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INTRODUCTION

A method that can definitively determine the exact time of death has not yet been discovered. The lack of a clear method for such an important issue has led scientists to conduct numerous studies to determine the time of death, with many studies aimed at determining the time of death carried out every year (1). Because many personal and environmental factors vary from person to person in each death case, determining the exact time of death becomes much more complex. The precise time of death is difficult to determine in each case, as the temperature, humidity, precipitation, wind, and seasonal meteorological factors of the environment, where the body is found, altitude, whether it is buried or exposed, the depth if buried and soil characteristics, animal and insect effects, the person's age, weight, health and disease status and a wide variety of other personal and environmental factors vary (2). Due to the challenges posed by

Research trends on postmortem interval with bibliometric analysis

Abstract

Aim: This study aims to examine the changing dynamics of the subject and to contribute to scientists who will work in the field by conducting a bibliometric analysis of the studies in the Web of Science database on the subject of postmortem interval.

Materials and Methods: A comprehensive bibliometric search was executed within the Web of Science Core Collection for publications containing "postmortem interval" in the title or author keywords section on 31/12/2024, 991 results were obtained between 1980 and 2024. The IBM SPSS 23 package program was used for simple frequency analysis, and the VOSviewer 1.6.20 program was used for network analysis and visualization.

Results: It was seen that the most frequent study was published in 2021 with 67 publications, and the USA produced the highest output, contributing 275 publications. It was determined that the institution with the most publications was in the People's Republic of China, and the author with the most publications was from the People's Republic of China, with 40 publications. It was seen that the most cited study was published in 1992, and the most citations by year were made in 2001.

Conclusion: As no single method definitively determines the time of death, the subject of postmortem interval remains relevant in global research, attracting more and more attention, and the number of publications is increasing over the years.

Keywords: Postmortem interval, bibliometric analysis, forensic sciences, research trend

these diverse factors, research is being conducted to improve the reliability of methods used to determine the time of death (3). The concept of "postmortem interval" arose because a method for accurately determining the time of death has not yet been discovered. This method attempts to estimate the time lapsed after death (4). As the prevailing view has emerged that while the exact time elapsed after death cannot be determined, inferences can be made about the time intervals following death, current research has focused on improving postmortem interval estimation (5). Significant advancements are being made in many scientific fields to more accurately determine the postmortem interval, and numerous new studies are being conducted and new methods developed each year. Although many methods are used due to the lack of a single definitive method, routine forensic medicine practices most commonly involve examining external physical appearance and changes (6). There are many

methods used in postmortem interval estimation in fields such as molecular biology, histology, pathology, entomology, microbiology, biochemistry, anthropology, thanatochemistry, electrophysiology, and radiology (7).

In our study, we aimed to explore the topic of postmortem intervals, a subject in which new research is ongoing, and the number of publications is rapidly growing, through a comprehensive analysis. We employed bibliometric analysis methods to accomplish this. Bibliometric analysis is an analytical method that performs qualitative and quantitative analysis of published works in a specific field and the relationships between these publications, enabling numerical evaluation of current publication status, subject trends, and citation relationships using visualization software (8). We aimed to enable researchers interested in the postmortem interval, whether from the field of forensic science or another, to quickly gain an understanding of relevant publications, authors, and citations.

MATERIALS AND METHODS

In our study, publications included in the Web of Science database between 1980 and 2024 were evaluated. On 31/12/2024, publications containing "postmortem interval" in the title or author keywords section were scanned (9). When the Web of Science "all field" and "topic" sections were searched, the abstract section of the publications was also scanned, and since it was determined that studies unrelated to "postmortem interval" were also included in the data set, the search section was limited to the "title" heading and "author keywords" sections. IBM SPSS 23 package program was used for simple frequency analysis, and the VOSviewer 1.6.20 program was used for analysis and visualization (10). The steps performed are shown in a flowchart for better understanding in Figure 1.

