



## Review Article

# The hot spots and global trends of prevention and treatment in postoperative delirium (POD) from 2004 to 2023: A bibliometric analysis

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## ABSTRACT

**Background:** Postoperative delirium (POD) is an acute postoperative syndrome of the central nervous system that seriously affects the prognosis of patients. Many vital advances have been made in the study of the management of POD. We conducted a bibliometric analysis of research on the prevention and treatment of POD over the past 20 years to consolidate current research focal points and emerging trends in this domain.

**Methods:** We searched the Web of Science Core Collection database for literature published between 2004 and 2023. VOSviewer, CiteSpace, Microsoft Excel, Scimago Graphica, and the R tool “bibliometrix” were used to analyze and visualize annual publications, countries, organizations, journals, authors, keywords, and references.

**Results:** A total of 1848 eligible publications were identified, with a general uptrend observed in both annual publications and citations. The USA was the most profitable country, ranking first in total publications. The most active institution was Harvard Medical School. Inouye, Sharon K was the most prolific scholar due to her numerous publications and citations. According to the co-occurrence network, the strongest citation bursts and co-cited references analysis fresh hot topics included “dexmedetomidine,” “neuroinflammation,” “haloperidol prophylaxis,” and “guideline.”

**Conclusions:** Research on prevention and treatment of POD is gaining significant momentum worldwide. Current hot spots include early perioperative prevention strategies and integrated multi-method treatments. Effective drugs for it is one of the directions in the future. The management of pediatric patients with POD has caused concern in recent years. This bibliometric analysis is poised to guide future research trajectories in this field.

## Introduction

Delirium, characterized by acute impairments in attention and cognition, represents a prevalent, detrimental, costly, and frequently life-threatening condition among the elderly [1]. Postoperative delirium (POD) is defined as a clinical entity meeting the diagnostic criteria outlined in DSM-5, manifesting within the hospital setting within one week post-surgery or before discharge [2]. The incidence of delirium ranges from 6 % to 46 % after cardiac surgery, while non-cardiac surgery patients exhibit an approximate 23.8 % incidence rate [3,4]. The clinical presentation of POD can be characterized by acute onset and fluctuating course and can be categorized into subtypes, including “hyperactive,” “hypoactive,” and mixed presentations. The hyperactive variant is

characterized by restlessness, irritability, and even rambling in about 25 % of patients, easily noticed by healthcare professionals. The hypoactive variant may be underrecognized, accounting for about 50 % of patients, which is characterized by lethargy, silence, and quietness, as well as cognitive dissociation. The mixed type accounts for about 25 % of cases, combining some clinical features of both the hyperactive and hypoactive activity types [5]. POD may lead to dementia, post-traumatic stress disorder, prolonged hospital stays, additional medical care, and even death [6]. The annual healthcare costs in the United States attributable to POD were \$32.9 billion in 2020 [7]. Many studies have been conducted on the management of POD, including diagnosis, prevention, and treatment, in the past 20 years. However, the research trends, details, and hotspots in preventing and treating POD are less reported.

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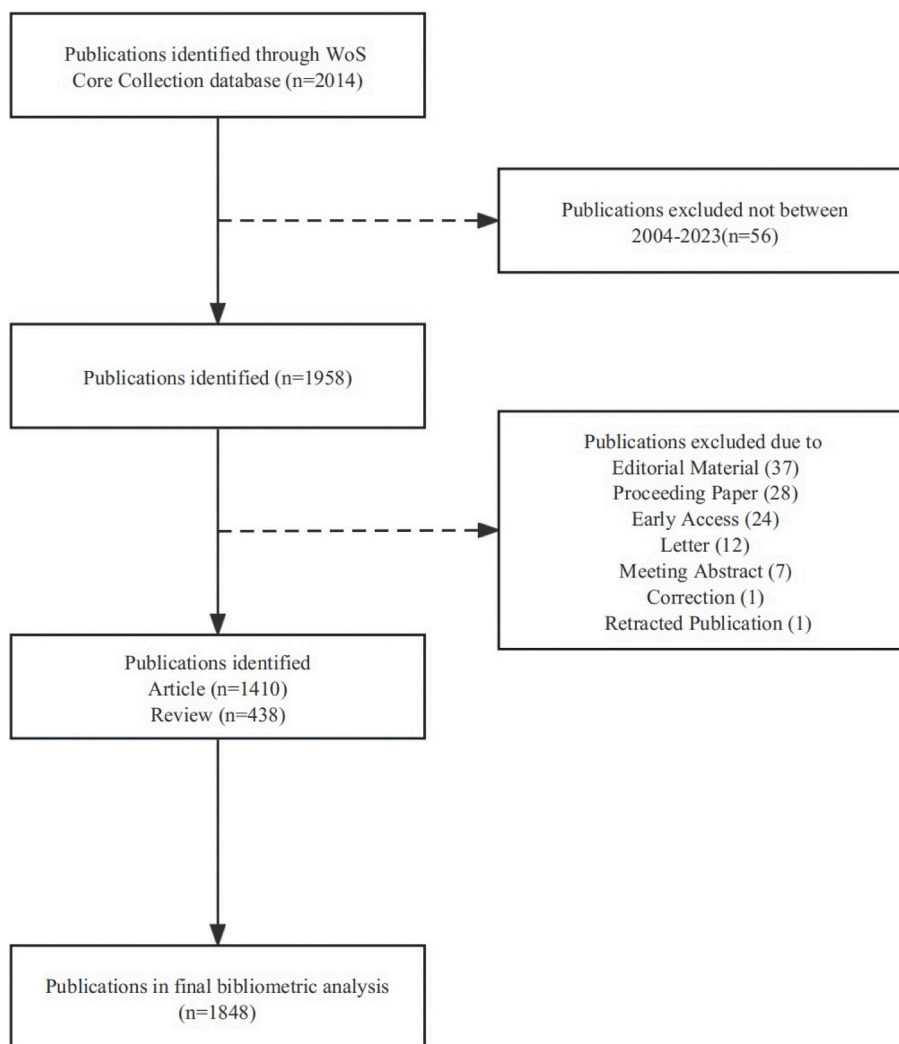
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**Fig. 1.** Flowchart for literature retrieval and screening.

Bibliometric analysis evaluates scholarly output, delineates academic frontiers, and anticipates trends within a particular research realm by drawing upon scientific literature databases and metrology attributes. It is widely accepted that bibliometric analysis can yield and provide detailed information, including but not limited to nations, institutions, authors, journals, keywords, and visual co-citation analysis. By contrast, other methodologies, including mate analysis, traditional reviews, and experimental research, need to achieve the thoroughness provided by bibliometric analysis [8]. Nevertheless, a systematic bibliometric appraisal focusing on POD prevention and treatment must be presented. Therefore, we are leveraging metric analysis software such as CiteSpace and VOSviewer to scrutinize patterns and prominent areas in the current POD prevention and treatment landscape.

## Materials and methods

### Search strategy

Web of Science (WOS) is widely regarded as a premier academic database source for bibliometric analysis [9]. Therefore, we investigated the Web of Science Core Collection (WoSCC) database for papers published between 2004 and 2023 on the prevention and treatment of POD. Our search criteria included the terms “(TS = (prevention) OR TS = (prophylaxis) OR TS = (treatment) OR TS = (therapy) OR TS = (therapeutic)) AND TS = (postoperative delirium)”. Subsequently, we

excluded Editorial Material, Letters, Meeting Abstracts, and any other document types deemed irrelevant to our study and focused on two categories: “Article” and “Review” [10]. “Article” encompassed original research pieces, while “Review” constituted surveys of research deemed authoritative. Additionally, we excluded any duplicate literature and literature published outside the specified year range of 2004 to 2023, ensuring the timeliness of our analysis. Data collection was completed with an expiration date of December 20, 2023.

