Zhang *et al. Artery Research* (2025) 31:11
https://doi.org/10.1007/s44200-025-00080-0

Artery Research

REVIEW ARTICLE

Open Access

A Bibliometric Analysis of Global Research Trends in Blood Pressure Variability

Zheng Zhang[1†], Yi Duan[1†], Zhifeng Gao[1*], Yue Cao[2] and Huan Zhang[1]

Abstract

Background The term "blood pressure variability" refers to the degree of fluctuations in blood pressure over a specified period. Given the ongoing emergence of clinical concepts and innovative technologies, a bibliometric analysis was undertaken to reveal worldwide research patterns, focal areas, scientific frontiers, and output characteristics related to blood pressure variability between 2000 and 2022.

Materials and Methods A bibliometric analysis was performed to assess the number of publications, keywords, journals, citations, affiliations, and countries. The Web of Science Core Collection was used to retrieve relevant literature and associated information from the period spanning 2000–2022. To provide a comprehensive visual analysis of the research trends and hotspots related to blood pressure variability, the visualization tools VOSviewer and CiteSpace were employed.

Results A total of 3188 documents (including 2815 articles and 373 reviews) published from 2000 to 2022 were retrieved, indicating consistent growth in the volume of publications over the specified duration. JOURNAL OF HYPERTENSION is the leading journal on BPV. The United States was identified as the most significant contributor to this research area, whereas UDICE FRENCH RESEARCH UNIVERSITIES from France emerged as the leading institution actively engaging in relevant research. The scholarly contributions of Kario, Kazuomi, Su, Ding-Feng and other researchers were deemed notable. Powers. WJ's paper, published in 2018, received the highest global citation score. Keywords such as "hypertension", "blood pressure", "mortality" and "stroke" were found to be the most frequently recurring, and research on blood pressure variability encompasses both clinical and fundamental investigations.

Conclusions The number of studies conducted in the field of blood pressure variability has consistently increased over time. This article presents a comprehensive overview of the foremost scholarly journals, nations, academic institutions, researchers, and extensively referenced articles on a global scale. Research in this domain has transitioned from investigating the underlying mechanisms associated with fluctuations in blood pressure to appraising the public health implications of blood pressure variability. Mounting recognition of the clinical significance of blood pressure variability has established robust groundwork for forthcoming advancements in clinical medicine and scientific inquiry.

Keywords Blood pressure variability, Bibliometrics, VOSviewer, Network, Hotspot

†Zheng Zhang and Yi Duan contributed equally to this article.

*Correspondence:
Zhifeng Gao
btchgzf@hotmail.com
Full list of author information is available at the end of the article

1 Introduction

Blood pressure variability (BPV) [1] refers to the extent of changes in blood pressure over a specific duration and was first introduced by Hammarstrom et al. [2] in 1948. Despite the commonly held belief that blood pressure is a relatively stable physiological quantitative indicator, BPV is subject to fluctuations due to the variety of environmental, behavioral, and emotional stimuli encountered in daily life [3]. From a physiological perspective, BPV may reflect the adaptive fluid and neural responses of the body to these stimuli while also indicating changes in cardiovascular regulatory mechanisms that can influence cardiovascular prognosis [1]. Currently, BPV is recognized as an independent risk factor [4–6] for significant cardiovascular diseases and has been extensively adopted in disease management across various fields. For example, BPV-based management strategies are considered one of the most effective methods in intraoperative blood pressure management guidelines [7], and BPV also plays a critical role in target-oriented fluid therapy [8]. Research on BPV is highly important for managing perioperative patients, public health, and chronic diseases because elevated BPV can lead to organ damage, cardiovascular incidents, and even mortality. Notably, multiple risk factors can influence BPV [9–11].

While the concept of BPV has been implemented for an extended period, modern research advances have led to more precise definitions and measurement techniques [12]. However, recent shifts in the trends and hotspots of BPV research present challenges for researchers and highlight the need for further exploration of this topic [13]. Conducting a quantitative analysis of the current state of research, focus areas, and future prospects for BPV is crucial for achieving a better understanding of this field and informing future scientific research directions.

Bibliometrics is an interdisciplinary science that employs statistical, mathematical, and bibliographic methods to perform quantitative analysis of all knowledge carriers [14, 15]. Recently, bibliometric analyses of the literature related to the circulation system, such as studies of cardioembolic stroke [16], hypertension [17], heart failure [18], and coronary heart disease [19], have been reported. Bibliometric analysis holds significant application value in cardiovascular-related research, as it can reveal the focal points of cardiovascular-related research by scrutinizing the characteristics of databases and publications, providing a reference for future research directions. However, there is no bibliometric analysis of the literature related to BPV. This article analyzes the current status of BPV research through bibliometric methods and provides an overview of the research trends, aiming to explore the development trend of BPV research and offer a reference for future investigations.

2 Materials and Methods

2.1 Data Sources and Search Strategies

To obtain a standardized and comprehensive dataset suitable for export and widespread use in academia, the Web of Science Core Collection (WoSCC) was utilized to compile the publication dataset for this study. To avoid any biases resulting from daily updates made to the database, all documents published from 2000 to 2022 were retrieved and downloaded from the WoSCC database's SCIE on March 26, 2022. Our search criteria included the following: (TS = ("blood pressure variability") OR TS = ("blood pressure variation")). Only articles and reviews written in English were included in the analysis, whereas other types of relevant publications, such as meeting abstracts, editorial materials, prior papers, letters, news items, corrections, book chapters, early access, book reviews, data papers, reprints, reference works, and biographical entries, were excluded. A total of 2815 articles and 373 reviews were searched and analyzed for this study, as illustrated in Fig. 1, which depicts our search strategy. Our study related to BPV has been registered on ClinicalTrials.gov (Registration No: NCT05698433) to ensure ethical compliance and transparency (registration date: 16 January 2023).

2.2 Bibliometric Analysis

Text data were extracted from the Web of Science Core Collection (WoSCC) and subjected to analysis via VOSviewer (version 1.6.19) and CiteSpace (version 6.2.R5). We utilized VOSviewer [20] to visually analyze the collaborative networks between countries, institutions, journals, and authors, as well as the cocitation of keyword clusters, and the minimum co-occurrence threshold for keywords was set to 35. Furthermore, CiteSpace [21] was employed to analyze research progress, investigate research status and hot spots, track trend distribution maps over time, and determine field development trends. For CiteSpace, the resolution parameter was set to 0.8. To assess research productivity, the number of

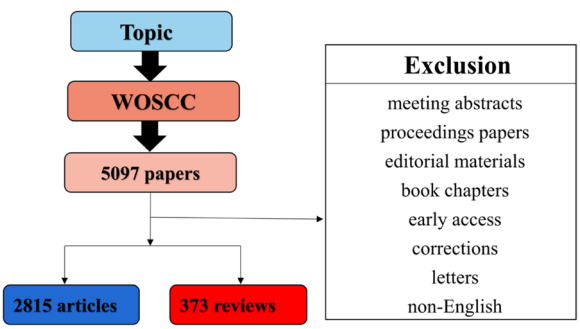


Fig. 1 Flowchart of the screening process

publications (NP) was used, whereas the number of citations (NC) served as an indicator of impact since they form the two primary angles for evaluating the research level. Additionally, the H-index [22] provides a unification of productivity and impact by identifying thresholds that link NP and NC. Furthermore, keyword co-occurrence measures the frequency of occurrence of keywords in the same literature. An analysis of the co-occurrence of keywords and cocited references presents a viable means of identifying crucial areas of research focus that are intricately linked with a specific topic [23]. As such, a co-occurrence network of keywords was constructed to illustrate the hotspots related to BPV. The burst [24] detection algorithm is an effective analytical tool for capturing rapid increases in the popularity of references or keywords over a specified time period, and bursting keywords and references are frequently used to detect new research trends in the field. Cocitation refers to the situation where both items are referenced by a third item and can also be used to identify research trends [25]. The impact factor (IF) obtained from Journal Citation Reports (JCR) is a widely accepted method for measuring journal quality and impact. The annual number of global citation scores (GCS) of the top 10 publications indicates the total number of times that the top 10 publications in a given field or subject area have been cited globally within a year. This metric is essential for bibliometric analysis, as it provides insight into the influence and impact of research publications within a specific field.

3 Results

3.1 Annual Trends in NP Incidence

In accordance with the aforementioned search strategy, 3188 references were retrieved from a total of 5097 articles and reviews published from 2000 to 2022, with a total NC of 88,961, excluding self-citations. The average NC per publication was 27.9, and the H-index of all publications was 112. Figure 2A shows the polynomial fitting curve of the annual trend of publications. The number of publications is obviously related to the year of publication, with a correlation coefficient (R^2) of 0.938. Figure 2B shows the annual NC related to BPV. Overall, despite fluctuations over the past 23 years, the annual NC has increased from 30 in 2000 to 9958 in 2022, with a peak NC of 10,557 in 2021.

3.2 Characteristics of Countries/Region

The NP and NC in different countries can partly reflect a country's level of emphasis and influence in the field. From 2000 to 2022, 93 countries or regions published research related to BPV (Fig. 3A). By selecting a minimum of five collaborating countries as a screening criterion, a total of 59 countries were ultimately included. Based on the NC ranking, the top five countries/regions with the highest output are listed in Fig. 3B, and the total NP from these five countries has shown an increasing trend. Since 2000, the NP from the United States and China has steadily increased, whereas that from Japan and Italy has fluctuated. The maximum number of NPs from Japan was 29 in 2020, and the maximum number of NPs from Italy was 29 in 2019.

