Trend topics in emergency medicine: a comprehensive bibliometric analysis of CPR research

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Abstract: **Objective:**   This study aims to comprehensively evaluate the scientific contributions, research trends, and influential studies related to cardiopulmonary resuscitation (CPR), a critical life-saving intervention in cases of sudden cardiac arrest (SCA). By performing a bibliometric analysis of academic articles published between 1980 and 2023 in the Web of Science (WoS) database, the study seeks to identify key trends, thematic areas, and advancements in CPR research to provide valuable insights for guiding future studies and enhancing emergency medicine practices.

Methods: This study conducted a bibliometric analysis of academic articles on CPR published between 1980 and 2023 in the WoS database. A total of 4393 articles were examined to identify trends and contributions to the scientific literature. Various metrics were analyzed, including publication counts, citation rates, leading countries and institutions, prominent researchers, and the most cited studies. Performance analysis, keyword analysis, co-citation analysis, and thematic analyses were performed.

Results: The analysis revealed concentrated topics in CPR research and evolving trends over time. The findings showed significant contributions from leading countries, institutions, and researchers. The most cited studies highlighted key areas of focus and advancements in CPR practices. Thematic analysis indicated the major research themes and their development over the decades.

Conclusion: This bibliometric analysis provides an in-depth examination of the place and importance of CPR in emergency medicine. It offers a comprehensive perspective on the current state and future directions of CPR research. The findings help us better understand CPR's position in the scientific literature and its contributions to emergency medicine practices. These insights will guide future research directions and enhance scientific contributions to CPR practices in emergency medicine.

Keywords: Bibliometric Analysis; Cardiopulmonary Resuscitation ; Emergency Medicine; Neurological Protection; Research Trends

1. Introduction

Cardiopulmonary resuscitation (CPR) is a life-saving intervention performed in cases of sudden cardiac arrest (SCA) to restore spontaneous circulation and preserve cerebral function (1,2). It is not limited to SCA alone and may be applied in various clinical scenarios involving circulatory or respiratory arrest. CPR consists of standardized emergency procedures including chest compressions and ventilatory support, and it is classified as an immediate rather than merely urgent medical intervention (1,2).

The effectiveness and necessity of CPR are well-established in emergency and critical care settings, where rapid intervention is often the only chance of survival. As such, CPR represents a cornerstone of emergency medicine practice. Scientific research on CPR has proliferated in recent decades, contributing significantly to the body of knowledge on clinical interventions and patient survival. Understanding the scope, patterns, and evolution of this literature is essential for guiding future research and optimizing clinical practice (3–5).

Bibliometric analysis is a quantitative research method used to evaluate the publication patterns, scientific impact, and thematic development of a specific field over time. By analyzing metrics such as publication counts, citation networks, co-authorship, and keyword trends, this method helps identify research hotspots, intellectual structures, and knowledge gaps within the scientific literature (6,7).

In addition to mapping the historical trajectory of a field, bibliometric analysis provides evidence-based insights for guiding future research strategies and funding decisions. Its application is particularly valuable in fast-evolving domains where researchers face an overwhelming volume of academic output (8).

When applied to CPR-related research, bibliometric analysis reveals the most influential publications, key contributors, prominent themes, and emerging trends, offering a compre-

hensive overview of the scientific landscape (9).

A previous bibliometric study by Jia et al. (10) analyzed CPR-related publications from 2010 to 2019 and identified emerging topics such as therapeutic hypothermia, extracorporeal membrane oxygenation (ECMO), and brain injury. However, their analysis was limited to a single decade and did not focus specifically on the emergency medicine (EM) category. In contrast, the present study includes a broader time frame (1980–2023) and focuses solely on CPR research within EM, providing a more domain-specific and longitudinal perspective.