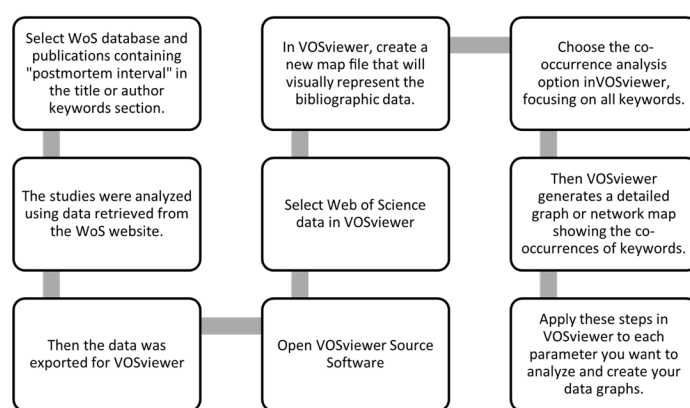


Figure 1. Flowchart for bibliometric analysis

Ethics committee approval is not required for bibliometric analyses that do not involve human or animal testing and are conducted using publication data obtained from publicly available/subscription-based databases such as Web of Science or Scopus.

RESULTS

Our search revealed a total of 991 publications between 1980 and 2024. The first publication in our search was the study titled "Estimation of postmortem interval by chemical means," published in the "American Journal of Forensic Medicine and Pathology" in 1980 (11).

It was observed that the number of publications related to the postmortem interval has generally increased over the years, and publication volume peaked in 2021, with 67. It was determined that 50 publications were made in 2022, 54 in 2023, and 65 in 2024. The total number of publications by year is shown in Figure 2.

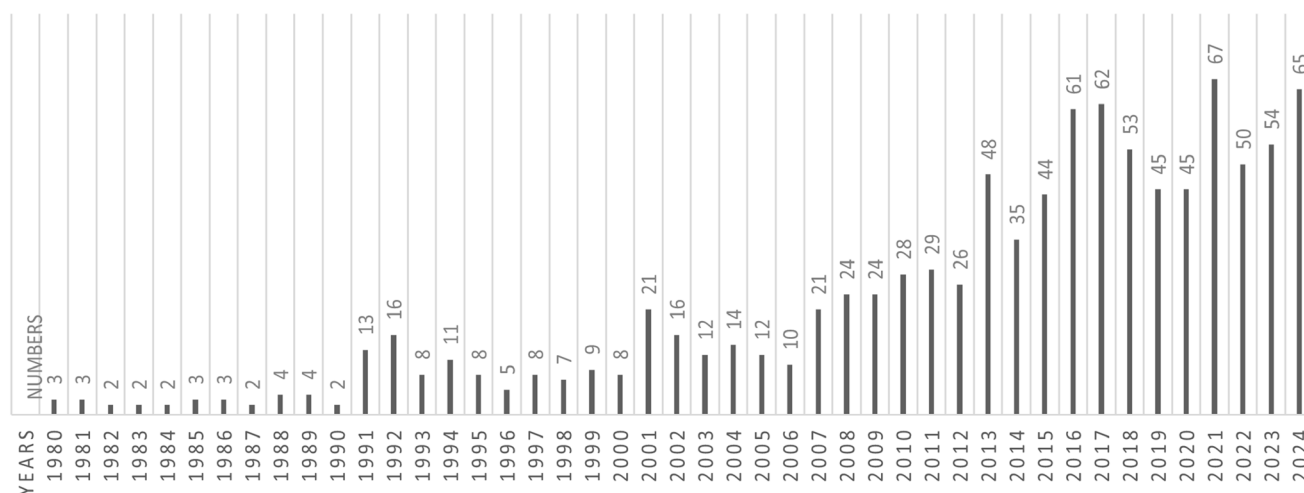


Figure 2. The total number of publications by years

In the document type evaluation, it was determined that there were 864 articles, 49 review articles, 40 proceeding papers, and 38 meeting abstracts. In the Web of Science categories evaluation, it was seen that 576 publications were in the field of

legal medicine, 105 publications in the field of entomology, 88 publications in the field of pathology, 76 publications in veterinary sciences, 32 publications in neurosciences, 29 publications in biochemistry and molecular biology, and 19

publications in microbiology. In our search, it was determined that a total of 91 different scientific categories were published between 1980-2024. It was determined that the studies received a total of 24271 citations between 1980-2024. The total number of citations received by the studies by year is shown in Figure 3. It was seen that the Review study named

“Forensic entomology in criminal investigations” by Catts EP and Goff ML was the most cited study (12). The top 10 studies according to the number of citations they received and the total number of citations, and the number of citations they received in the last 3 years, and the total number of citations are shown in Table 1 (12-21).