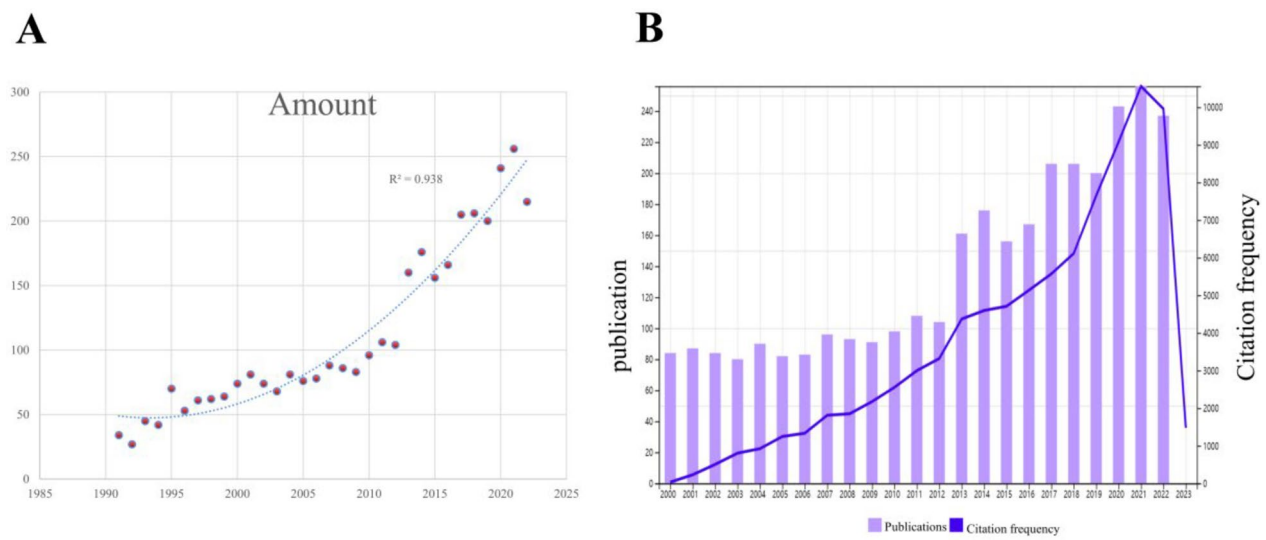


Fig. 2 **A** Curve fitting of the total annual growth trend of publications ($R^2 = 0.938$). **B** The number of publications and citations by year over the past 23 years

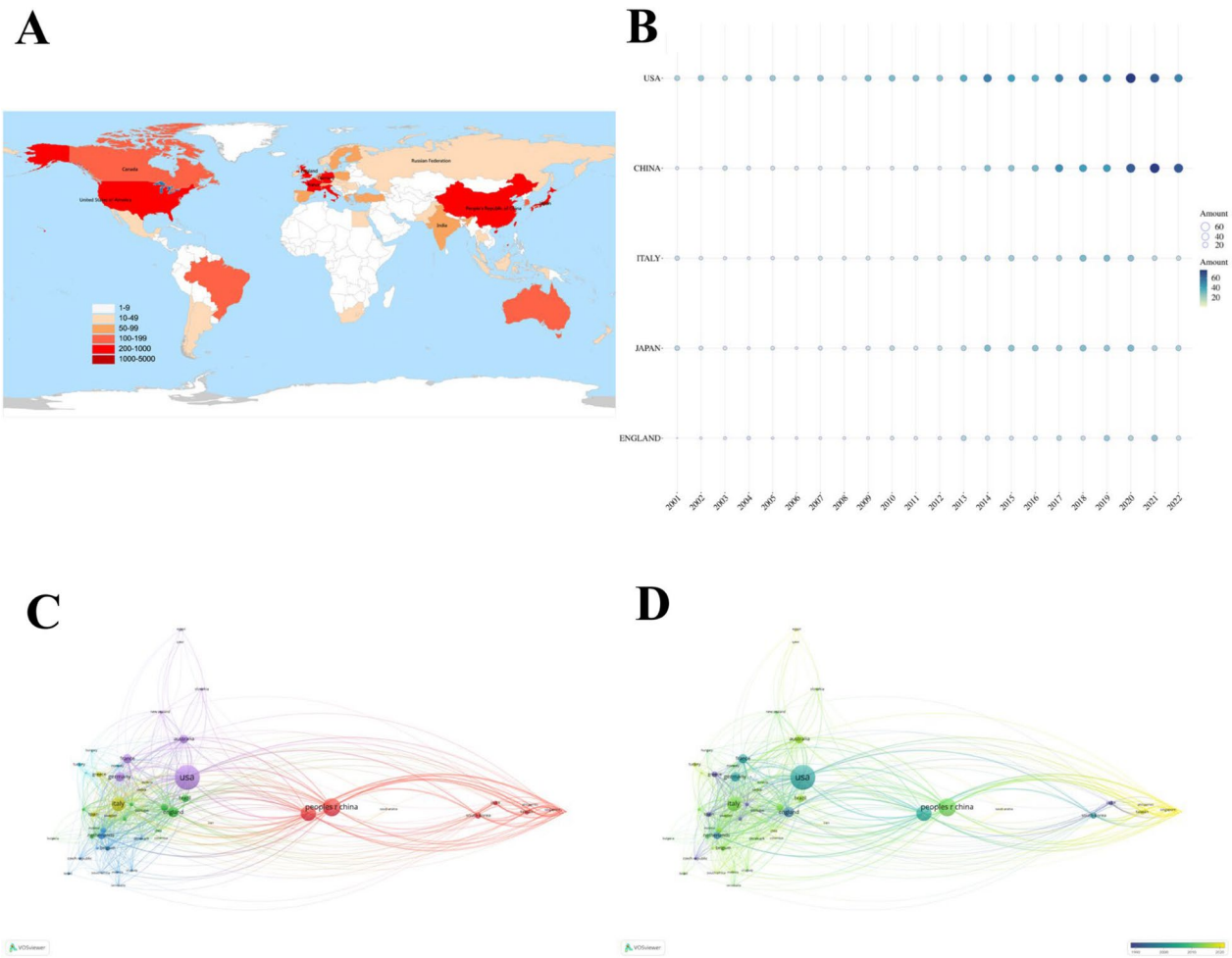


Fig. 3 Countries/regions involved in BPV research. **A** Geographical distribution of global output; **B** annual output trend of the top 10 productive countries/regions; **C** visual cluster analysis of cooperation among countries/regions; and **D** timeline visualization of cooperation among countries/regions

Table 1 Publications in the top 10 productive countries/regions

Rank	Country/region	NP	NC	H-index	Average citation per item
1	USA	821	28,999	76	37.21
2	China	483	5864	38	14.38
3	Japan	383	9286	50	26.66
4	Italy	348	13,928	64	42.74
5	England	219	8387	44	39.6
6	Germany	189	5991	41	32.88
7	France	176	6263	44	36.63
8	Australia	165	5887	41	36.53
9	Netherlands	135	5984	40	45.44
10	Brazil	131	2326	27	18.44

Overall, these findings indicate that research on BPV has entered a stage of rapid development and has attracted widespread attention. As shown in Table 1, the United States published the most articles related to BPV (821), followed by China (483) and Japan (383). The number of publications from the United States is close to the sum of the number of publications from China and Japan. Papers from the United States were cited 28,999 times, accounting for 33% of the total NC. Italy (13,928) and Japan (9286) ranked second and third in terms of NC, respectively. In addition, the United States had the highest H-index (76), which was more than twice that of China (38) and Brazil (27). Although the NP of Italy was slightly lower than that of China, its H-index, NC, and average NC per publication were higher than those of China. New England had the highest average NC per publication (45.44), followed by Italy (42.74), indicating that the quality of publications from these two countries

is high. The average NC per publication from China, Brazil, and Japan was relatively low, suggesting that the quality of their publications needs to be improved. The US, Japan, and Italy conducted research in this field earlier than other countries did (Fig. 3C).

The visualization of international collaborative networks in Fig. 3C indicates that there are close collaborative relationships among countries, which are divided into seven clusters. Cluster 1 (in red) is represented mainly by Asian countries such as China and Japan, whereas Clusters 4 (in yellow) and 5 (in purple) are represented by countries such as the United States and Italy, with collaborative relationships closely related to geography. Publications from Asia are more innovative than those from European and American countries are (Fig. 3D), indicating that Asia has a leading advantage in certain aspects over Europe and the United States.

3.3 Performance of Affiliations and Authors

Table 2 lists the top 10 institutions that published the most publications related to BPV. The Association of French Research Universities (Udice), UDICE FRENCH RESEARCH UNIVERSITIES had the highest NP (122), followed by UNIVERSITY OF MILANO BICOCCA and HARVARD UNIVERSITY, with HARVARD UNIVERSITY having the highest NC (6698) and average NC per publication (69.84). In addition, the IRCCS ISTITUTO AUXOLOGICO ITALIANO had the highest H-index (43), followed by UNIVERSITY OF MILANO BICOCCA (39) and HARVARD UNIVERSITY (34). Moreover, the countries of origin of the top 10 institutions were distributed relatively evenly, with the United States and Italy each accounting for 20% of all institutions. The University of Milano-Bicocca had the highest link weight, whereas Shanghai Jiao Tong University and Columbia University occupied core positions (Fig. 4A).

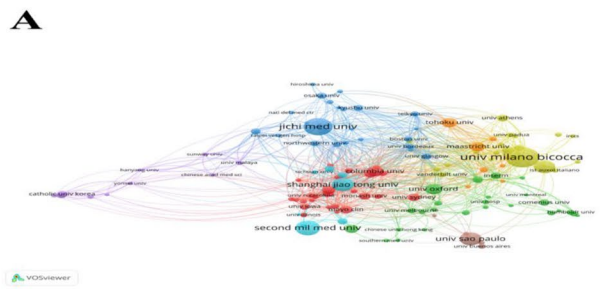
Figure 4B shows the top 20 institutions that are most representative in terms of outbreak intensity, duration, and timing. Columbia University had the highest outbreak intensity. In addition, 10 clusters were identified (Fig. 4C), including "follow-up studies", "ambulatory blood pressure monitoring", "aging", "risk factors", "Asia", "arterial stiffness", "calcium channel blocker", etc.

Table 3 lists the top 10 authors who have published the most publications related to BPV. They published 419 articles, accounting for 13.14% of the total NP. The NC was 13,543, accounting for 18.91% of the total NC. Kazuomi Kario from Jichi Medical University in Japan ranked first in the field of BPV research, followed by Ding-Feng Su from Naval Medical University in China and Satoshi Hoshide from Jichi Medical University in Japan.

