring the potential of these natural products in cancer treatment.¹ Furthermore, polysaccharides from marine biological sources, such as algae and chitosan, have exhibited promise in direct treatment or auxiliary methods for managing breast cancer.⁸ While marine products offer potential advantages, it is crucial to recognize

that they are not standalone substitutes for established medical interventions like chemotherapy. The future trajectory of research in this domain entails exploring the untapped potential of marine compounds for innovative breast cancer therapeutics. Studies have underscored the need to investigate further marine-derived drugs' role in breast cancer treatment, such as trabectedin and eribulin, and the opportunities that may emerge from these natural reservoirs.⁹

The advantages of utilizing marine-derived secondary metabolites in cancer treatment lie in their potent growth inhibition of tumor cells, both in laboratory studies and in clinical trials. These compounds have demonstrated efficacy in inhibiting cancer cell proliferation, inducing apoptosis, and modulating key pathways involved in cancer progression.¹⁰⁻¹³ Moreover, marine natural products offer a rich source of bioactive compounds that can serve as epigenetic modulators, providing a unique approach to cancer therapy. The exploration of these compounds has highlighted their potential as effective agents in combating cancer through various mechanisms, including antioxidant, anti-inflammatory, and anti-cancer properties.¹⁴⁻¹⁶

The discovery of novel secondary metabolites from marine organisms, such as sponges, corals, and algae, has opened up new avenues for natural product drug discovery. These bioactive compounds have shown significant biological activities against cancer and other diseases, making them valuable resources for drug development.¹⁷⁻¹⁹

The current bibliometric analysis study on using marine natural products in treating breast cancer patients has demonstrated promising benefits with no reported adverse side effects. This study adds to the expanding literature investigating the potential of marine products as complements to traditional breast cancer treatments. The analysis likely explores citation patterns, international collaborations, and emerging research trends in marine natural products and breast cancer therapy. Marine natural products have attracted attention due to their varied bioactive compounds that possess anti-cancer properties, such as estrogen receptor expression modulation, tumor growth and metastasis inhibition, apoptosis induction, and sensitization of tumor cells to conventional therapies.⁷

Marine natural products have attracted significant attention for their diverse bioactive compounds with anti-cancer properties. These compounds, derived from various marine organisms such as algae, sponges, and cyanobacteria, have demonstrated promising effects in combating cancer through mechanisms like apoptosis induction, cell proliferation inhibition, and modulation of cancer-related pathways.^{16, 20-23}

The advantages of utilizing marine-derived secondary metabolites in cancer treatment are multifaceted. These compounds have shown potent anti-cancer effects in both *in vitro* and *in vivo* studies, displaying activity in preventing tumor formation and inducing apoptosis in cancer cells.²¹ The rich biodiversity of marine organisms offers a vast array of bioactive compounds with unique chemical structures and biological activities, making them valuable resources for drug discovery and development.^{24, 25}

Furthermore, marine natural products have been investigated for their potential as epigenetic modulators, presenting a novel approach to cancer therapy. These compounds provide a promising avenue for developing innovative and effective anticancer treatments, underscoring the importance of further research in this field.^{8, 26, 27}

The exploration of marine natural products in cancer therapy offers a unique opportunity to develop novel pharmacophores with potent anti-cancer effects. These compounds not only provide alternative treatment options but also have the potential to synergize with conventional therapies like chemotherapy, leading to improved therapeutic outcomes. Moreover, marine natural products are often cost-effective compared to

traditional pharmaceutical developments, making them an attractive avenue for cancer treatment.^{28, 29}

By combining the benefits of marine natural products with modern medicine solutions, researchers aim to obtain improved therapies with synergistic effects and a considerable reduction in costs. Additionally, the use of marine products in conjunction with chemotherapy may offer less detrimental treatments to healthy organs and tissues, thereby enhancing the overall quality of cancer care.^{2, 28, 30, 31}

The capacity of marine-derived compounds to overcome mechanisms of breast cancer resistance has been a topic of interest, emphasizing their role in enhancing treatment effectiveness.³² Furthermore, the bibliometric analysis could illuminate the research landscape concerning marine products and breast cancer, potentially identifying significant research clusters, popular themes, and emerging trends in this area. The study likely offers a comprehensive overview of scientific outputs, collaborations, and citation patterns within marine natural products and breast cancer therapy using bibliometric methods. The absence of reported adverse side effects linked to the use of marine natural products in breast cancer treatment underscores their potential as safe and effective complementary interventions. This discovery aligns with the broader exploration of natural compounds as alternative or supplementary approaches to conventional cancer therapies to enhance treatment outcomes and patient well-being.

While marine products offer potential benefits in breast cancer treatment, they are not standalone replacements for established medical interventions like chemotherapy and surgery. Palliative care, including spiritual and psychological support, plays a crucial role in enhancing the overall well-being and quality of life of breast cancer patients, especially those with advanced or metastatic disease. Integrating various treatment modalities, including marine products and palliative care, can contribute to a comprehensive approach to managing breast cancer and improving patient outcomes.³³

The bibliometric analysis study on marine natural products in breast cancer therapy indicates a growing interest in harnessing the therapeutic potential of these compounds. The lack of adverse side effects and the promising benefits observed in this analysis emphasizes the necessity for further research to elucidate the mechanisms of action, optimize treatment regimens, and potentially integrate marine products into standard breast cancer care protocols.

CONCLUSION

Bibliometric analysis was conducted on 341 articles obtained from the Scopus database to analyze research trends visually map and guide future research on supplementary marine products and chemotherapy in breast cancer. This analysis aims to get a precise picture of research topics that are interesting to do. Most publications were obtained in 2014, totaling 25 articles in identifying journals. The journal that most frequently discusses this topic is Marine Drugs Journal, which leads by a significant margin, publishing 55 records. The top ten most frequently occurring keywords in research articles provide insight into the predominant topics and areas of focus. Humans or human keywords appear most frequently, with 507 occurrences—potential future topics in this research field. Based on the research results, 2009 experienced the highest significant growth. These bibliometric findings can serve as a framework for future research, mainly focusing on the potential benefits of marine natural products in breast cancer therapy. This present bibliometric analysis study showed that the benefit and potential of marine natural products in the therapy of breast cancer patients are promising, and no adverse side effects have been reported.

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