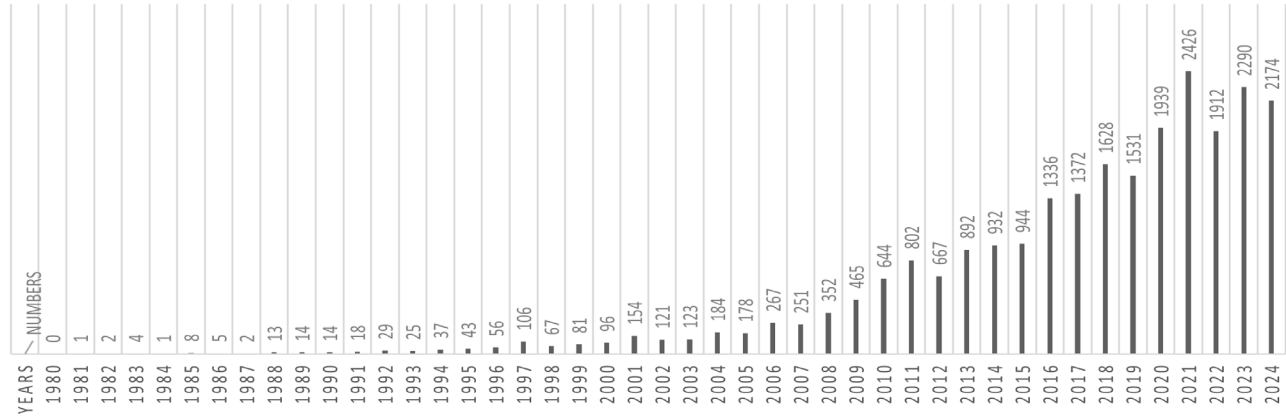


Figure 3. Total number of citations of studies by year

Table 1. Top 10 studies according to the number of citations they received and the total number of citations					
Top 10 studies	2022	2023	2024	Av per	Total
Catts EP, Goff ML. Forensic entomology in criminal investigations. Annual review of Entomology. 1992;37:253-72. (Review)	36	44	35	19.6	627
Amendt J, Campobasso CP, Gaudry E, et al. Best practice in forensic entomology—standards and guidelines. Int J Legal Med. 2007;121:90–104. (Review)	36	46	36	30.9	525
Hashimoto K, Sawa A, Iyo M. Increased levels of glutamate in brains from patients with mood disorders. Biological Psychiatry. 2007;62:1310-6. (Original Research)	29	22	21	28.5	485
Megyesi MS, Nawrocki SP, Haskell NH. Using accumulated degree-days to estimate the postmortem interval from decomposed human remains. Journal of Forensic Sciences. 2005;50:JFS2004017. (Original Research)	28	40	40	21.6	410
Campobasso CP, Di Vella G, Introna F. Factors affecting decomposition and Diptera colonization. Forensic Science International. 2001;120:18-27. (Original Research)	23	30	29	17.7	406
Harrison PJ, Heath PR, Eastwood SL, et al. The relative importance of premortem acidosis and postmortem interval for human brain gene expression studies: selective mRNA vulnerability and comparison with their encoded proteins. Neuroscience letters. 1995;200:151-4. (Original Research)	4	4	8	10.7	310
Grassberger M, Reiter C. Effect of temperature on <i>Lucilia sericata</i> (Diptera: Calliphoridae) development with special reference to the isomegalen-and isomorphen-diagram. Forensic Science International. 2001;120:32-6. (Original Research)	15	20	12	13.3	306
Tomita H, Vawter MP, Walsh DM, et al. Effect of agonal and postmortem factors on gene expression profile: quality control in microarray analyses of postmortem human brain. Biological psychiatry. 2004;55:346-52. (Original Research)	6	6	8	13.3	267
Metcalf JL, Wegener Parfrey L, Gonzalez A, et al. A microbial clock provides an accurate estimate of the postmortem interval in a mouse model system. elife. 2013;2:e01104. (Original Research)	27	23	22	21.6	238
Sperling FA, Anderson GS, Hickey DA. A DNA-based approach to the identification of insect species used for postmortem interval estimation. Journal of Forensic Sciences. 1994;39:418-27. (Original Research)	2	5	4	7.4	223
Av per: Average of citations per year					

It was determined that 915 of the studies were published in journals indexed in the Science Citation Index Expanded (SCI-Expanded), Conference Proceedings Citation Index (CPCI-S), and 51 in the Emerging Sources Citation Index (ESCI). It was seen that the studies were published most frequently in the Journal of Forensic Science, and second most frequently in Forensic Science International. The journal names in which the studies were published most frequently are given in Table 2.