As shown in Table 3, Kazuomi Kario from Japan had the highest NP (87), but his average NC per publication (30.23) was relatively moderate. On the other hand, although Gianfranco Parati from Italy had an NP (84) that was less than half that of Kario, Parati had the highest average NC per publication (75.78). Grzegorz Bilo from Italy had the lowest NP (24). However, Bilo ranked third in terms of NC (2192), indicating that the quality of his publications was high. In addition, 40% of the top 10 authors were from China, all from Naval Medical University, among which Ding-Feng Su had the second highest NP (60), but his average NC per publication (26.38) and H-index (22) were relatively ordinary. The average NC per publication of the top 10 authors differed greatly, ranging from 93.42 for Bilo to 18.24 for Fu-Ming Shen, and the H-index ranged from 31 for Kazuomi Kario to 12 for A. Voss from Germany, indicating great differences in their influence.

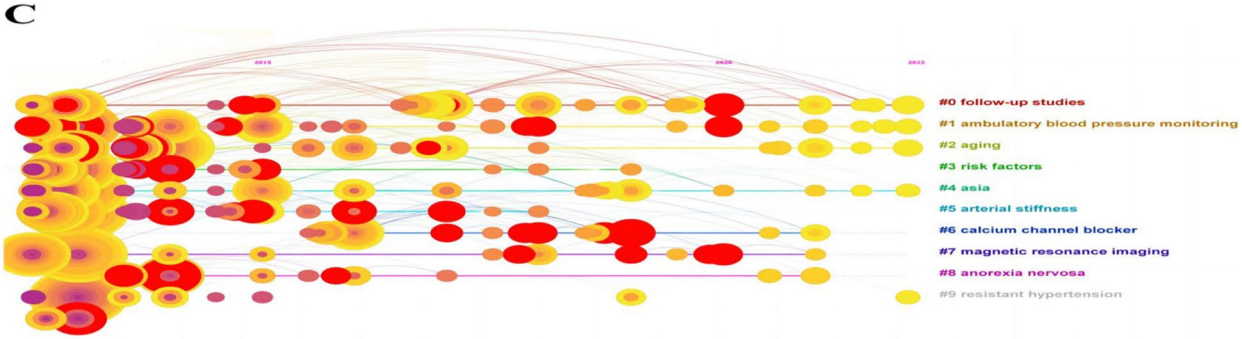
Table 2 The top 10 productive affiliations

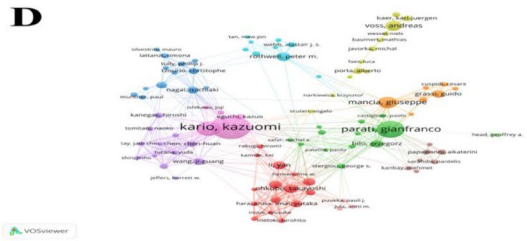
Rank	Affiliations	Country	NP	NC	H-index	Average citation per item
1	UDICE FRENCH RESEARCH UNIVERSITIES	France	122	3684	33	31.17
2	UNIVERSITY OF MILANO BICOCCA	Italy	102	5167	39	53.05
3	HARVARD UNIVERSITY	USA	97	6698	34	69.84
4	IRCCS ISTITUTO AUXOLOGICO ITALIANO	Italy	97	6409	43	69.55
5	JICHI MEDICAL UNIVERSITY	Japan	94	2630	32	29.98
6	INSTITUT NATIONAL DE LA SANTE ET DE LA RECHERCHE MEDICALE INSERM	France	80	2650	26	34.00
7	UNIVERSITY OF CALIFORNIA SYSTEM	USA	79	4939	28	63.53
8	NAVAL MEDICAL UNIVERSITY	China	75	1251	25	23.13
9	UNIVERSIDADE DE SAO PAULO	Brazil	67	1485	22	23.04
10	UNIVERSITY OF OXFORD	England	66	3222	29	50.8



B Top 20 Institutions with the Strongest Citation Bursts

Institutions	Year	Strength	Begin	End	2013 - 2022
Columbia University	2013	7.58	2013	2016	
Veterans Health Administration (VHA)	2013	4.14	2013	2017	
State University System of Florida	2014	4.49	2014	2016	
National Institutes of Health (NIH) - USA	2014	4.11	2014	2018	
Chinese Academy of Sciences	2014	3.6	2014	2017	
Boston University	2015	4.01	2015	2018	
IRCCS Istituto Auxologico Italiano	2013	3.69	2015	2017	
University of Oslo	2015	3.65	2015	2018	
Athens Medical School	2017	5.06	2017	2018	
Capital Medical University	2014	4.18	2017	2019	
Pfizer	2017	3.53	2017	2018	
University of Ulsan	2018	5.02	2018	2019	
Asan Medical Center	2018	4.01	2018	2019	
Sichuan University	2018	3.9	2018	2020	
Sapienza University Rome	2018	3.51	2018	2019	
Korea University Medicine (KU Medicine)	2019	4.07	2019	2020	
Korea University	2019	4.07	2019	2020	
Seoul National University (SNU)	2019	3.59	2019	2022	
Harvard T.H. Chan School of Public Health	2020	4.28	2020	2022	
University of Iowa	2020	4.28	2020	2022	





E Top 10 Authors with the Strongest Citation Bursts

Authors	Year	Strength	Begin	End	2013 - 2022
Imai, Yutaka	2013	2.89	2013	2016	
Mancia, Giuseppe	2013	2.61	2015	2017	
Eguchi, Kazuo	2014	2.73	2016	2018	
Stergiou, George S	2017	3.2	2017	2018	
Chen, Chen-Huan	2019	3.44	2019	2022	
Park, Sungha	2019	3.02	2019	2020	
Turana, Yuda	2019	2.59	2019	2020	
Loutradis, Charalampos	2019	2.59	2019	2020	
Siddique, Saulat	2019	2.59	2019	2020	
Tzourio, Christophe	2020	2.94	2020	2022	

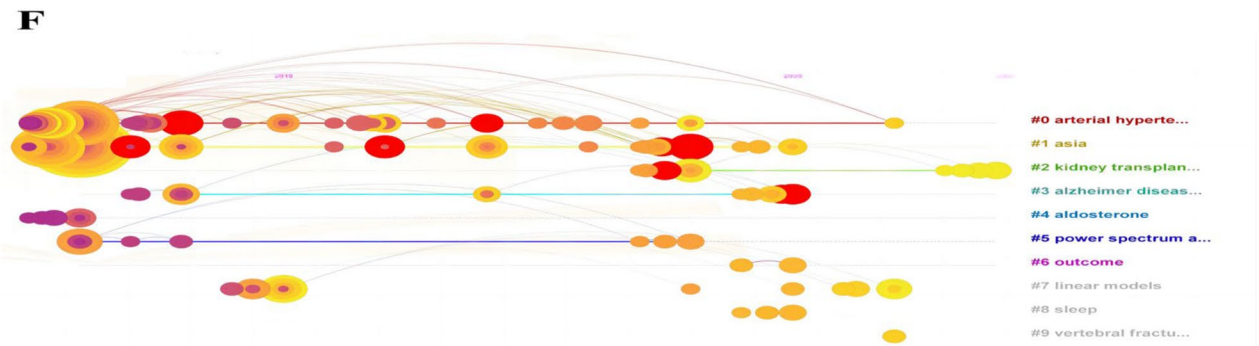


Fig. 4 Visualization of active affiliations and author analysis. **A** Analysis of cooperation among affiliations. **B** Top 20 representative burst affiliations. **C** Timeline distribution of the cluster analysis of affiliations. **D** Analysis of cooperation among authors. **E** Top 10 representative burst authors. **F** Timeline distribution of cluster analysis of the author

Table 3 The top 10 authors with the most publications

Rank	Author	Country	Affiliations	NP	NC	H-index	Average citation per item
1	Kario, Kazuomi	Japan	Jichi Medical University	87	2447	31	30.23
2	Su, Ding-Feng	China	Naval Medical University	60	1217	22	26.38
3	Hoshide, Satoshi	Japan	Jichi Medical University	44	1351	20	32.63
4	Parati, Gianfranco	Italy	IRCCS Istituto Auxologico Italiano	42	3042	29	74.98
5	Voss, A	Germany	Technical University Of Munich	41	512	12	25.9
6	Mancia, Giuseppe	Italy	University of Milano-Bicocca	35	1102	18	32.6
7	Miao, Chao-yu	China	Naval Medical University	29	691	16	27.79
8	Shen, Fu-Ming	China	Naval Medical University	29	471	13	18.24
9	Xie, He-hui	China	Naval Medical University	28	518	15	20.75
10	Bilo, Grzegorz	Italy	IRCCS Istituto Auxologico Italiano	24	2192	22	93.42

The co-occurrence network of authors is shown in Fig. 4D, with Yutaka Imai having the highest outbreak intensity among all the authors (Fig. 4E). The cluster analysis of the authors revealed 10 clusters, including "arterial blood pressure", "Asia" and "renal transplantation" (Fig. 4F).

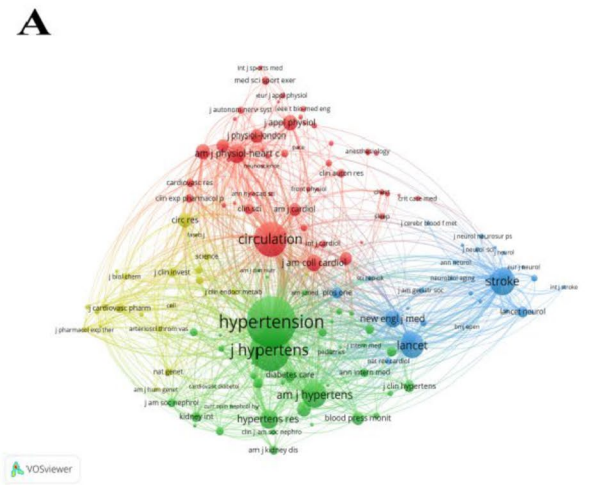
3.4 Performance of Journals and Cocitation Analysis

As shown in Table 4, the JOURNAL OF HYPERTENSION (191 publications, IF: 4.776) published the most articles related to BPV. The second and third were HYPERTENSION (138 publications, IF: 9.897) and AMERICAN JOURNAL OF HYPERTENSION (124 publications, IF: 3.076). The top 10 journals published approximately 30% (937/29.39%) of the total articles. Except for HYPERTENSION (IF: 9.897), the impact factors of all other journals were relatively low (defined as less than 5.000), indicating that researchers should improve the quality of their articles and conduct more in-depth and valuable research. Moreover, HYPERTENSION had the highest H-index, NC, and average NC per publication. Although AUTONOMIC NEUROSCIENCE-BASIC CLINICAL had the lowest NP, its H-index was higher than that of CLINICAL AND EXPERIMENTAL HYPERTENSION and PLOS ONE.