### Data analysis

Various software tools and methodologies were employed to analyze the collected data, with VOSviewer and CiteSpace recognized as prominent bibliometric tools [11,12]. VOSviewer 1.6.19 was utilized to scrutinize publications from different countries, institutions, and authors alongside their collaboration networks to unveil collaboration patterns within these networks. CiteSpace 6.1.R6 facilitated the visual analysis of co-citations and provided insights into keyword trends. Moreover, the R package “bibliometrix” (version 4.1.4) was applied for the *author’s h-index* in this study field. Journal Impact Factors (IF) was obtained from Journal Citation Reports 2022. Microsoft Office Excel was used to analyze total publications and annual publications. Moreover, we also used Scimago Graphica (version 1.0.37) to visualize the international collaboration between countries.

We followed Bradford’s law to analyze journals, categorizing

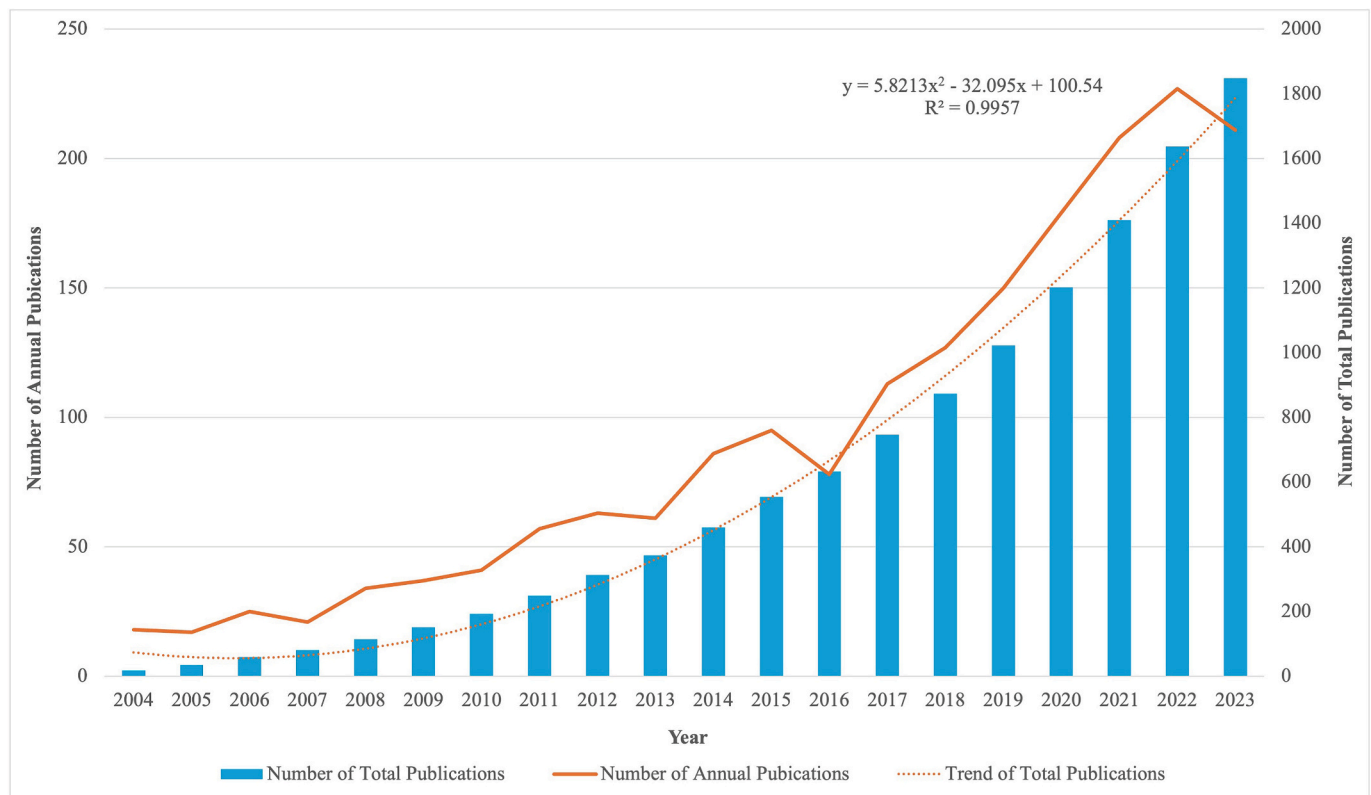


Fig. 2. Annual and total publications on the prevention and treatment of POD research. The bar chart represents the total publications. The line chart shows the annual publications. The dotted line represented the trend line for total publications. The polynomial curve fits the trend line.

scientific journals within a subject into core, related, and non-related journals based on the frequency of publications. The ratio of these categories typically adheres to a 1:n:n<sup>2</sup> ratio, with core journals being the most significant [13,14]. We referred to the following evaluation indicators for Co-Citation analysis. Modularity (Q-value) is a quantitative metric for assessing the quality of partitioning a network into clusters or modules through advanced data clustering techniques. Networks exhibiting high modularity boast robust intra-cluster connectivity, signifying strong relationships among nodes belonging to the same cluster. The silhouette score (S-value) provides a nuanced evaluation of the clustering’s overall fitness, quantifying how well a sample belongs to its designated cluster compared to neighboring clusters [15]. Expressly, Q-value > 0.3 signifies the presence of a distinct and statistically significant clustering structure. At the same time, an S-value >0.7 underscores the excellent homogeneity among members within a given cluster, indicating a tight and cohesive grouping [16].