Table 2. Journals in which the articles were published

Journal name	Total article	Percentage (%)
Journal of Forensic Sciences	171	17.25
Forensic Science International	151	15.23
International Journal of Legal Medicine	68	6.86
Journal of Medical Entomology	59	5.95
American Journal of Forensic Medicine and Pathology	33	3.32
Journal of Forensic and Legal Medicine	29	2.92
Legal Medicine	28	2.82
Forensic Science, Medicine and Pathology	20	2.01
Forensic Sciences Research	13	1.31
Scientific Reports	13	1.31
Others	406	40.95

When the institutions and organizations where the studies were conducted were examined, it was seen that Soochow University China, was in first place with 41 studies, and the State University System of Florida was in second place with 25 studies. In the examination of the funding institutions, it was seen that 101 studies received funding from the National Natural Science Foundation of China (NSFC), 32 studies from Priority Academic Program Development Jiangsu Higher Education, and 27 studies from the United States Department of Health Human Services. The institutions where the studies were conducted are given in Table 3.

Table 3. Institutions where the studies were conducted

Institutions	Total article	Percentage (%)
Soochow University China	41	4.13
State University System of Florida	25	2.52
Xi An Jiaotong University	25	2.52
Goethe University Frankfurt	21	2.11
University of Hawaii System	20	2.01
Central South University	19	1.91
Institute of Forensic Science Ministry of Justice Pre	19	1.91
Egyptian Knowledge Bank Ekb	18	1.81
University of Tennessee Knoxville	17	1.71
University of Tennessee System	17	1.71
Others	769	77.59

It was found that 975 of the studies were published in English, five each in Chinese and German, four in Spanish, and one each in Croatian and Portuguese. Wang Yu, Wang Jiangfeng, and Wang Zhenyuan were determined to be the authors with the most studies, respectively. The authors with the most studies are listed in Table 4, respectively.

Table 4. Authors with the most studies

Authors	Studies	Percentage (%)
WANG Yu	40	4.03
WANG Jiangfeng	37	3.73
WANG Zhenyuan	23	2.32
LI Liangliang	21	2.11
GOFF M. Lee	20	2.01
WANG Min	20	2.01
ZHANG Yanan	16	1.61
WANG Yinghui	15	1.51
AMENDT Jens	14	1.41
HUANG Ping	14	1.41
Others	771	77.8

DISCUSSION

Determining the time of death in a death case is one of the most important issues. Since there is no single method that can clearly determine the time of death, all known findings should be considered and a time period as narrow as possible should be determined. In routine forensic medicine practices, the most commonly used methods for estimating the postmortem interval are dead body cooling, dead body hardness, dead body stains, and postmortem decomposition, that is, changes that occur during the decomposition process (1). Electrical and chemical excitability of muscles and nerves, gastric emptying rate, blood and vitreous fluid analysis, tissue element level analysis, molecular genetic studies, microbiological and entomological analyses are other methods used routinely in postmortem interval estimation (22). There are many scientific fields that deal with postmortem interval estimation. Due to the interesting nature of the subject and its current status, many new studies are conducted and published every year. Our research shows that publications have been made in 64 different scientific fields in this category in the last five years, and in 91 different scientific fields throughout all years (1980-2024), demonstrating the breadth of the field of interest.

One of the most striking findings from our analysis is that the number of studies published on postmortem interval has increased in recent years. Although the number of publications was less than 10 per year until 1990, it was observed that the number of publications started to increase rapidly in the 2000s and reached the highest number of publications, especially in the

2020s. It is seen in other bibliometric analyses that the number of articles published in the field of forensic medicine and other forensic sciences has also increased in recent years (23). As with many forensic issues, the issue of time of death attracts the attention of researchers.

When the countries that publish the most on postmortem interval, as in the field of forensic sciences in general, are examined, it is seen that countries with high financial power are leading in this field (24). In our search, it was seen that the country with the most publications between 1980-2024 was the USA. However, when recent years were evaluated, it is striking that the People's Republic of China came first in publications on postmortem intervals. Between 2020-2024, the People's Republic of China made 67 publications, while the USA made 53. When the institutions and funding organizations where the studies were conducted were examined, it was seen that the institutions and organizations belonging to the People's Republic of China were in the first place. When the publication language of the studies was examined, it was seen that English, which is used as the dominant language in the scientific field, was in the foreground. It was determined that 98.3% of the studies identified in our search were published in English. It was determined that the country with the most publications and the most citations was

the United States. While 27.74% of the publications were made in the United States, it was determined that these publications received a total of 9860 citations. It was seen that the People's Republic of China made 15.94% of the publications and received 2349 citations. The countries where the publications were made are given in Table 5, and the analysis of the citations of the countries where the publications were made is given in Figure 4.