The co-occurrence network of the cited journals is illustrated in Fig. 5A. The top three most frequently cited journals are HYPERTENSION, JOURNAL OF HYPERTENSION, and CIRCULATION. Figure 5B displays the burst strength, burst duration, and burst time of the 20 most representative journals. In the cocitation network, a line between two nodes indicates that two articles were cited in one publication. The size of a node represents the number of cocitations for a given article. Moreover, nodes are colored to represent different clusters. Considering the enormous number of cited studies, the minimum NC was set as 46. A cocitation relationship was formed when two articles appeared together in the third cited study. Among the 76,494 cited articles retrieved from the publications, 128 were selected for cocitation analysis (Fig. 5C). The top 10 cocited references are listed in

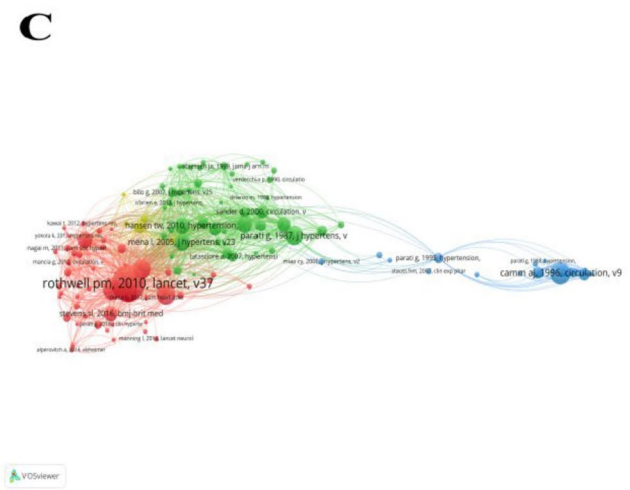
Table 4 The top 10 most active journals

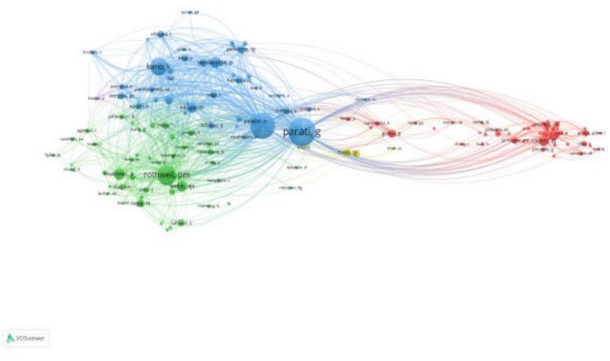
Rank	Journal	NP	NC	IF(2021)	H-index	Average citation per item
1	JOURNAL OF HYPERTENSION	191	5014	4.776	45	39.95
2	HYPERTENSION	138	8595	9.897	56	64.28
3	AMERICAN JOURNAL OF HYPERTENSION	124	3239	3.076	33	26.84
4	HYPERTENSION RESEARCH	119	2237	4.414	28	19.68
5	BLOOD PRESSURE MONITORING	88	1252	1.430	21	14.42
6	JOURNAL OF CLINICAL HYPERTENSION	73	905	2.885	17	12.93
7	JOURNAL OF HUMAN HYPERTENSION	59	1241	2.877	22	21.37
8	CLINICAL AND EXPERIMENTAL HYPERTENSION	55	621	2.088	15	11.67
9	PLOS ONE	46	735	3.752	15	16.17
10	AUTONOMIC NEUROSCIENCE BASIC CLINICAL	44	892	2.355	16	20.34



B **Top 20 Cited Journals with the Strongest Citation Bursts**

Cited Journals	Year	Strength	Begin	End	2013 - 2022
CLIN PHYSIOL	2013	10.02	2013	2016	
AM J PHYSIOL	2013	9.8	2013	2015	
PACE	2013	8.48	2013	2016	
J CARDIOVASC PHARM	2013	8.18	2013	2016	
J CLIN HYPERTENS (GREENWICH)	2014	9.49	2014	2017	
PHYSIOL REP	2019	9.91	2019	2022	
EUR J PREV CARDIOL	2019	9.22	2019	2022	
EUR J EPIDEMIOL	2019	7.93	2019	2022	
J AM HEART ASSOC	2014	26.71	2020	2022	
FRONT NEUROL	2019	16.05	2020	2022	
JAMA CARDIOL	2020	15.02	2020	2022	
J CLIN MED	2020	13.54	2020	2022	
PLOS MED	2019	11.73	2020	2022	
JAMA NEUROL	2018	10.22	2020	2022	
DIABETES OBES METAB	2017	9.08	2020	2022	
INT J GEN MED	2020	8.24	2020	2022	
FRONT NEUROSCI-SWITZ	2020	7.94	2020	2022	
NUTRIENTS	2020	7.65	2020	2022	
INT J STROKE	2018	7.5	2020	2022	
J CLIN NEUROSCI	2020	7.35	2020	2022	





D **Top 20 References with the Strongest Citation Bursts**

References	Year	Strength	Begin	End	2013 - 2022
Rothwell PM, 2010, LANCET, V375, P895, DOI 10.1016/S0140-6736(10)60308-X, DOI	2010	58.98	2013	2015	
Rothwell PM, 2010, LANCET, V375, P938, DOI 10.1016/S0140-6736(10)60309-1, DOI	2010	35.58	2013	2015	
Rothwell PM, 2010, LANCET NEUROL, V9, P469, DOI 10.1016/S1474-4422(10)70066-1, DOI	2010	35.18	2013	2015	
Webb AJS, 2010, LANCET, V375, P906, DOI 10.1016/S0140-6736(10)60235-8, DOI	2010	30.81	2013	2015	
Muntner P, 2011, HYPERTENSION, V57, P160, DOI 10.1161/HYPERTENSIONAHA.110.162255, DOI	2011	29.98	2013	2016	
Hansen TW, 2010, HYPERTENSION, V55, PE27, DOI 10.1161/HYP.0b013e3181dfc0ad, DOI	2010	24.49	2013	2015	
Shimbo D, 2012, HYPERTENSION, V60, P625, DOI 10.1161/HYPERTENSIONAHA.112.193094, DOI	2012	12.64	2013	2017	
Parati G, 2013, NAT REV CARDIOL, V10, P143, DOI 10.1038/nrcardio.2013.1, DOI	2013	26.03	2015	2018	
Mancia G, 2013, J HYPERTENS, V31, P1281, DOI 10.1097/01.hjh.0000431740.32696.cc, DOI	2013	17.3	2015	2018	
Parati G, 2015, CURR HYPERTENS REP, V17, P0, DOI 10.1007/s11906-015-0537-1, DOI	2015	15.08	2016	2020	
Diaz KM, 2014, HYPERTENSION, V64, P965, DOI 10.1161/HYPERTENSIONAHA.114.03903, DOI	2014	13.27	2016	2019	
Muntner P, 2015, ANN INTERN MED, V163, P329, DOI 10.7326/M14-2803, DOI	2015	16.72	2017	2020	
Manning LS, 2015, STROKE, V46, P2482, DOI 10.1161/STROKEAHA.115.010075, DOI	2015	12.82	2017	2020	
Gosmanova EO, 2016, J AM COLL CARDIOL, V68, P1375, DOI 10.1016/j.jacc.2016.06.054, DOI	2016	22.18	2018	2022	
Stevens SL, 2016, BMJ-BRIT MED J, V354, P0, DOI 10.1136/bmj.i4098, DOI	2016	36.74	2019	2022	
Mena LJ, 2017, J AM HEART ASSOC, V6, P0, DOI 10.1161/JAHA.117.006895, DOI	2017	15.7	2019	2022	
Williams B, 2018, EUR HEART J, V39, P3021, DOI 10.1093/eurheartj/ehy339, DOI	2018	15.3	2019	2022	
Oishi E, 2017, CIRCULATION, V136, P516, DOI 10.1161/circulationaha.116.025667, DOI	2017	13.84	2019	2022	
Mehlum MH, 2018, EUR HEART J, V39, P2243, DOI 10.1093/eurheartj/ehx760, DOI	2018	15.65	2020	2022	
Parati G, 2018, J CLIN HYPERTENS, V20, P1133, DOI 10.1111/jch.13304, DOI	2018	15.6	2020	2022	

Fig. 5 Visualization of the cited journal, cocited reference, and cocited author analysis. **A** Co-occurrence network of cited journals. **B** Top 20 representative burst-cited journals. **C** Co-occurrence network of cocited references. **D** Top 20 representative burst cocited references. **E** Co-occurrence network of the cocited authors

Supplementary Table 1. The articles written by Rothwell PM in 2010 had the highest cocitation frequency, with 569 citations, followed by the articles written by Camm AJ in 1996 and Parati G in 2013. Cluster 1 (red) includes 50 references focused mainly on predicting adverse outcomes, such as cardiovascular events, neurological diseases, and even death, caused by blood pressure variability. Cluster 2 (green) focuses mainly on interventions to reduce blood pressure variability and drug use strategies. Cluster 3 (blue) focuses on the generation mechanism and interfering factors of blood pressure variability. Cluster 4 (yellow) centers on the clinical significance of long-term follow-up of blood pressure variability.

Among all cocited references, the burst strength of the articles written by Rothwell PM in 2013 was the highest (Fig. 5D). Considering the large number of cited authors, the minimum cocitation frequency was set as 67. Among the 46,364 authors retrieved from the publications, 159 cocited authors were selected for analysis (Fig. 5E). The top 10 cocited authors are listed in Supplementary Table 2. Parati G had the most citations (2000), followed by Mancia G (1803 times) and Rothwell PM (1197 times). In terms of total link strength, Parati G still ranked first (29,589), followed by Mancia G (29,149) and Kario K (17,548). Although the number of citations of Kario K was slightly lower, the author's total link strength was greater than that of Rothwell PM.