## Results

### Publications analysis

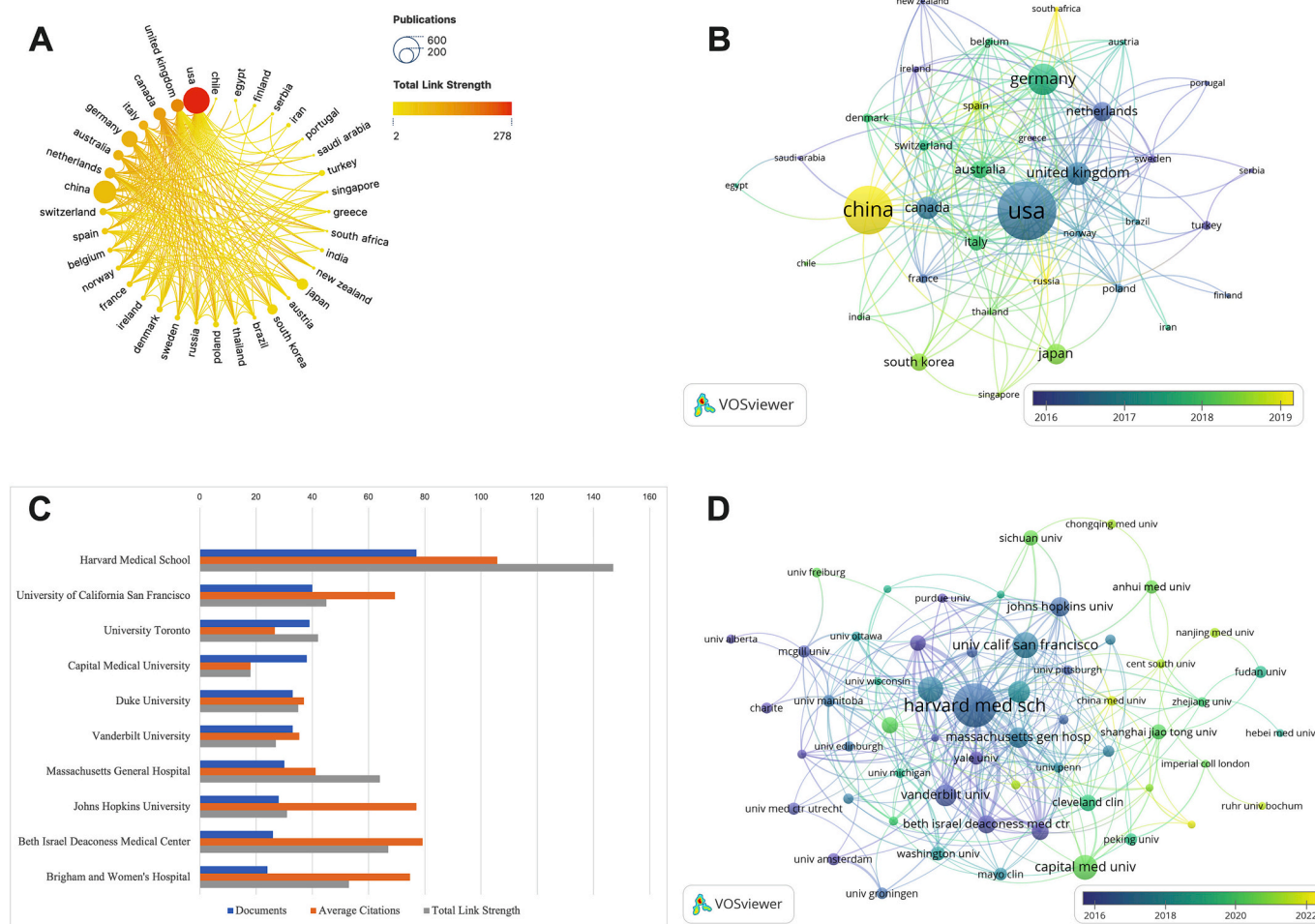
After researching the WoSCC database, we collected 2014 documents on the prevention and treatment of POD research. We eventually accepted 1848 papers for bibliometric analysis after removing those not eligible for publication years or study types. Fig. 1 depicts a complete flowchart for screening.

We collected 1848 publications published in 596 journals from January 2004 to December 2023. These papers gained 51,675 citations, averaging 27.96 per publication and an *h*-index of 104. As shown in Fig. 2, the annual and total publications were presented as line and bar charts, respectively. We also used a polynomial ( $R^2 = 0.9958$ ) to fit the trend in the total publications. The total publications in the field were steadily increasing, and based on the trend line, the total publications are expected to reach about 2000 in 2024. Except for a decline in 2012 and 2019, the annual publications showed a wave-like upward trend, and the annual publications in the past three years were >200 publications yearly. It has been discovered that research on the prevention

Table 1

The top 10 most productive countries/regions in the research of the prevention and treatment of postoperative delirium.

Rank	Country/region	Documents	Citations	Average citations	Total link strength	<i>h</i> -Index
1	USA	557	24,879	44.67	278	159
2	China	412	6375	15.47	78	59
3	Germany	207	4413	21.32	91	50
4	United Kingdom	129	6509	50.46	165	61
5	Canada	121	5365	44.34	130	76
6	Japan	104	1539	14.80	13	41
7	Netherlands	97	7019	72.36	89	67
8	South Korea	84	1483	17.65	18	29
9	Australia	83	3264	39.33	91	44
10	Italy	69	1985	28.77	96	35



**Fig. 3.** Contributions and cooperation of countries and institutions in preventing and treating POD research. (A) Distribution and cooperation among countries for research. (B) Country cooperation map related to research (threshold = 5). The node's color indicated the average year of publication, and the line thickness indicated the frequency of cooperation between countries. (C) The total number of documents, average citations, and link strength of the top 10 institutions. (D) Institutions' co-authorship network maps related to research (threshold = 10). The node's color indicated the average year of publication, and the line thickness indicated the frequency of cooperation between institutions.

and treatment of POD has reached an all-new level in recent years.

**Countries/regions analysis**

Sixty-six countries/regions were involved in preventing and treating POD-related research between January 2004 and December 2023. Table 1 shows the top ten countries/regions in terms of publications. The USA was the most productive and influential country, with 557 appropriate articles and an *h*-index of 159, followed by China, which published 412 documents. Meanwhile, the Netherlands had the most significant average citations per document, with 72.36. Fig. 3A represents international collaboration among countries. To represent total link strength, we chose different colors. Most research collaborations occurred between American, European, and Asian countries, with the USA and China collaborating the most frequently (frequency = 38). We used VOSviewer to analyze nations with more than five documents visually. Finally, 37 countries were considered for visual analysis, and Fig. 3B depicts the country cooperation map. The diameters of the nodes showed the number of publications, with the USA, China, the United Kingdom, and Germany having comparatively substantial numbers. The colors of the nodes indicated the distribution of national research tendencies throughout time, with China, Russia, South Africa, and Spain becoming increasingly active in recent years.

**Organizations analysis**

Approximately 2478 organizations contributed to the research on the prevention and treatment of POD. Fig. 3C depicted the top ten institutions, eight of which were associated with the USA, one (Capital Medical University) was based in China, and the remaining agency (University of Toronto) was located in Canada. With 77 publications, Harvard Medical School was regarded as the most productive in this domain. Publications from Harvard Medical School were referenced 105.78 times on average, significantly more than other institutions. Organizational co-authorship analysis might assess linkages between institutions based on the number of coauthored articles. As shown in Fig. 3D, a collaborative network of 61 organizations with a minimum of 10 publications was built based on each institution's total number and relationship of publications. Harvard Medical School and Beth Israel Deaconess Medical Center collaborated closely, and there was substantial collaboration between Capital Medical University and Peking University. Furthermore, we observed that Chinese institutes have undertaken more studies in this sector and have collaborated closely in recent years.

**Journals analysis**

From 2004 to 2023, 596 journals issued articles on the prevention



**Table 2**

The top 15 most productive journals in the research of the prevention and treatment of postoperative delirium.

Rank	Sources	Documents	Impact factor (2022)	Journal citation reports (2022)	Country
1	BMJ Open	38	2.9	Q2	England
2	Anesthesia and Analgesia	35	5.9	Q1	USA
3	Journal of the American Geriatrics Society	34	6.3	Q1	USA
4	Medicine	30	1.6	Q3	USA
5	British Journal of Anaesthesia	29	9.8	Q1	England
6	Current Opinion in Anesthesiology	29	2.5	Q3	USA
7	Plos One	29	3.7	Q2	USA
8	Trials	29	2.5	Q3	England
9	Journal of Cardiothoracic and Vascular Anesthesia	28	2.8	Q3	USA
10	BMC Anesthesiology	23	2.2	Q3	England
11	Journal of Clinical Anesthesia	23	6.7	Q1	USA
12	BMC Geriatrics	21	4.1	Q2	England
13	Journal of Clinical Medicine	21	3.9	Q2	Switzerland
14	Pediatric Anesthesia	21	1.7	Q4	England
15	Anesthesiology	20	8.8	Q1	USA

Note: JCR classifies the journals into Q1–4 according to the IF of the journal in the current years. The journal with the top 25 % (including 25 %) impact factors is Q1. Journals with IF ranging from 25 % to 50 %, 50 % to 75 %, and after 75 % are Q2, Q3, and Q4, respectively.

**Table 3**

The top 10 influential authors in the prevention and treatment of postoperative delirium.