Table 5. Countries where the studies were made

Countries	Studies	Percentage (%)
USA	275	27.74
Peoples R China	158	15.94
Italy	53	5.34
Germany	50	5.04
England	49	4.94
Japan	44	4.43
India	41	4.13
Spain	39	3.93
Brazil	35	3.53
Canada	34	3.43
Others	213	21.49

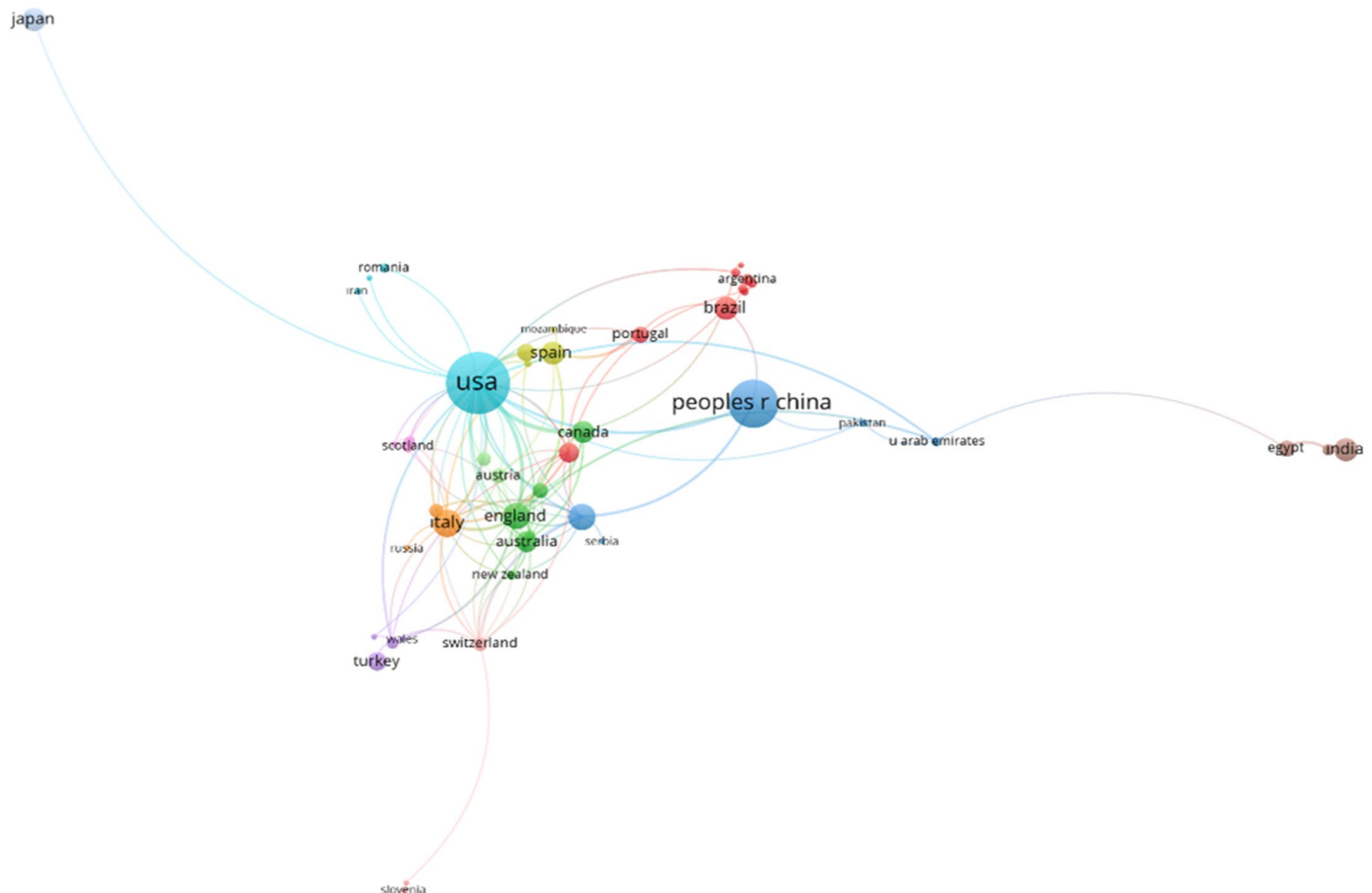


Figure 4. Citation analysis of the countries where the studies were conducted

In our search, the journal with the most publications between 1980-2024 was the Journal of Forensic Sciences with 17.25%. 2020-2024, it was seen that the most publications were in the International Journal of Legal Medicine with 8.48% and the Journal of Medical Entomology with 8.12%. When we look at the journals in which the studies were published, it was seen that 8 of the top ten journals were forensic science journals, one was entomology and one was a multidisciplinary science journal. Although the concept of time of death is generally thought to be the subject of forensic scientists, it was seen that studies on postmortem interval estimation were conducted in many scientific fields. When our search was evaluated according to Web of Science categories, it was seen that the most striking output was in the studies conducted in the field of microbiology. While 3 studies were conducted in the field of microbiology between 1980-2020, 16 studies were conducted between 2020-

2024. This increase suggests that microbiology is an important field of science in the postmortem interval (25).

The most frequently accompanying keywords for the postmortem interval were forensic entomology, forensic science, decomposition, forensic anthropology, forensic pathology and Calliphoridae. The importance of entomological organisms, which are the most important external factors of the decomposition process in postmortem changes, is reflected in the keywords section of the studies. The most frequently used keywords in the publications were found to be postmortem interval in 617 publications, forensic entomology in 225 publications, forensic science in 186 publications, decomposition in 65 publications, forensic anthropology in 49 publications, forensic pathology in 45 publications, and Calliphoridae in 38 publications. The analysis of the co-occurrence of the keywords is given in Figure 5.