3.5 Analysis of the Global Citation Score

Figure 6 displays the annual global citation score (GCS) of the top 10 publications. The top two articles are guidelines published by Powers, WJ, in the STROKE journal. Among them, the highest GCS was achieved by the paper published by Powers in 2018 [26], with a score of 993. The updated version of the paper in 2019 [27] also received a high GCS of 943. This series of guidelines suggests that stroke patients with greater BPV are at greater risk of cerebral hemorrhage after receiving reperfusion therapy. In a review, Parati et al. [1] provided strict definitions for long-term and short-term BPV and clearly noted that an increase in both long- and short-term BPV increases the risk of adverse outcomes, such as cardiovascular events and even death. Hippisley-Cox et al. [6] constructed a risk prediction model that included 7,889,803 patients from prospective cohort studies and identified high systolic BPV as a high-risk factor for cardiovascular events. Stevens et al.'s review [28] concluded that long-term BPV is associated with cardiovascular events and mortality outcomes, and its impact may even exceed that of mean blood pressure on the basis of a systematic evaluation of 41 papers, including 19 observational cohort studies and 17 clinical trial cohorts. Plews et al. [29] described the correlation between BPV and heart rate variability. Additionally, Alvares et al. [9] speculated that the mechanism underlying BPV and heart rate variability might be related to autonomic dysfunction. Furthermore, the basic research conducted by Zeng et al. [30] These findings suggest that the mechanically activated ion channels PIEZO1 and PIEZO2 are crucial pressure-sensing mechanoreceptors that have long been sought to control acute blood pressure and are correlated with increased BPV when lacking. On the basis of a study including 2,865,157 patients, Gosmanova et al. [31] concluded that higher systolic BPV is associated with an increased risk of mortality, coronary heart disease, stroke, and end-stage renal disease, regardless of the presence of hypertension. Additionally, Harrison et al. [32] believed that genes are also significant factors affecting BPV. Although the effect of a single nucleotide polymorphism on blood pressure is minimal, when multiple single nucleotide polymorphisms are analyzed as a polygenic risk score (PRS), they can explain up to 13 mmHg of BPV. Although these publications have different focuses on BPV, they are all groundbreaking and provide valuable guidance for subsequent research in this field.

3.6 Analysis of Keywords

This study analyzed the keywords in the abstracts and titles of 3188 publications (Fig. 7), ultimately including 158 keywords (with a minimum co-occurrence frequency of 35). As shown in Fig. 7A, Cluster 1 (red) focuses mainly on mechanisms associated with BPV, heart rate variability, baroreflex sensitivity, and circulatory fluctuations, indicating a high correlation within the internal circulatory system, signifying a research focus on the fundamental mechanisms underlying. Cluster 2 (presented in green) is characterized by research endeavors pertaining to adverse prognoses. It primarily reflects adverse outcomes such as cardiovascular disease and mortality, while delving into the factors that influence the predictive value of BPV in patients afflicted with these conditions. Cluster 3 (in blue) is dedicated to exploring the pathophysiological basis related to BPV. It underscores vascular thickness, stiffness, and atherosclerotic lesions as the underlying pathological substrates for BPV and probes into the mechanisms governing its emergence. Cluster 4 (yellow) focuses on the diagnosis and follow-up of BPV, highlighting its unique public health value.

The top 20 most frequently occurring keywords are listed in Supplementary Table 3. The most frequent keywords included "hypertension", "blood pressure variability", "blood pressure", "mortality", "risk", "heart rate variability", "stroke", and "association", indicating that research related to BPV has focused mainly on clinical studies and public health.

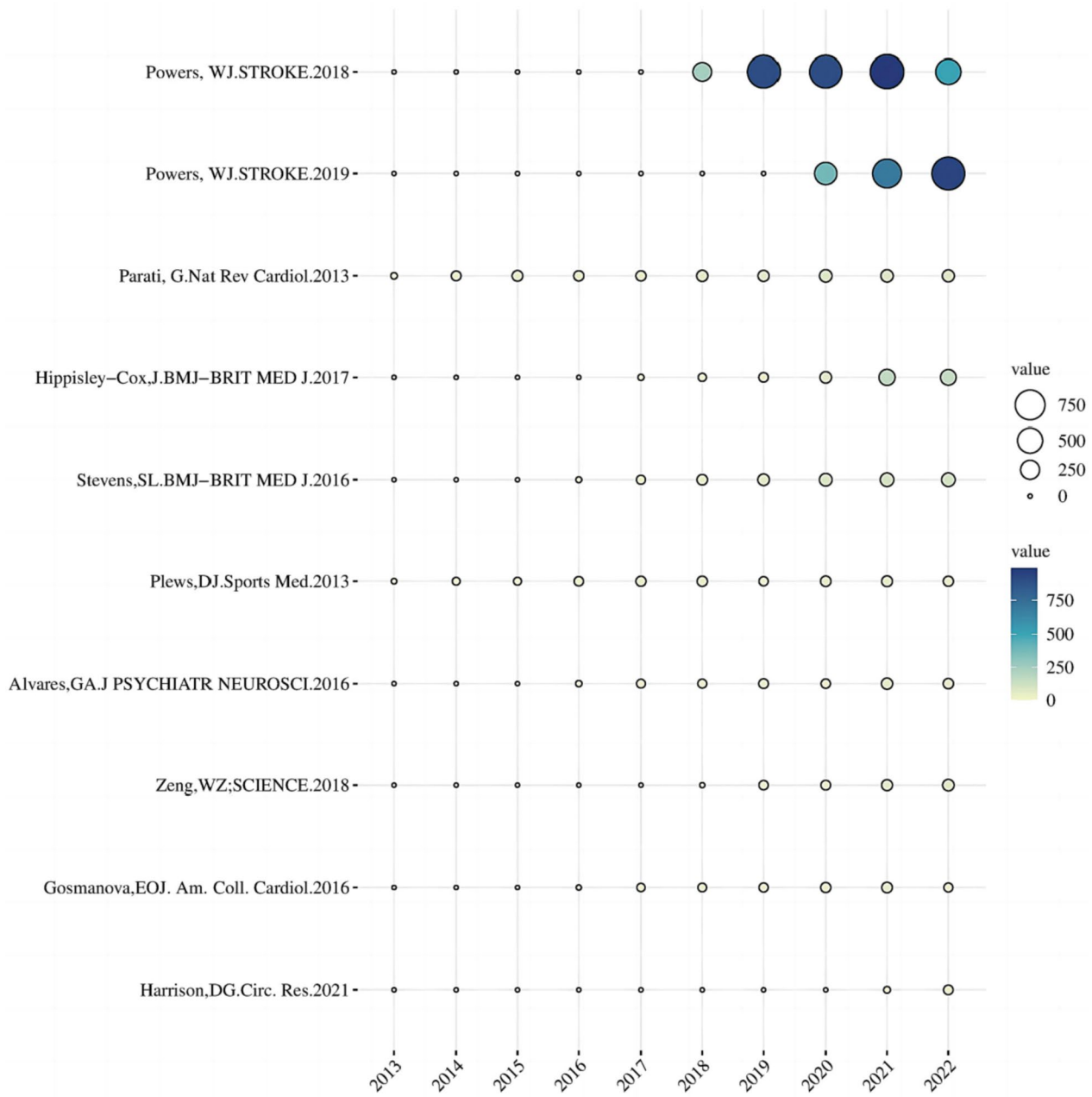
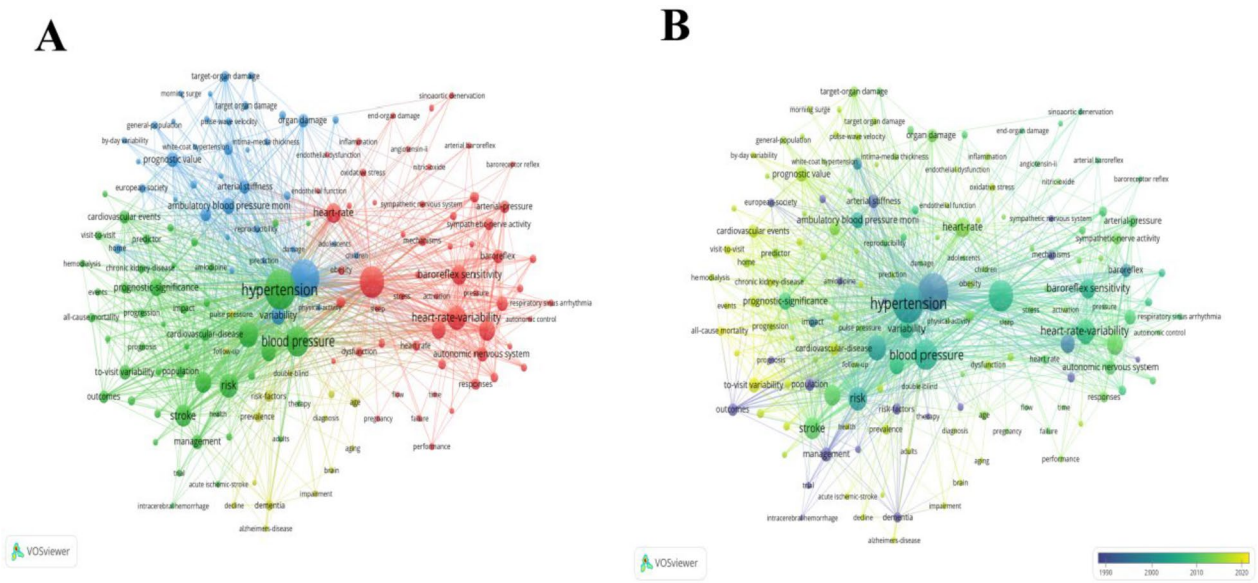


Fig. 6 Yearly number of global citations of papers with high global citations (GCS). The size and color of the circles represent the GCSs of the papers

As shown in Fig. 7B, all the keywords were grouped into different color types according to their average publication year (APY) via VOSviewer. Compared with hypertension-related mechanisms and other early research keywords, follow-up, prediction, and adverse outcomes have become the main research directions in this field. A comparison of Fig. 7A, B reveals that the public health predictive significance of BPV has become a more important research topic in recent years.

As shown in Fig. 7C, the 20 most representative keywords are displayed according to burst strength, burst duration, and burst time. The results revealed that the internal circulatory system fluctuation mechanism was a hot topic during the early stage of BPV research.