Rank	Authors	Documents	<i>h</i> -Index	Local citations
1	Inouye, Sharon K	32	24	1090
2	Marcantonio, Edward R	22	15	462
3	Claudia Spies	15	8	203
4	Niccolò Terrando	11	9	114
5	Zhongcong Xie	11	8	38
6	Daniel I. Sessler	11	10	119
7	Neufeld, Karin J	10	9	171
8	Fong, Tamara G	9	9	343
9	E. Wesley Ely	9	8	48
10	Mervyn Maze	9	8	176

and treatment of POD. According to Bradford's law, we studied the core journals in this field, as Additional File 1 showed. This analytical approach provided us with 29 core journals. For further investigation, we exhibited the top 15 journals with the largest publications, their Journal Impact Factors (IF), Journal Citation Reports (JCR), and the countries where the publisher was located. Journals of Q1–4 have undergone peer review and editorial screening, and journals defined as Q1 or Q2 indicate higher quality journals. Trials to be published in Q1 and Q2 journals require more rigorous design and implementation. Table 2 showed that the top 15 most productive journals produced 410 papers on this subject, accounting for 22.18 % of 1848 publications. The most active journal was BMJ Open, which had 38 papers, followed by Anesthesia and Analgesia ( $n = 35$ ). Furthermore, the journal with the greatest IF was the British Journal of Anaesthesia, 9.8(2022). The majority of the journals were classified as Q1 ( $n = 5$ ), Q2 ( $n = 4$ ), and Q3 ( $n = 5$ ), with only one journal classified as Q4. Eight of the top fifteen journal publishers were from the USA, six were from England, and one was from Switzerland.

with only one journal classified as Q4. Eight of the top fifteen journal publishers were from the USA, six were from England, and one was from Switzerland.

### Authors analysis

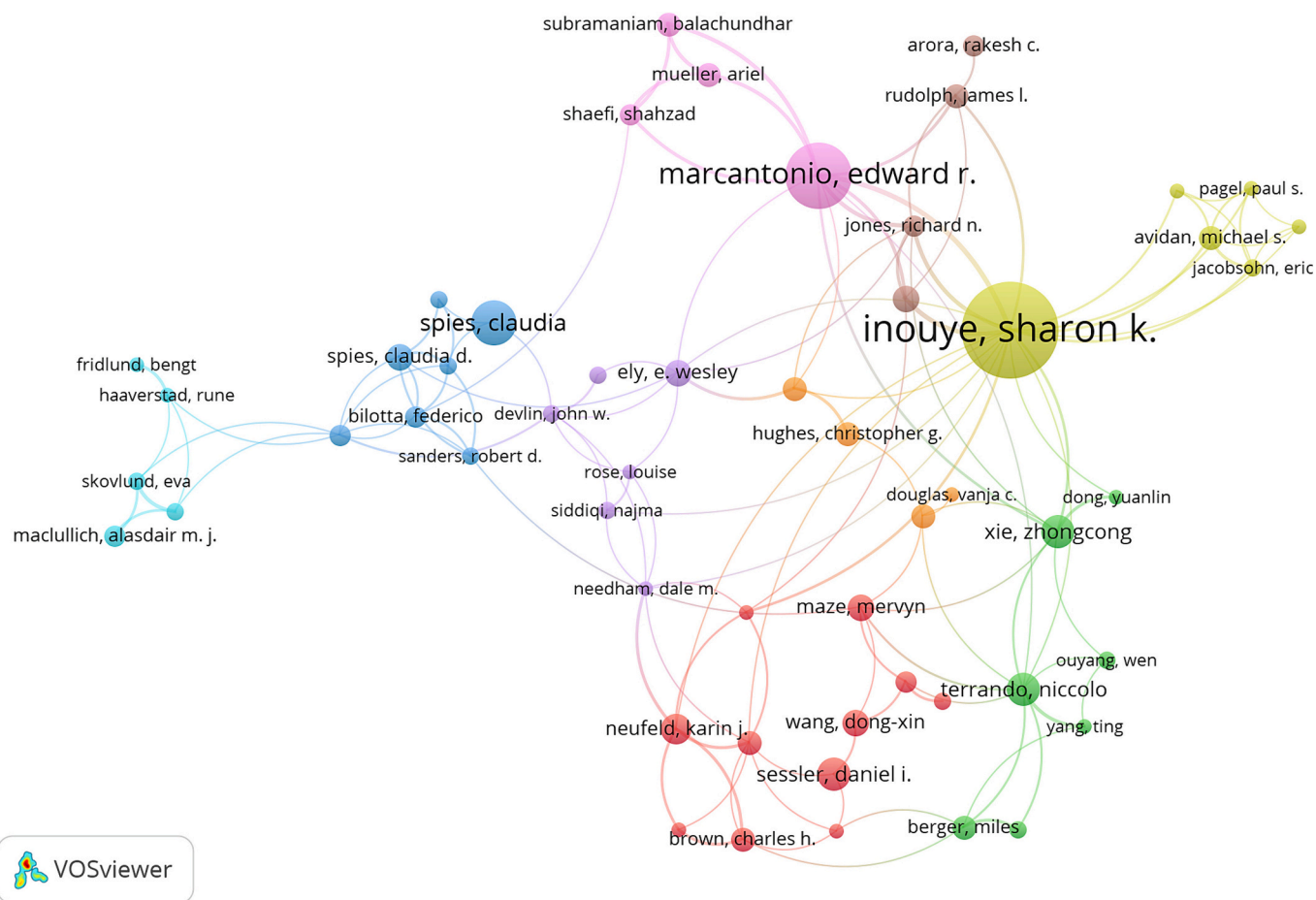
Between 2004 and 2023, 9491 writers participated in preventing and treating POD research. We counted the publications of the top ten scholars in the field in Table 3. Inouye, Sharon K of Harvard Medical School in the United States was the most productive and prominent author, with 32 publications and an *h*-index of 24. She also had the most citations in this field, with 1090. Closely followed by Marcantonio, Edward R. with 22 published articles. To reveal information about the study field's representative academics, we created a collaborative network based on authors with more than five published publications, as shown in Fig. 4. Some of the network's 26 writers were disconnected, we only displayed 54 authors. A cluster of the same color indicates close collaboration of authors within it, and the connecting lines between the dots represent communication between scholars. Inouye, Sharon K, and Marcantonio, Edward R., had the most vital relationship, with a link strength 10.

### Keywords analysis

Keywords summarize the core of an article and keyword co-occurrence analysis may find research hotspots in the topic. We found 5132 keywords related to the prevention and treatment of POD. As shown in Fig. 5A, we counted the top 10 keywords that appeared frequently in the article and created a funnel chart. We then mapped the co-occurrence network on 237 keywords with at least 15 occurrences as shown in Fig. 5B. The detected keywords were grouped into three clusters and the same-colored nodes indicated that these keywords were in the same cluster. Cluster 1 (blue) refers to treatment which includes "therapy," "oxidative stress," and "quality-of-life." Cluster 2 (green) was primarily connected with risk factors such as "older patients," "sub-syndromal delirium," and "dementia." Cluster 3 (red) was mainly linked with prevention such as "dexmedetomidine," "bispectral index," and "general anesthesia." We used CiteSpace to subdivide the keyword clusters in Fig. 5C which showed a graphic representation of the transformation of keywords over time to assist researchers in understanding the hotspots in the field and the progress of research in the time dimension. The horizontal axis represents different clusters the color of the dots represents the year in which the keywords appeared and the size of the dots represents the number of relevant literature. Fig. 5C shows the change of keywords over time from left to right. Lastly, we glanced at this study's top 25 burst keywords (Fig. 5D). "Burst keywords" refer to the phenomenon in which any keyword appears repeatedly in just a brief time with the red band in the figure. These data did not just show the evolution of research areas of most significant concern; they indicated recent research trends and might foreshadow future directions. The top five keywords with the most bursts were "mechanically ventilated patient," "intensive care unit," "haloperidol prophylaxis," "randomized controlled trial," and "acute confusional states." Moreover, the latest burst keywords were "neuroinflammation" and "guideline."