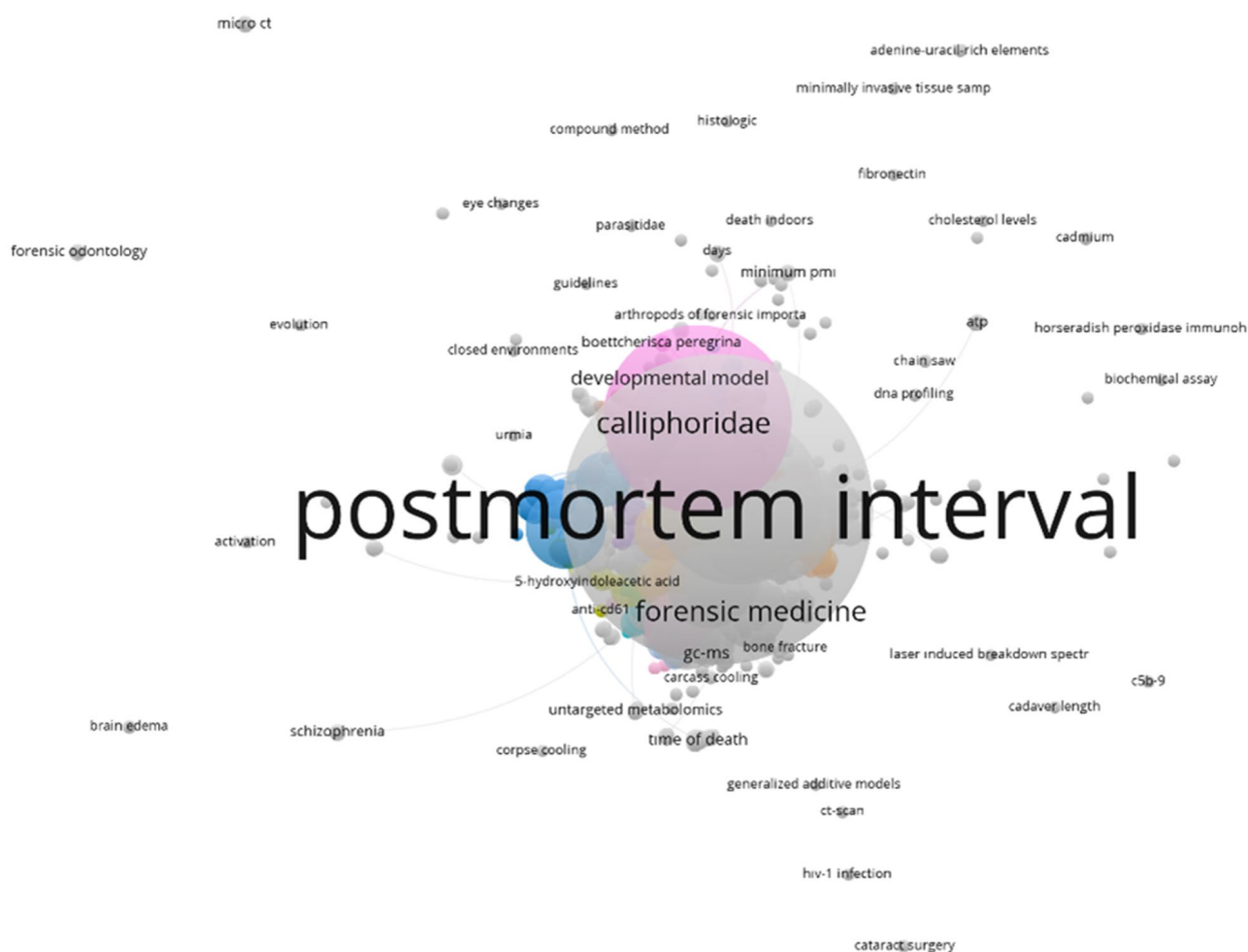


Figure 5. Analysis of the co-occurrence of the keywords

In our search, according to the Web of Science database dataset information, it was determined that the most publications were made by Wang Yu. It was determined that Wang Yu made the most publications between 2020-2024, and Goff ML made the

most publications between 1980-2019. Goff ML was also seen to be one of the authors of the most cited publications. The increase in citations to studies on postmortem interval over the years indicates that scientific interest in the subject has

increased. The most cited author was Goff M. Lee with 1819 citations despite having 20 documents. Catts E. Paul had 801 citations despite having 3 documents, and Amendt Jens had 14 documents and 797 citations. The co-authorship analysis for authors with at least one text and at least one citation is given in Figure 6, and the author citation analysis for their co-citations is given in Figure 7. In our study, it was seen that the most cited studies were made in 2021 with 2426 citations, and the second most cited was in 2023 with 2290 citations. According to our search, it was seen that the most cited study on postmortem interval was “Forensic entomology in criminal investigations” by Catts EP and Goff ML, published in Annual Review of Entomology with 627 citations. It was seen that the study “Applications of Metabolomics in Forensic Toxicology and Forensic Medicine” by Szeremeta, M and Pietrowska, K et al. published in International Journal Of Molecular Sciences with 43 citations between 2020-2024 and the study “Predicting postmortem interval based on microbial community sequences and machine