C

Top 20 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2013 – 2022
episodic hypertension	2013	7.56	2013	2017	
general population	2013	6.18	2013	2017	
humans	2013	6.05	2013	2015	
time rate	2013	5.85	2013	2016	
endothelial function	2013	5.81	2013	2015	
autonomic control	2013	4.77	2013	2014	
sensitivity	2013	4.65	2013	2016	
essential hypertension	2013	4.54	2013	2015	
reproducibility	2014	4.99	2014	2016	
cardiovascular risk	2013	4.41	2014	2015	
spontaneously hypertensive rats	2015	5.82	2015	2016	
masked hypertension	2015	5.74	2015	2018	
metaanalysis	2013	5.42	2016	2018	
trial	2013	5.17	2016	2018	
hypertensive patients	2013	4.9	2016	2018	
intima media thickness	2013	4.58	2016	2018	
european society	2014	6.18	2017	2019	
practice guidelines	2018	4.85	2018	2019	
adults	2018	5.22	2020	2022	
systolic blood pressure	2016	5.07	2020	2022	

Fig. 7 Network of keywords related to BPV. **A** The 158 keywords that occurred more than 35 times were divided into 4 clusters by different colors: cluster 1: red; cluster 2: green; cluster 3: blue; and cluster 4: yellow. The size of the nodes represents the frequency of occurrence. **B** Visualization of keywords according to the average publication year (APY). Keywords in yellow appeared later than those in blue. **(C)** Top 20 representative burst keywords

However, as time progressed, the public health value of BPV received more attention.

3.7 Bibliographic Coupling Analysis

Bibliographic coupling refers to the relationship between two articles if they cite the same reference. Link strength, on the other hand, refers to the number and quality of links between one paper and others. The latest version of the JCR provides us with the main indicator—IF—widely used to measure the quality and impact of journals. Bibliographic coupling network analysis is presented in Fig. 8, while the publication status of the top ten countries is detailed in Supplementary Table 4.

The United States has the highest NP, NC, and total link strength, with China ranking second in NP but

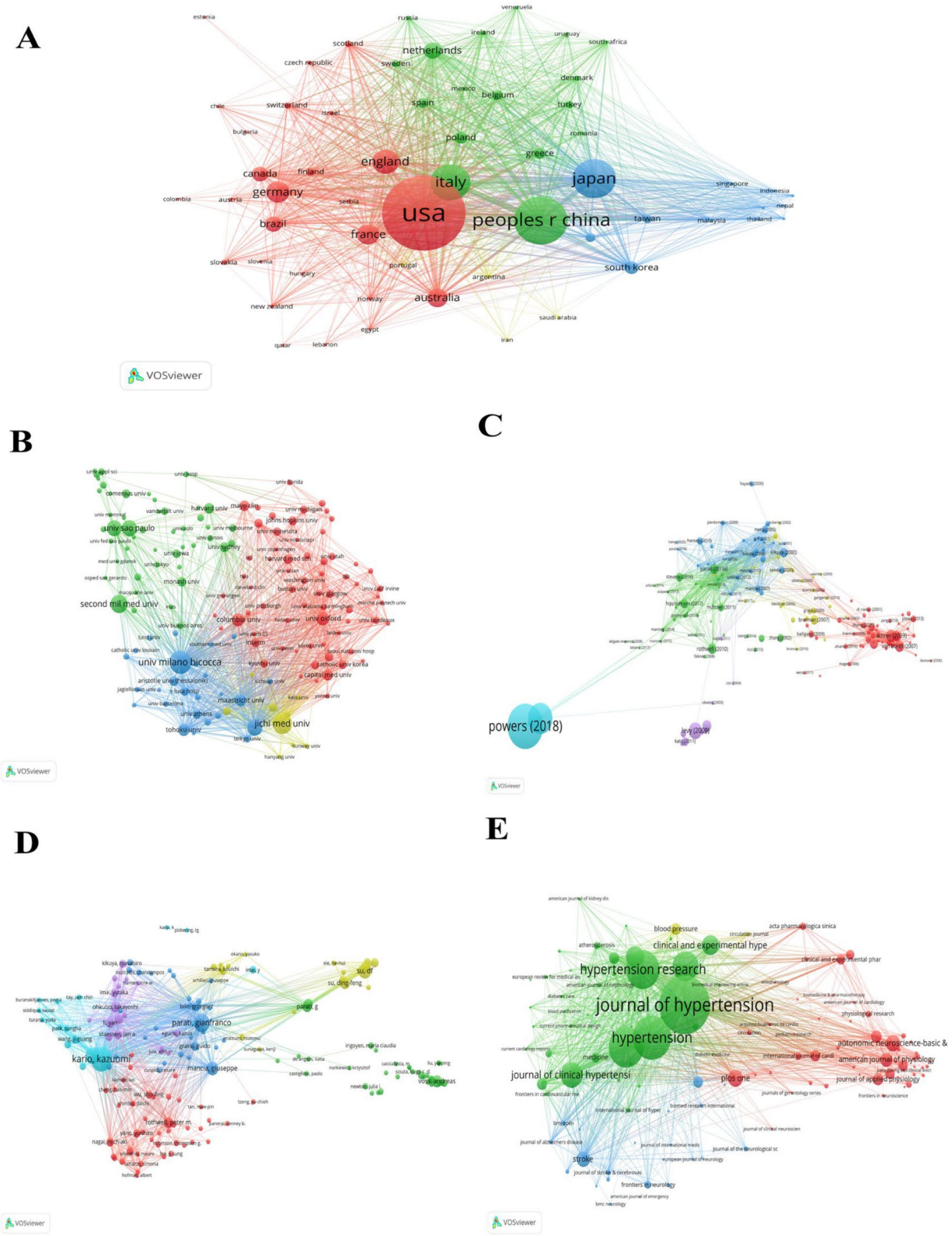


Fig. 8 Bibliographic coupling analysis. **A** Network of co-occurrence of countries/regions. **B** Network of co-occurrence of affiliations. **C** Network of co-occurrences of documents. **D** Network of co-occurrence of authors. **E** Network of co-occurring journals

having lower total link strength than Italy does. China's NC is also lower than that of Italy, Japan, and England. Except for the United States and China, the number of NPs in other countries is less than 500.

Overall, researchers typically disseminate and share their research results through publishing papers. When other researchers cite a paper, it indicates that the paper has academic value and influence. Therefore, the more a paper is cited, the greater its academic importance. In terms of institutions (Supplementary Table 5), Univ Milano Bicocca ranks first in terms of NP, NC, and total link strength, followed by Jichi Med Univ and Second Mil Med Univ. Shanghai Jiao Tong Univ also has a leading advantage in terms of NP and total link strength.

As shown in Supplementary Table 6, Kazuomi Kario has the highest NP and the second-highest total link strength, whereas Gianfranco Parati has the greatest total link strength and ranks second in terms of NP. Furthermore, although Grzegorz Bilo has fewer NPs, his citation count and total link strength are relatively high. The situations of the top ten journals are shown in Supplementary Table 7. The Journal of Hypertension has the highest NP, NC, and total link strength, followed by Hypertension and the American Journal of Hypertension. In terms of authors, Powers has the highest NC for papers published in 2018, whereas Parati has the highest total link strength for papers published in 2015 (Supplementary Table 8).

4 Discussion

4.1 Summary of Key Findings

BPV refers to the fluctuation in blood pressure over a period of time. Blood pressure management strategies centered around BPV have become a paradigm during the perioperative period, and BPV in medical fields outside of the perioperative period has also attracted much attention from academia. In this study, we conducted a bibliometric analysis using WoSCC as a basis and VOSviewer and CiteSpace to explore the hotspots and development trends of BPV research.

A total of 3,188 original articles and reviews published from 2000 to 2022 were retrieved for this study. The NP of the United States ranks first among all countries/regions, indicating that the country has a high output in BPV research. Although China ranks second in the number of publications, its publication output is approximately half that of the United States, indicating that the United States has an absolute leading advantage in this field. The H-index, average citation count, and NC of Chinese publications are lower than those of Japanese, Italian, and English publications, indicating that the quality of Chinese papers needs improvement.

China has four authors who rank among the top 10 authors in BPV research, indicating that China has many top researchers in BPV. At the institutional level, France, Italy, and the United States each have two institutions in the top 10 list. These countries are all leaders in BPV research, and the distribution of the best institutions is relatively balanced. Compared with the United States, Italy and England have relatively high average citation counts per paper, indicating that the research quality in these two countries is high. The relatively lower average citation count of Chinese publications may be attributed to several factors, including Italy's earlier initiation of research in the field, language barriers that impede international dissemination, and disparities in levels of international cooperation. However, China is progressively closing this gap through sustained and concerted efforts.

Among the top 10 productive journals, only one journal has an IF above 5, indicating that the quality of research papers in this field needs improvement, and the depth of BPV research also needs to be strengthened. Publishing BPV research in high-quality journals is a challenge.

The Journal of Hypertension is a professional journal related to hypertension and has a certain influence on the field of cardiovascular disease. It publishes the most BPV-related papers, indicating that BPV research is highly correlated with hypertension patients. However, the IF of this journal is not high (4.776). This may be because, compared with top-tier journals such as Hypertension, the Journal of Hypertension has relatively lower requirements for the amount of data and innovation in articles. Considering the difficulty of publication, the fact that most scholars publish articles in the Journal of Hypertension also indicates that this journal has a strong influence in the field of BPV research. Among the top 10 articles with the highest GCS, eight were published in high-IF journals, indicating that these journals have made significant breakthroughs in this field. This finding reminds researchers who are interested in this field to closely follow these journals.

Research in the field of BPV has revealed multiple mechanisms for regulating blood pressure. Long-term blood pressure regulation is mainly controlled by blood volume, whereas short-term regulation is mainly mediated by pressure sensors located in the walls of the aorta and carotid sinuses [33]. Multiple ion channels have been identified as playing important roles in pressure sensing, with the mechanosensitive ion channels PIEZO1 and PIEZO2 being considered the most important contributors. An experiment [30] in mice revealed that organisms

lacking Piezo1 and Piezo2 exhibit more unstable hypertension and greater BPV. Additionally, PIEZO1 is significantly expressed in the cardiovascular system [34], whereas PIEZO2 is widely expressed in various types of sensory neurons [35, 36].