### Co-citation analysis

When a third publication references two references, they set up a co-citation connection. The frequency of citations might show the influence of papers in a specific study field, and co-citation analysis was an effective technique for assessing the most widely cited publications [17]. Table 4 offered the greatest ten references regarding co-citations, along with their authors, journal, IF(2022), QCR(2022), and co-citation times. They were all published between 1990 and 2014 and arrived in the JCR Q1 division. 60 % of these studies had an IF more significant than 100 and were published in journals such as the Lancet, New England Journal



**Fig. 4.** Authors co-authorship network maps. A network map of cooperation among authors that have collaborative relationships. The nodes of the same color represented the same cluster, and authors within the same cluster collaborated closely together. The line thickness indicated the frequency of cooperation between authors.

of Medicine, and JAMA, with far-reaching effects. In particular, the paper entitled “Clarifying Confusion: The Confusion Assessment Method. A new method for detecting delirium,” published in 1990, was the reference with the most co-citations on this topic, with 377 co-citations [18]. Then, we produced the visualized networks of the cited references using CiteSpace, illustrated in Fig. 6A. The publication date of the reference was indicated by the nodes that appear in various colors. The circle surrounding the node indicated the significance of references in this area. The size of the node showed the frequency at which references were cited. Moreover, cluster analysis was carried out based on the co-correlation analysis, which discovered 17 primary clusters with significant advantages of modularity ( $Q = 0.7216$ ) and silhouette scores ( $S = 0.8665$ ). The results of the cluster analysis were highly trustworthy. Cluster 0 was among the largest, called “post-operative delirium,” followed by Cluster 1, named “intensive care unit.” Additional file 2 contained further information on all clusters. References with citation bursts are those that scholars constantly reference in a specific topic throughout time [19]. We used CiteSpace to discover 25 references with high citation bursts in our investigation. The red band in Fig. 6B means high citation burstiness. The reference with the most significant number of citations burst (strength = 48.47) was named “Delirium in Elderly People” and was written by Inouye, Sharon K et al. with citation bursts ranging from 2015 to 2019.

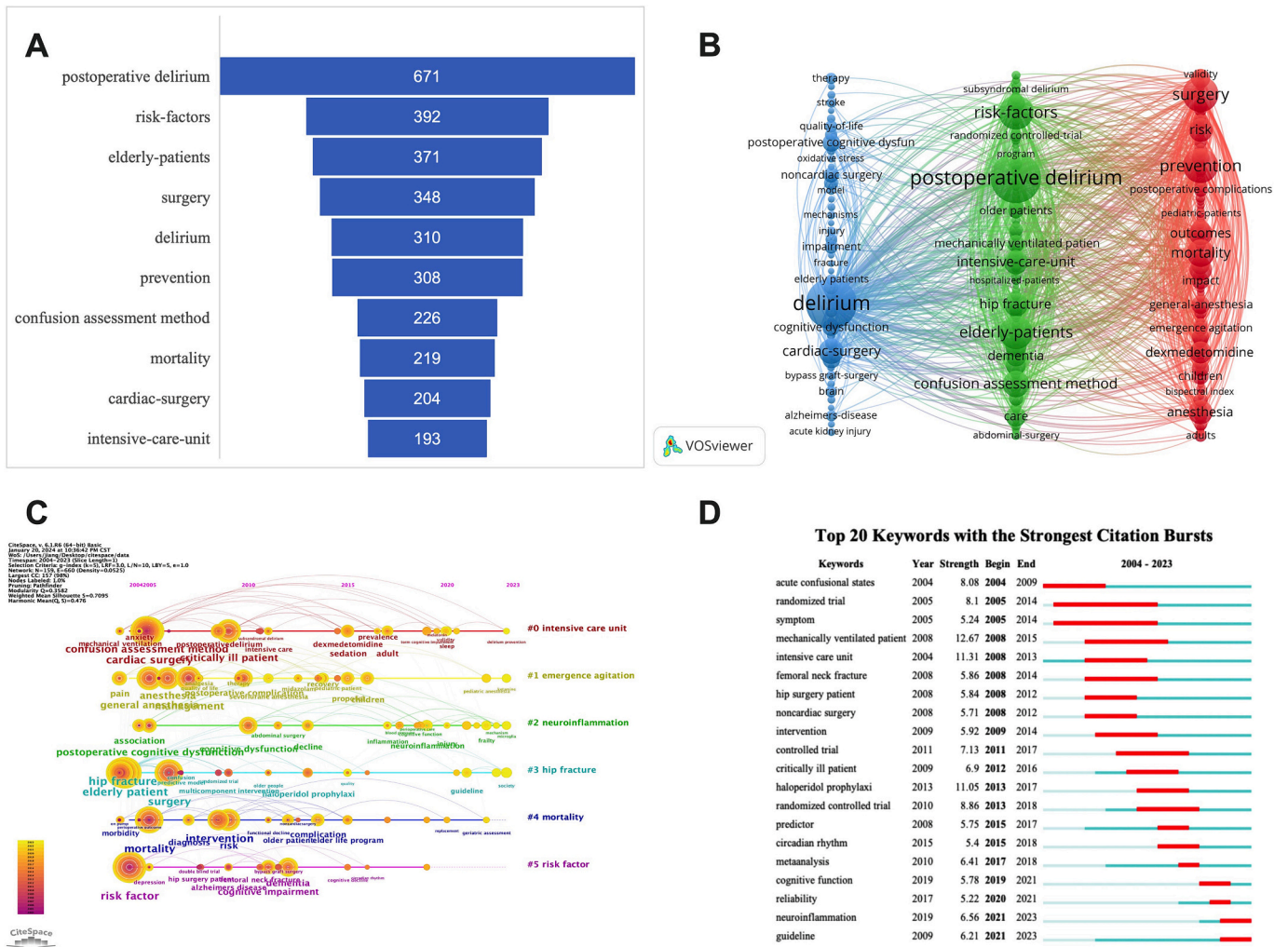
## Discussion

In this bibliometric analysis, we collected all publications on the prevention and treatment of POD from 2004 to 2023. Then, we

visualized and analyzed the information retrieved from the literature through bibliometric software and methods. The analysis revealed the hot spots and frontiers in preventing and treating POD.

A significant number of relevant studies have been published annually. It indicated that research on the prevention and treatment of POD has received much attention. In 2018, an essential advancement in neurocognitive function was establishing the concept of perioperative neurocognitive dysfunction (PND), which covered all perioperative cognitive alterations occurring in the preoperative and postoperative periods, including POD [2]. This decision reflected the importance that scholars worldwide placed on this field. The number of publications in this field will likely continue to increase in the coming years because of the population ages and the prediction of the trend models [20].

International cooperation is essential and often leads to high-quality outputs. Notable collaborations, like those between Sichuan University in China and esteemed institutions in the USA like Johns Hopkins University and Beth Israel Deaconess Medical Center, have led to the publication of influential papers, such as “Effect of the Tailored, Family-Involved Hospital Elder Life Program on Postoperative Delirium and Function in Older Adults A Randomized Clinical Trial” (IF = 39) [21], “Hospital Elder Life Program: Systematic Review and Meta-analysis of Effectiveness” (IF = 7.2) [22]. These articles explored the effectiveness of the “HELP” program and provided a strong rationale for prevention in long-term hospitalized elderly patients. Through the analysis of the keywords, we found that non-pharmacological prevention of POD was closely related to “HELP,” such as intensive care, nutritional support, avoidance of circadian rhythm disturbance, removal of triggers, and psychosocial support.