learning algorithms” by Liu R and Gu Y et al. published in Environmental Microbiology (26,27). Looking at the last 3 years (2022,2023 and 2024), it was observed that the study with the most citations on average was the study by “Best practice in forensic entomology-standards and guidelines”

by Ament J, Campobasso C and Gaudry E et al. (International Journal of Legal Medicine in 2007) (13). This study also received the highest average annual citation rate, at 30.9. The most cited study in 2024 was; “Using accumulated degree-days to estimate the postmortem interval from decomposed human remains” by Megyesi MS, Nawrocki SP, Haskell NH. (Journal of Forensic Sciences in 2005) (15). The most cited study in 2023 was; “Best practice in forensic entomology-standards and guidelines” by Ament J, Campobasso C and Gaudry E et al. (13). The most cited studies in 2022 were: “Forensic entomology in criminal investigations” by Catts EP, Goff ML. and “Best practice in forensic entomology-standards and guidelines” by Ament J, Campobasso C and Gaudry E et al. (12,13) We can see from these citation numbers how important the concept of metabolomics, which has come to the fore in recent years, and the concept of artificial intelligence, which has been the most trendy topic in recent years, have become in studies on postmortem intervals (28). It is noteworthy that microbiome analysis and metageomics analyses and artificial intelligence-based studies have rapidly become trends in recent years. The speed provided by artificial intelligence and the advantages of being able to analyze large data sets more comprehensively are also among the reasons why it is used in postmortem intervals (29).