Research has also revealed that multiple single nucleotide polymorphisms have a considerable effect on BPV [37]. Arteriosclerosis contributes to both long-term [38, 39] and long-term [40, 41] BPV. Changes induced by poorly controlled hypertension treatment drugs can also affect BPV. In addition, individual differences between patients play an important role in BPV, which is influenced by factors such as autonomic nervous disorders [9], sex [10], age [9], and history of preterm birth [11]. Together, these factors contribute to the formation and development of BPV. In summary, the increasing amount of research in the field of BPV helps to reveal the complex mechanisms of blood pressure regulation and variability. Understanding these mechanisms may help improve the diagnosis and treatment of hypertension.

4.2 Trends and Challenges

A comparison of Fig. 7A, B reveals the shift in the hot research directions of BPV over the past few years. Initially, the focus was on the mechanism and pathophysiology of BPV, but research gradually shifted to the importance of BPV in perioperative and critical care management, as well as its prognostic value in public health. Intraoperative BPV is significantly associated with patient prognosis, such as being identified as a risk factor for postoperative delirium [42–45], and relevant literature and guidelines recommend that the increase or decrease in blood pressure during surgery should not exceed 20% of the baseline blood pressure value [46, 47]. Standardized intraoperative blood pressure management based on the BPV coefficient is still considered the classic management strategy. BPV also plays a critical role in fluid management during the perioperative period, with target-oriented fluid therapy based on BPV becoming the current consensus for perioperative volume management [8].

In addition, BPV has been reported to be associated with acute and chronic cognitive impairments in some ICU patients [48]. High BPV has been identified as a significant positive predictor of mortality [28, 31, 49] and an important risk factor for cardiovascular events such as stroke [26, 27, 50]. Hence, understanding and applying relevant knowledge of BPV is highly clinically important. Recent progress [51] has been made in treating BPV, with controlling BPV being crucial. Certain classes of antihypertensive drugs, such as calcium channel blockers, have been shown to limit BPV and provide benefits to patients [52]. Studies suggest that targeting systolic blood pressure variability via specific antihypertensive drugs can be more effective in reducing the risk of stroke [52, 53]. However, current clinical guidelines advise against treating intermittent hypertension [54–56], which overlooks the potential risks of residual BPV in hypertensive patients [57]. Therefore, adjustments need to be made on the basis of new findings. Currently, the understanding of basic research related to BPV is relatively comprehensive, but social-level secondary prevention still needs to be further expanded. More resources and efforts need to be invested in exploring this field in depth to better understand the impact of BPV on human health and provide a stronger basis for developing more effective preventive measures.

Although there are an increasing number of research results related to BPVs, the definition methods and statistical methods of BPVs have not been unified. There are multiple ways to define BPV, including commonly used measures such as standard deviation (SD) and coefficient of variation (CV), as well as quantitative methods that represent fluctuations, such as average real variability (ARV) [58], independent of the mean (VIM) [50], and maximum minus minimum blood pressure (MMD) [59]. Each method has a unique purpose. For example, SD is one of the most frequently employed metrics for defining BPV, owing to its straightforward calculation. However, it is incapable of comprehensively reflecting the real-time fluctuations in blood pressure. ARV and VIM are more capable of capturing the absolute magnitude of blood pressure oscillations. The CV, which is both concise and accounts for individual baseline blood pressure levels, facilitates the comparison of BPV among patients with disparate baseline values. Therefore, there is no single index that can be universally applicable for calculating the BPV in all situations. In addition, the clinical significance of BPV varies at different time points [12]. The difference between long-term and short-term BPV is still unclear. The lack of standardization in definition methods and calculation periods makes it challenging to compare study results. Therefore, in the field of BPV research, a more thorough and comprehensive evaluation and standardization are needed to improve the quality and comparability of research findings.

5 Conclusion

In this study, the most relevant authors, the most cited published papers, authors' research outputs, leading journals, and relevant countries in the publications of BPV from 2000 to 2022 were analyzed quantitatively and qualitatively for visualization and evaluation of the findings on BPV research. Over the past 23 years, the number of NPs related to BPV has steadily increased. The United States and China have had important influences in this field. Effective cooperation between different countries/regions can promote further development of BPV research. BPV, as a clinical indicator with significant predictive value, needs more attention in terms of its mechanisms, clinical significance, and public health value.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1007/s44200-025-00080-0.

Below is the link to the electronic supplementary material.Supplementary file1 (XLSX 20 KB)

Supplementary file2 (XLSX 18 KB)

Supplementary file3 (XLSX 23 KB)

Supplementary file4 (XLSX 16 KB)

Supplementary file5 (XLSX 24 KB)

Supplementary file6 (XLSX 26 KB)

Supplementary file7 (XLSX 22 KB)

Supplementary file8 (XLSX 49 KB)

Acknowledgements

We thank LetPub (www.letpub.com) for its linguistic assistance during the preparation of this manuscript.

Author Contributions

Z.Z. completed the data analysis, prepared the figures, and wrote the manuscript. Y.D. revised the manuscript. Z.G. contributed to the conceptual design of the study. Y.C. polished the text. H.Z. provided expert advice. All authors reviewed and approved the final manuscript.

Funding

This work was supported by the Tsinghua Precision Medicine Foundation [Grant number 2022 TS016].

Data Availability

No datasets were generated or analysed during the current study.

Declarations

Conflict of Interest

The authors declare no competing interests.

Author details

[1]Department of Anesthesiology, Beijing Tsinghua Changgung Hospital, School of Clinical Medicine, Tsinghua Medicine, Tsinghua University, Beijing 102218, China. [2]Department of Electronic Engineering, Tsinghua University, Beijing 100084, China.

Received: 19 September 2024 Accepted: 11 April 2025
Published online: 06 May 2025

References

1. Parati G, Ochoa JE, Lombardi C, Bilo G. Assessment and management of blood-pressure variability. Nat Rev Cardiol. 2013;10(3):143–55. https://doi.org/10.1038/nrcardio.2013.1.
2. Hammarstrom S. The variability of blood pressure in hypertension. Acta Med Scand. 1948;131(Suppl 206):94–101.
3. Grassi G, Bombelli M, Brambilla G, Trevano FQ, Dell'oro R, Mancia G. Total cardiovascular risk, blood pressure variability and adrenergic overdrive in hypertension: evidence, mechanisms and clinical implications. Curr Hypertens Rep. 2012;14(4):333–8. https://doi.org/10.1007/s11906-012-0273-8.
4. Asayama K, Schutte R, Li Y, Hansen TW, Staessen JA. Blood pressure variability in risk stratification: what does it add? Clin Exp Pharmacol Physiol. 2014;41(1):1–8. https://doi.org/10.1111/1440-1681.12091.
5. Tatasciore A, Renda G, Zimarino M, et al. Awake systolic blood pressure variability correlates with target-organ damage in hypertensive subjects. Hypertension. 2007;50(2):325–32. https://doi.org/10.1161/HYPERTENSIONAHA.107.090084.
6. Hippisley-Cox J, Coupland C, Brindle P. Development and validation of QRISK3 risk prediction algorithms to estimate future risk of cardiovascular disease: prospective cohort study. BMJ. 2017;357: j2099. https://doi.org/10.1136/bmj.j2099.
7. Aronson S, Stafford-Smith M, Phillips-Bute B, et al. Intraoperative systolic blood pressure variability predicts 30-day mortality in aortocoronary bypass surgery patients. Anesthesiology. 2010;113(2):305–12. https://doi.org/10.1097/ALN.0b013e3181e07ee9.
8. Carrara M, Bollen Pinto B, Baselli G, Bendjelid K, Ferrario M. Baroreflex sensitivity and blood pressure variability can help in understanding the different response to therapy during acute phase of septic shock. Shock. 2018;50(1):78–86. https://doi.org/10.1097/SHK.0000000000001046.
9. Alvares GA, Quintana DS, Hickie IB, Guastella AJ. Autonomic nervous system dysfunction in psychiatric disorders and the impact of psychotropic medications: a systematic review and meta-analysis. J Psychiatry Neurosci Jpn. 2016;41(2):89–104. https://doi.org/10.1503/jpn.140217.
10. Muntner P, Shimbo D, Tonelli M, Reynolds K, Arnett DK, Oparil S. The relationship between visit-to-visit variability in systolic blood pressure and all-cause mortality in the general population: findings from NHANES III, 1988 to 1994. Hypertension. 2011;57(2):160–6. https://doi.org/10.1161/HYPERTENSIONAHA.110.162255.
11. Shi L, An S, Niu J, et al. Effect of premature birth on long-term systolic blood pressure variability in women. Anatol J Cardiol. 2018;20(6):347–53. https://doi.org/10.14744/AnatolJCardiol.2018.97415.
12. Casali KR, Schaan BD, Montano N, et al. Correlation between very short and short-term blood pressure variability in diabetic-hypertensive and healthy subjects. Arq Bras Cardiol. 2018;110(2):157–65. https://doi.org/10.5935/abc.20180020.
13. Krakoff LR. Fluctuation: does blood pressure variability matter? Circulation. 2012;126(5):525–7. https://doi.org/10.1161/CIRCULATIONAHA.112.124750.
14. Zhai K, Ma W, Huang T. Hot spots and trends in knee revision research since the 21st century: a bibliometric analysis. Ann Transl Med. 2021;9(5):388. https://doi.org/10.21037/atm-20-3969.
15. Demir E, Yaşar E, Özkoçak V, Yıldırım E. The evolution of the field of legal medicine: a holistic investigation of global outputs with bibliometric analysis. J Forensic Leg Med. 2020;69: 101885. https://doi.org/10.1016/j.jflm.2019.101885.
16. Wang L, Chen Y, Shen W, et al. A bibliometric analysis of cardioembolic stroke from 2012 to 2022. Curr Probl Cardiol. 2023;48(3): 101537. https://doi.org/10.1016/j.cpcardiol.2022.101537.
17. Devos P, Menard J. Bibliometric analysis of research relating to hypertension reported over the period 1997–2016. J Hypertens. 2019;37(11):2116–22. https://doi.org/10.1097/HJH.0000000000002143.
18. Wang H, Shi J, Shi S, Bo R, Zhang X, Hu Y. Bibliometric analysis on the progress of chronic heart failure. Curr Probl Cardiol. 2022;47(9): 101213. https://doi.org/10.1016/j.cpcardiol.2022.101213.
19. Zhou Y, Zhu XP, Shi JJ, et al. Coronary heart disease and depression or anxiety: a bibliometric analysis. Front Psychol. 2021;12: 669000. https://doi.org/10.3389/fpsyg.2021.669000.
20. van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics. 2010;84(2):523–38. https://doi.org/10.1007/s11192-009-0146-3.