**Fig. 5.** Analysis of the research hotspots on preventing and treating POD. (A) Top 10 most frequent keywords. (B) Network visualization of keywords. The nodes of the same color represented the same cluster. (C) Mapping of the time zone view of recent 20 years of the treatment and prevention of POD. (D) The map of the top 20 keywords with the strongest citations bursts.

As the author’s analysis shows, Inouye, Sharon K was the most influential author in this field. Her most influential paper was “Delirium in elderly people” published in the Lancet in 2014, which stated the general content of the research on delirium and summarized the risk factors and comprehensive treatment of POD [1]. The risk factors play an essential role in the prevention of POD. Elderly patients were mentioned as an independent risk factor in POD, and other risk factors included preoperative cognitive impairment, the type of surgery, and the occurrence of postoperative complications such as stroke, acute kidney injury, and infection. Some studies have confirmed the link between Alzheimer’s disease and POD by monitoring molecular levels in cerebrospinal fluid [23,24]. Dementia, frailty, and operations with heavy trauma or bleeding, such as hip surgery and cardiac surgery, have also been linked to the development of POD [25–29]. Familiarity with the risk factors allows us to develop more targeted preventive measures to reduce the incidence of POD. Inouye, Sharon K also proposed several assessment scales, such as CAM, CAM-ICU, CAM-S, and 3D-CAM, which can facilitate the early detection of potential POD [18,30–32]. Since early detection of POD and differentiation from other diseases could prevent the deterioration of the disease or cause unnecessary losses, these scales were of great significance. For example, timely identification of subsyndromal delirium as an incomplete state of POD was essential to improve the cognitive level of patients and reduce the fatality rate [33]. The emergence of agitation had similar symptoms with

hyperactive type POD, but their treatment was different, so the correct diagnosis of POD was conducive to timely and effective treatment [34].

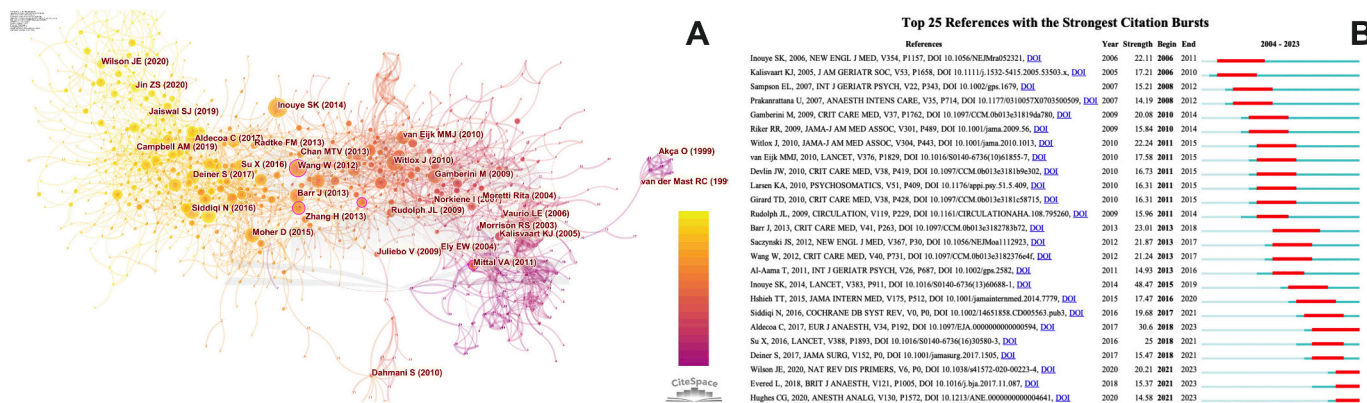
Analysis of the keywords and co-citations burst showed that guidelines proposed in recent years have attracted much attention. “European Society of Anaesthesiology evidence-based and consensus-based guideline on postoperative delirium” has gained the strongest citation bursts strength of the past few years [35]. This guide discussed some exciting issues. Firstly, the guide pointed out that intraoperative monitoring of vital signs (e.g., “bispectral index,” “blood pressure,” “electroencephalogram”) helped prevent POD. A meta-analysis also showed that the intraoperative bispectral index could reduce the occurrence of POD [36]. Secondly, in addition to elderly patients, the guide researched POD in pediatric patients. Their primary manifestation was emergence delirium, which mainly occurred in postanesthesia care unit (PACU). It might be related to postoperative pain, and the specific pathogenesis was not clear. Due to the specificity of pediatric patients, the prevention and treatment of POD will differ from adults, so these topics warrant further studies. Another hot guideline from the USA also raised some key questions [37]. This guide has summarized pharmacological prevention and found that insufficient evidence recommends that administering prophylactic medications can reduce the risk of POD. It pointed out that dexmedetomidine may reduce the occurrence of POD. In 2016, Dongxin Wang also investigated that prophylactic use of low-dose dexmedetomidine in elderly patients undergoing non-cardiac surgery would reduce



**Table 4**

The top 10 co-cited publications in the prevention and treatment of postoperative delirium research.

Rank	Title	Author	Publish time	Journal (IF)	QCR	DOI	Co-citation	Total link strength
1	Clarifying confusion: the confusion assessment method. A new method for detection of delirium	Inouye, Sharon K	Dec. 1990	Annals of Internal Medicine (39.2)	Q1	<a href="https://doi.org/10.7326/0003-4819-113-12-941">https://doi.org/10.7326/0003-4819-113-12-941</a>	377	6724
2	Delirium in elderly people	Inouye, Sharon K	Mar. 2014	Lancet (168.9)	Q1	<a href="https://doi.org/10.1016/s0140-6736(13)60688-1">https://doi.org/10.1016/s0140-6736(13)60688-1</a>	314	4927
3	A multicomponent intervention to prevent delirium in hospitalized older patients	Inouye, Sharon K	Mar. 1999	New England Journal of Medicine (158.5)	Q1	<a href="https://doi.org/10.1056/nejm199903043400901">https://doi.org/10.1056/nejm199903043400901</a>	267	6159
4	Delirium in elderly patients and the risk of postdischarge mortality, institutionalization, and dementia: a meta-analysis	Joost Witlox	Jul. 2010	JAMA-Journal of the American Medical Association (120.7)	Q1	<a href="https://doi.org/10.1001/jama.2010.1013">https://doi.org/10.1001/jama.2010.1013</a>	208	4101
5	Reducing delirium after hip fracture: a randomized trial	Marcantonio, Edward R	May 2001	Journal of the American Geriatrics Society (6.3)	Q1	<a href="https://doi.org/10.1046/j.1532-5415.2001.49108.x">https://doi.org/10.1046/j.1532-5415.2001.49108.x</a>	186	4515
6	Delirium as a predictor of mortality in mechanically ventilated patients in the intensive care unit	E. Wesley Ely	Apr. 2004	JAMA-Journal of the American Medical Association (120.7)	Q1	<a href="https://doi.org/10.1001/jama.291.14.1753">https://doi.org/10.1001/jama.291.14.1753</a>	172	3536
7	Delirium in older persons	Inouye, Sharon K	Mar. 2006	New England Journal of Medicine (158.5)	Q1	<a href="https://doi.org/10.1056/nejmra052321">https://doi.org/10.1056/nejmra052321</a>	171	3269
8	Delirium in mechanically ventilated patients: validity and reliability of the confusion assessment method for the intensive care unit (CAM-ICU)	E. Wesley Ely	Dec. 2001	JAMA-Journal of the American Medical Association (120.7)	Q1	<a href="https://doi.org/10.1001/jama.286.21.2703">https://doi.org/10.1001/jama.286.21.2703</a>	170	3520
9	Haloperidol prophylaxis for elderly hip-surgery patients at risk for delirium: a randomized placebo-controlled study	Kees J Kalisvaart	Oct. 2005	Journal of the American Geriatrics Society (6.3)	Q1	<a href="https://doi.org/10.1111/j.1532-5415.2005.53503.x">https://doi.org/10.1111/j.1532-5415.2005.53503.x</a>	160	4527
10	Evaluation of delirium in critically ill patients: validation of the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU)	E. Wesley Ely	Jul. 2001	Critical Care Medicine (8.8)	Q1	<a href="https://doi.org/10.1097/00003246200107000-00012">https://doi.org/10.1097/00003246200107000-00012</a>	148	3127