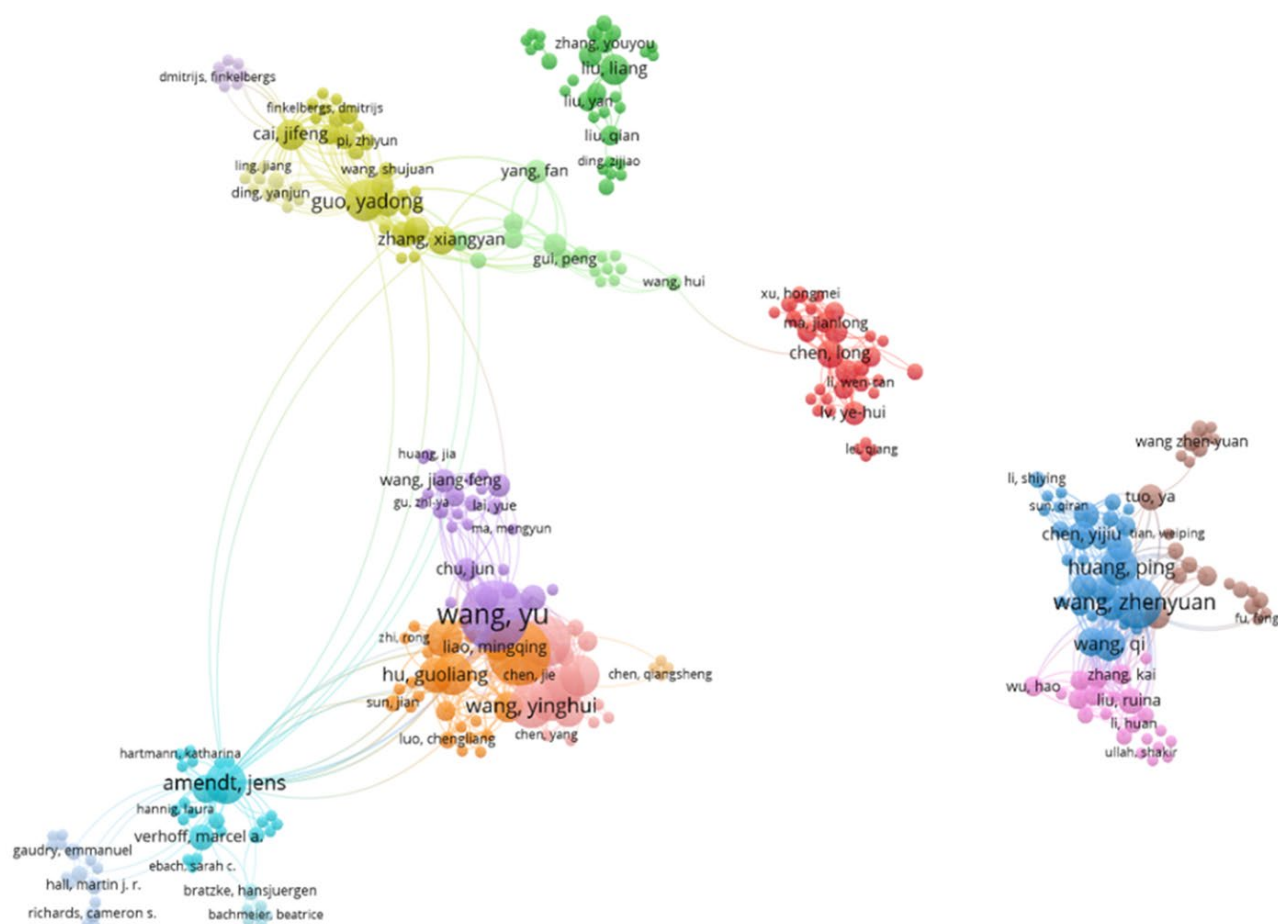


Figure 6. Analysis of co-authors



Figure 7. Analysis of co-citations of authors

Although the Web of Science database is one of the largest academic resources, it does not include all journals and studies (30). The limitation of our study is that only the keyword “postmortem interval” was used while scanning in this study and also only the Web of Science database was used to search for publications, and publications in other databases could not be included in the analysis. Language bias is also a limitation of our study, due to Web of Science's predominantly English-language focus.

CONCLUSION

Our study focuses on the current analysis and research trends of the postmortem interval topic. As can be understood from the general trend, since a single method that can clearly determine the time of death has not yet been discovered, the postmortem interval topic has increasingly attracted more attention in global research and the number of publications on this topic has been increasing over the years. The fact that developed countries such as the USA and the People's Republic of China, as well as other countries, have made significant contributions to the literature on postmortem interval suggests that the trend on the subject will increase even more.

Conflict of Interests

The authors declare that there is no conflict of interest in the study.

Financial Disclosure

The authors declare that there is no financial support.

Ethical Approval

Ethics committee approval is not required for bibliometric analyses that do not involve human or animal testing and are conducted using publication data obtained from publicly available/subscription-based databases such as Web of Science or Scopus.

Patient Consent

Not necessary for this manuscript.

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