21. Chen C. Searching for intellectual turning points: progressive knowledge domain visualization. Proc Natl Acad Sci USA. 2004;101(Supp1 1):5303–10. https://doi.org/10.1073/pnas.0307513100.
22. Hirsch JE. An index to quantify an individual's scientific research output. Proc Natl Acad Sci U S A. 2005;102(46):16569–72. https://doi.org/10.1073/pnas.0507655102.
23. Liu T, Yang L, Mao H, Ma F, Wang Y, Zhan Y. Knowledge domain and emerging trends in podocyte injury research from 1994 to 2021: a bibliometric and visualized analysis. Front Pharmacol. 2021;12: 772386. https://doi.org/10.3389/fphar.2021.772386.
24. Kleinberg J. Bursty and hierarchical structure in streams. Data Min Knowl Discov. 2003;7(4):373–97. https://doi.org/10.1023/A:1024940629314.
25. Wei Q, Shen J, Wang D, et al. A bibliometric analysis of studies on flap endonuclease 1 from 2005 to 2019. BMC Cancer. 2021;21(1):374. https://doi.org/10.1186/s12885-021-08101-2.
26. Powers WJ, Rabinstein AA, Ackerson T, et al. 2018 Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2018;49(3):e46–110. https://doi.org/10.1161/STR.0000000000000158.
27. Powers WJ, Rabinstein AA, Ackerson T, et al. Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2019;50(12):e344–418. https://doi.org/10.1161/STR.0000000000000211.
28. Stevens SL, Wood S, Koshiaris C, et al. Blood pressure variability and cardiovascular disease: systematic review and meta-analysis. BMJ. 2016;354: i4098. https://doi.org/10.1136/bmj.i4098.
29. Plews DJ, Laursen PB, Stanley J, Kilding AE, Buchheit M. Training adaptation and heart rate variability in elite endurance athletes: opening the door to effective monitoring. Sports Med Auckl NZ. 2013;43(9):773–81. https://doi.org/10.1007/s40279-013-0071-8.
30. Zeng WZ, Marshall KL, Min S, et al. PIEZOs mediate neuronal sensing of blood pressure and the baroreceptor reflex. Science. 2018;362(6413):464–7. https://doi.org/10.1126/science.aau6324.
31. Gosmanova EO, Mikkelsen MK, Molnar MZ, et al. Association of systolic blood pressure variability with mortality, coronary heart disease, stroke, and renal disease. J Am Coll Cardiol. 2016;68(13):1375–86. https://doi.org/10.1016/j.jacc.2016.06.054.
32. Harrison DG, Coffman TM, Wilcox CS. Pathophysiology of hypertension: the mosaic theory and beyond. Circ Res. 2021;128(7):847–63. https://doi.org/10.1161/CIRCRESAHA.121.318082.
33. Wehrwein EA, Joyner MJ. Regulation of blood pressure by the arterial baroreflex and autonomic nervous system. Handb Clin Neurol. 2013;117:89–102. https://doi.org/10.1016/B978-0-444-53491-0.00008-0.
34. Wang S, Chennupati R, Kaur H, Iring A, Wettschureck N, Offermanns S. Endothelial cation channel PIEZO1 controls blood pressure by mediating flow-induced ATP release. J Clin Invest. 2016;126(12):4527–36. https://doi.org/10.1172/JCI87343.
35. Nonomura K, Woo SH, Chang RB, et al. Piezo2 senses airway stretch and mediates lung inflation-induced apnea. Nature. 2017;541(7636):176–81. https://doi.org/10.1038/nature20793.
36. Chesler AT, Szczot M, Bharucha-Goebel D, et al. The role of PIEZO2 in human mechanosensation. N Engl J Med. 2016;375(14):1355–64. https://doi.org/10.1056/NEJMoa1602812.
37. Cabrera CP, Ng FL, Nicholls HL, et al. Over 1000 genetic loci influencing blood pressure with multiple systems and tissues implicated. Hum Mol Genet. 2019;28(R2):R151–61. https://doi.org/10.1093/hmg/ddz197.
38. Schillaci G, Bilo G, Pucci G, et al. Relationship between short-term blood pressure variability and large-artery stiffness in human hypertension: findings from 2 large databases. Hypertension. 2012;60(2):369–77. https://doi.org/10.1161/HYPERTENSIONAHA.112.197491.
39. García-García Á, García-Ortiz L, Recio-Rodríguez JI, et al. Relationship of 24-h blood pressure variability with vascular structure and function in hypertensive patients. Blood Press Monit. 2013;18(2):101–6. https://doi.org/10.1097/MBP.0b013e32835ebc58.
40. Nagai M, Hoshide S, Ishikawa J, Shimada K, Kario K. Visit-to-visit blood pressure variations: new independent determinants for carotid artery measures in the elderly at high risk of cardiovascular disease. J Am Soc Hypertens. 2011;5(3):184–92. https://doi.org/10.1016/j.jash.2011.03.001.
41. Mancia G. Short- and long-term blood pressure variability: present and future. Hypertension. 2012;60(2):512–7. https://doi.org/10.1161/HYPERTENSIONAHA.112.194340.
42. Wang NY, Hirao A, Sieber F. Association between intraoperative blood pressure and postoperative delirium in elderly hip fracture patients. PLoS ONE. 2015;10(4): e0123892. https://doi.org/10.1371/journal.pone.0123892.
43. Radinovic K, Markovic Denic L, Milan Z, Cirkovic A, Baralic M, Bumbasirevic V. Impact of intraoperative blood pressure, blood pressure fluctuation, and pulse pressure on postoperative delirium in elderly patients with hip fracture: a prospective cohort study. Injury. 2019;50(9):1558–64. https://doi.org/10.1016/j.injury.2019.06.026.
44. Hirsch J, DePalma G, Tsai TT, Sands LP, Leung JM. Impact of intraoperative hypotension and blood pressure fluctuations on early postoperative delirium after noncardiac surgery. Br J Anaesth. 2015;115(3):418–26. https://doi.org/10.1093/bja/aeu458.
45. Lizano-Díez I, Poteet S, Burniol-Garcia A, Cerezales M. The burden of perioperative hypertension/hypotension: a systematic review. PLoS ONE. 2022;17(2): e0263737. https://doi.org/10.1371/journal.pone.0263737.
46. Meng L, Yu W, Wang T, Zhang L, Heerdt PM, Gelb AW. Blood pressure targets in perioperative care. Hypertension. 2018;72(4):806–17. https://doi.org/10.1161/HYPERTENSIONAHA.118.11688.
47. Sessler DI, Bloomstone JA, Aronson S, et al. Perioperative quality initiative consensus statement on intraoperative blood pressure, risk and outcomes for elective surgery. Br J Anaesth. 2019;122(5):563–74. https://doi.org/10.1016/j.bja.2019.01.013.
48. Garbajs NZ, Singh TD, Valencia Morales DJ, et al. Association of blood pressure variability with short- and long-term cognitive outcomes in patients with critical illness. J Crit Care. 2022;71: 154107. https://doi.org/10.1016/j.jcrc.2022.154107.
49. Di Iorio B, Pota A, Sirico ML, et al. Blood pressure variability and outcomes in chronic kidney disease. Nephrol Dial Transplant Off Publ Eur Dial Transpl Assoc Eur Ren Assoc. 2012;27(12):4404–10. https://doi.org/10.1093/ndt/gfs328.
50. Rothwell PM, Howard SC, Dolan E, et al. Prognostic significance of visit-to-visit variability, maximum systolic blood pressure, and episodic hypertension. Lancet. 2010;375(9718):895–905. https://doi.org/10.1016/S0140-6736(10)60308-X.
51. Webb AJS, Fischer U, Mehta Z, Rothwell PM. Effects of antihypertensive-drug class on interindividual variation in blood pressure and risk of stroke: a systematic review and meta-analysis. Lancet. 2010;375(9718):906–15. https://doi.org/10.1016/S0140-6736(10)60235-8.
52. Rothwell PM, Howard SC, Dolan E, et al. Effects of beta blockers and calcium-channel blockers on within-individual variability in blood pressure and risk of stroke. Lancet Neurol. 2010;9(5):469–80. https://doi.org/10.1016/S1474-4422(10)70066-1.
53. Webb AJS, Rothwell PM. Effect of dose and combination of antihypertensives on interindividual blood pressure variability: a systematic review. Stroke. 2011;42(10):2860–5. https://doi.org/10.1161/STROKEAHA.110.611566.
54. Mansia G, De Backer G, Dominiczak A, et al. 2007 ESH-ESC Guidelines for the management of arterial hypertension: the task force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). Blood Press. 2007;16(3):135–232. https://doi.org/10.1080/08037050701461084.
55. Parati G, Stergiou GS, Asmar R, et al. European Society of Hypertension practice guidelines for home blood pressure monitoring. J Hum Hypertens. 2010;24(12):779–85. https://doi.org/10.1038/jhh.2010.54.
56. O'Brien E, Asmar R, Beilin L, et al. Practice guidelines of the European Society of Hypertension for clinic, ambulatory and self blood pressure measurement. J Hypertens. 2005;23(4):697–701. https://doi.org/10.1097/01.hjh.0000163132.84890.c4.
57. Rothwell PM. Limitations of the usual blood-pressure hypothesis and importance of variability, instability, and episodic hypertension. Lancet. 2010;375(9718):938–48. https://doi.org/10.1016/S0140-6736(10)60309-1.
58. Mena L, Pintos S, Queipo NV, Aizpurua JA, Maestre G, Sulbaran T. A reliable index for the prognostic significance of blood pressure variability. J Hypertens. 2005;23(3):505–11. https://doi.org/10.1097/01.hjh.0000160205.81652.5a.
59. Masugata H, Senda S, Murao K, et al. Visit-to-visit variability in blood pressure over a 1-year period is a marker of left ventricular diastolic

dysfunction in treated hypertensive patients. Hypertens Res Off J Jpn Soc Hypertens. 2011;34(7):846–50. https://doi.org/10.1038/hr.2011.54.

Publisher's Note