**Fig. 6.** References analysis in the prevention and treatment of POD field by CiteSpace. (A) The visualized network of cited references. CiteSpace parameters were set as follows: time slicing (2004–2023), years per slice (1), node types (reference), selection criteria (Top N = 25), and select Pathfinder. (B) The top 25 references in the field with the highest citation bursts.

the incidence of POD after surgery [38]. What is more, there were conflicting results regarding the incidence and severity of POD through prophylactic administration of haloperidol. Some scholars believe low-dose haloperidol on POD prevents effectively [39], but there are still literature results in contrast [40].

What is more, there were numerous non-pharmacological treatment approaches for POD, including the management of postoperative pain [41], regulation of circadian rhythm [42], cognitive training [43], and so on. Nevertheless, similar to prevention strategies, the options for pharmacological treatment were also limited. Currently, researchers primarily concentrate on investigating the therapeutic effects of dexmedetomidine [44], haloperidol [45], ketamine [46], and other medications; however, clinical study results were contentious and

necessitated further research.

Our study still has some limitations. Firstly, the data used in this study were only from the WOSCC database and did not include data from other databases, such as PubMed, Cochrane Library, and Embase. Despite the comprehensiveness and reliability of the WOSCC, data from the WOSCC database may have particular articles that need to be included. Additionally, the use of impact factor and h-index for assessment may overlook specific high-quality articles or journals, necessitating a broader perspective in evaluating scholarly contributions.

**Conclusion**

This study used bibliometrics to collect 1848 articles published over



the past two decades, illuminating insights to delineate the evolving landscape and focal points in addressing POD. Significant studies have been conducted in the USA and China. Inouye, Sharon K was the most influential author in this field. The management of POD is primarily focused on prevention, with non-pharmacological interventions being the most commonly utilized in clinical practice. It is crucial to identify risk factors such as advanced age, major surgery, and postoperative complications and provide targeted preventive measures for these patients. Moreover, the distinct considerations associated with pediatric patients have emerged as a salient area of investigation, necessitating specialized approaches in both prevention and treatment paradigms. Treatment options for POD were relatively limited, mainly centered around pain relief, nutritional support, and symptomatic treatment. Early diagnosis of POD with appropriate scales and timely treatment can improve prognosis. Currently, there is controversy surrounding the effectiveness of medications like haloperidol in treating POD, so finding effective drugs for prevention and control remains a crucial focus in this area. The dissemination of these findings is poised to guide researchers toward pertinent avenues and burgeoning focal points within POD research, fostering a deeper understanding of the intricacies underpinning this critical area of clinical inquiry.

### Abbreviations

POD	postoperative delirium
ICU	intensive care unit
CAM	confusion assessment method
WOS	Web of Science
WoSCC	Web of Science Core Collection
JCR	Journal Citation Reports
IF	impact factor
PND	perioperative neurocognitive dysfunction
PACU	postanesthesia care unit

### Ethics approval

This review did not require ethics approval as no human or animal subjects were involved. The data came from the Web of Science.

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### CRediT authorship contribution statement

**Changshuo Jiang:** Writing – original draft, Software, Conceptualization. **Zijun Tian:** Writing – original draft, Formal analysis, Data curation. **Ming Jiang:** Investigation, Data curation. **Chenyang Xu:** Software. **Mingjie Mao:** Visualization, Methodology. **Shanwu Feng:** Visualization, Software, Methodology. **Hongmei Yuan:** Writing – review & editing, Funding acquisition.

### Declaration of competing interest

None.

### Data availability

All data generated or analyzed during this study are included in this published article (and its supplementary information files).

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.sopen.2024.09.005>.

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### References

- [1] Inouye SK, Westendorp RG, Saczynski JS. Delirium in elderly people. *Lancet* 2014; 383(9920):911–22.
- [2] Evered L, Silbert B, Knopman DS, Scott DA, DeKosky ST, Rasmussen LS, et al. Recommendations for the nomenclature of cognitive change associated with anaesthesia and surgery—2018. *Anesthesiology* 2018;129(5):872–9.
- [3] Silva AR, Regueira P, Albuquerque E, Baldeiras I, Cardoso AL, Santana I, et al. Estimates of geriatric delirium frequency in non-cardiac surgeries and its evaluation across the years: a systematic review and meta-analysis. *J Am Med Dir Assoc* 2021;22(3):613–620.e619.
- [4] Crocker E, Beggs T, Hassan A, Denault A, Lamarche Y, Bagshaw S, et al. Long-term effects of postoperative delirium in patients undergoing cardiac operation: a systematic review. *Ann Thorac Surg* 2016;102(4):1391–9.
- [5] Kostas TR, Zimmerman KM, Rudolph JL. Improving delirium care: prevention, monitoring, and assessment. *Neurohospitalist* 2013;3(4):194–202.
- [6] Jin Z, Hu J, Ma D. Postoperative delirium: perioperative assessment, risk reduction, and management. *Br J Anaesth* 2020;125(4):492–504.
- [7] Gou RY, Hshieh TT, Marcantonio ER, Cooper Z, Jones RN, Trivison TG, et al. One-year Medicare costs associated with delirium in older patients undergoing major elective surgery. *JAMA Surg* 2021;156(5):430–42.
- [8] Merigó JM, Gil-Lafuente AM, Yager RR. An overview of fuzzy research with bibliometric indicators. *Appl Soft Comput* 2015;27:420–33.
- [9] Ding X, Yang Z. Knowledge mapping of platform research: a visual analysis using VOSviewer and CiteSpace. *Electron Commer Res* 2022;22(3):787–809.
- [10] Wilson M, Sampson M, Barrowman N, Doja A. Bibliometric analysis of neurology articles published in general medicine journals. *JAMA Netw Open* 2021;4(4):e215840.
- [11] van Eck NJ, Waltman L. Citation-based clustering of publications using CitNetExplorer and VOSviewer. *Scientometrics* 2017;111(2):1053–70.
- [12] Hou JH, Yang XC, Chen CM. Emerging trends and new developments in information science: a document co-citation analysis (2009–2016). *Scientometrics* 2018;115(2):869–92.
- [13] Brookes BC. Bradford's law and the bibliography of science. *Nature* 1969;224(5223):953–6.
- [14] Venable GT, Shepherd BA, Loftis CM, McClatchy SG, Roberts ML, Fillinger ME, et al. Bradford's law: identification of the core journals for neurosurgery and its subspecialties. *J Neurosurg* 2016;124(2):569–79.
- [15] Sabe M, Chen C, Sentissi O, Deenik J, Vancampfort D, Firth J, et al. Thirty years of research on physical activity, mental health, and wellbeing: a scientometric analysis of hotspots and trends. *Front Public Health* 2022;10:943435.
- [16] Sabé M, Chen CM, El-Hage W, Leroy A, Vaiva G, Monari S, et al. Half a century of research on post-traumatic stress disorder: a scientometric analysis. *Curr Neuropharmacol* 2024;22(4):736–48.
- [17] Moed HF. New developments in the use of citation analysis in research evaluation. *Arch Immunol Ther Exp (Warsz)* 2009;57(1):13–8.
- [18] Inouye SK, van Dyck CH, Alessi CA, Balkin S, Siegel AP, Horwitz RI. Clarifying confusion: the confusion assessment method. A new method for detection of delirium. *Ann Intern Med* 1990;113(12):941–8.
- [19] Eom YH, Fortunato S. Characterizing and modeling citation dynamics. *PLoS One* 2011;6(9):7.
- [20] Juan SMA, Adlard PA. Ageing and cognition. *Subcell Biochem* 2019;91:107–22.
- [21] Wang YY, Yue JR, Xie DM, Carter P, Li QL, Gartaganis SL, et al. Effect of the tailored, family-involved hospital elder life program on postoperative delirium and function in older adults a randomized clinical trial. *JAMA Intern Med* 2020;180(1):17–25.
- [22] Hshieh TT, Yang TH, Gartaganis SL, Yue JR, Inouye SK. Hospital elder life program: systematic review and meta-analysis of effectiveness. *Am J Geriatr Psychiatry* 2018;26(10):1015–33.
- [23] Fong TG, Vasunilashorn SM, Gou Y, Libermann TA, Dillon S, Schmitt E, et al. Association of CSF Alzheimer's disease biomarkers with postoperative delirium in older adults. *Alzheimers Dement (N Y)* 2021;7(1):e12125.
- [24] Parker M, White M, Casey C, Kunkel D, Bo A, Blennow K, et al. Cohort analysis of the association of delirium severity with cerebrospinal fluid amyloid-tau-neurodegeneration pathologies. *J Gerontol A Biol Sci Med Sci* 2022;77(3):494–501.
- [25] Dodsworth BT, Reeve K, Falco L, Hueting T, Sadeghirad B, Mbuagbaw L, et al. Development and validation of an international preoperative risk assessment model for postoperative delirium. *Age Ageing* 2023;52(6).
- [26] Inouye SK. Delirium in older persons. *N Engl J Med* 2006;354(11):1157–65.
- [27] Sauèr AC, Veldhuijzen DS, Ottens TH, Slooter AJC, Kalkman CJ, van Dijk D. Association between delirium and cognitive change after cardiac surgery. *Br J Anaesth* 2017;119(2):308–15.
- [28] Bhusan S, Huang X, Duan Y, Xiao Z. The impact of regional versus general anesthesia on postoperative neurocognitive outcomes in elderly patients undergoing hip fracture surgery: a systematic review and meta-analysis. *Int J Surg* 2022;105:106854.
- [29] Steenblock J, Braisch U, Brefka S, Thomas C, Eschweiler GW, Rapp M, et al. Frailty index and its association with the onset of postoperative delirium in older adults undergoing elective surgery. *BMC Geriatr* 2023;23(1):90.
- [30] Ely EW, Inouye SK, Bernard GR, Gordon S, Francis J, May L, et al. Delirium in mechanically ventilated patients: validity and reliability of the confusion

- assessment method for the intensive care unit (CAM-ICU). *JAMA* 2001;286(21): 2703–10.
- [31] Inouye SK, Kosar CM, Tommet D, Schmitt EM, Puelle MR, Saczynski JS, et al. The CAM-S: development and validation of a new scoring system for delirium severity in 2 cohorts. *Ann Intern Med* 2014;160(8):526.
- [32] Marcantonio ER, Ngo LH, O'Connor M, Jones RN, Crane PK, Metzger ED, et al. 3D-CAM: derivation and validation of a 3-minute diagnostic interview for CAM-defined delirium a cross-sectional diagnostic test study. *Ann Intern Med* 2014;161(8):554–U553.
- [33] Kanno M, Doi M, Kubota K, Kanoya Y. Risk factors for postoperative delirium and subsyndromal delirium in older patients in the surgical ward: a prospective observational study. *PLoS One* 2021;16(8):e0255607.
- [34] Shen QH, Xu S, Lai L, Chen YJ, Liu K, Sun LJ. The effect of magnesium sulfate on emergence agitation in children undergoing general anesthesia: a systematic review and meta-analysis. *J Clin Anesth* 2022;78:110669.
- [35] Aldecoa C, Bettelli G, Bilotta F, Sanders RD, Audisio R, Borozdina A, et al. European Society of Anaesthesiology evidence-based and consensus-based guideline on postoperative delirium. *Eur J Anaesthesiol* 2017;34(4):192–214.
- [36] Sumner M, Deng C, Evered L, Frampton C, Leslie K, Short T, et al. Processed electroencephalography-guided general anaesthesia to reduce postoperative delirium: a systematic review and meta-analysis. *Br J Anaesth* 2023;130(2): e243–53.
- [37] Hughes CG, Boncyk CS, Culley DJ, Fleisher LA, Leung JM, McDonagh DL, et al. American Society for Enhanced Recovery and Perioperative Quality Initiative joint consensus statement on postoperative delirium prevention. *Anesth Analg* 2020;130(6):1572–90.
- [38] Su X, Meng ZT, Wu XH, Cui F, Li HL, Wang DX, et al. Dexmedetomidine for prevention of delirium in elderly patients after non-cardiac surgery: a randomized, double-blind, placebo-controlled trial. *Lancet* 2016;388(10054):1893–902.
- [39] Wang W, Li HL, Wang DX, Zhu X, Li SL, Yao GQ, et al. Haloperidol prophylaxis decreases delirium incidence in elderly patients after non-cardiac surgery: a randomized controlled trial. *Crit Care Med* 2012;40(3):731–9.
- [40] Hollinger A, Rüst CA, Riegger H, Gysi B, Tran F, Brügger J, et al. Ketamine vs. haloperidol for prevention of cognitive dysfunction and postoperative delirium: a phase IV multicentre randomised placebo-controlled double-blind clinical trial. *J Clin Anesth* 2021;68:110099.
- [41] Li T, Li J, Yuan L, Wu J, Jiang C, Daniels J, et al. Effect of regional vs general anesthesia on incidence of postoperative delirium in older patients undergoing hip fracture surgery: the RAGA randomized trial. *JAMA* 2022;327(1):50–8.
- [42] Tan C, Saito N, Miyawaki I, Shiotani H. Preoperative circadian physical activity rhythm and postoperative delirium in cardiovascular surgery patients. *Chronobiol Int* 2020;37(7):1059–66.
- [43] Zhao L, Zhu H, Mao W, Zhou X, Xie Y, Li L. Effects of perioperative cognitive function training on postoperative cognitive dysfunction and postoperative delirium: a systematic review and meta-analysis. *Front Neurol* 2023;14:1146164.
- [44] Momeni M, Khalifa C, Lemaire G, Watremez C, Tircoveanu R, Van Dyck M, et al. Propofol plus low-dose dexmedetomidine infusion and postoperative delirium in older patients undergoing cardiac surgery. *Br J Anaesth* 2021;126(3):665–73.
- [45] Shen YZ, Peng K, Zhang J, Meng XW, Ji FH. Effects of haloperidol on delirium in adult patients: a systematic review and meta-analysis. *Med Princ Pract* 2018;27(3): 250–9.
- [46] Wei W, Zhang A, Liu L, Zheng X, Tang C, Zhou M, et al. Effects of subanaesthetic S-ketamine on postoperative delirium and cognitive function in elderly patients undergoing non-cardiac thoracic surgery: a protocol for a randomized, double-blinded, placebo-controlled and positive-controlled, non-inferiority trial (SKED trial). *BMJ Open* 2022;12(8):e061535.