In recent years, bibliometric reviews have gained increasing popularity as a systematic approach to explore the intellectual landscape of scientific fields. However, unlike systematic reviews, bibliometric studies often lacked a standardized reporting guideline, leading to inconsistencies in structure, scope, and quality. To address this gap, Montazeri et al. (11) developed the biblio guideline, which outlines minimum reporting requirements for bibliometric reviews in biomedical literature. Their checklist structured into 20 core items across sections such as title, methods, results, and discussion aims to improve transparency and reproducibility in bibliometric reporting. As the present study also adopts a bibliometric approach, particularly within the EM literature on CPR, adherence to biblio recommendations ensures alignment with emerging standards and enhances the credibility and comparability of the findings.

Accordingly, the present study aims to conduct a comprehensive bibliometric analysis of publications on CPR indexed in the Web of Science (WoS) database. The analysis includes various indicators such as publication volume, citation metrics, leading countries and institutions, most **prolific** researchers, and frequently cited articles. In addition, temporal changes and emerging trends in the field will be examined.

The ultimate objective of this study is to evaluate how scientific knowledge on CPR has evolved and to delineate research directions that can further enhance clinical practice in EM. By doing so, this work aims to inform future academic and healthcare strategies regarding the implementation and advancement of CPR.

2. Methods

In our study, we used the WoS database, which is commonly preferred for bibliometric analyses or literature reviews. Databases vary significantly in terms of journal coverage, and WoS is one of the most widely used academic database sources for bibliometric analysis (12).

The data search was conducted in the WoS database on May 19, 2024. In the next phase, the data retrieved from the database was refined and filtered. When publications with the titles "Resuscitation OR Cardiopulmonary Resuscitation OR CPR" were searched in the WoS database, 30,498 articles were identified. The publication types were narrowed down to "Article OR Review Article," resulting in 17,668 ar-

ticles. When the WoS indices were set to "SCI_EXPANDED, ESCI, SSCI," the number of articles was reduced to 17,524. Limiting the language to "English" yielded 16,490 articles. Further filtering for articles in the Emergency Medicine category resulted in 4,490 articles. Excluding articles from 2024, since new publications are continually being added to the database, we obtained 4,393 articles, which were then analyzed.

The publication year range was restricted to 1980–2023 based on both methodological and bibliometric considerations. The year 1980 marks the onset of regular and trackable indexing of CPR-related publications in the EM category within the WoS database. Furthermore, the temporal distribution of research output starting from 1980 provides a longitudinal perspective, allowing for performance trends, citation dynamics, and keyword evolution to be analyzed comprehensively across decades. Publications from 2024 were excluded to avoid distortion in bibliometric indicators due to incomplete indexing.

To analyze the obtained data, we used the bibliometrix program. Bibliometrix is one of the latest open-source software tools, prepared in R, for performing science mapping (13).

In our review, the 4,393 articles were analyzed in four sections. The first section includes a performance analysis of articles in the field of CPR in EM. The second section conducts a keyword analysis, the third section performs a co-citation analysis, and the fourth section undertakes a thematic analysis. During the analysis, the keywords "cardiopulmonary resuscitation," "resuscitation," "cardiopulmonary resuscitation (cpr)," and "cardiopulmonary-resuscitation" were consolidated under the keyword "CPR."

2.1. Eligibility criteria

The inclusion and exclusion criteria for the selection of articles in this study were determined in accordance with the principles outlined in the biblio checklist (11), a validated guideline developed to enhance transparency and reproducibility in bibliometric reviews, particularly within health sciences.

2.2. Inclusion criteria

To ensure the relevance and quality of the data, the following inclusion criteria were applied:

(1) Articles indexed in the WoS database published between 1980 and 2023

(2) Publications containing the keywords "Resuscitation," "Cardiopulmonary Resuscitation," or "CPR" in the title field

(3) Articles categorized under the Emergency Medicine subject area

(4) Only original research articles and review articles

(5) Articles published in English

2.3. Exclusion criteria

The exclusion criteria were defined as follows:

(1) aArticles from 2024 were excluded to avoid the inclusion

Table 1   Main information

Description	Results	Description	Results
Main information about data		**AUTHORS**	
Timespan	1980:2023	Authors	15343
Sources (journals, books, etc)	58	Authors of single-authored docs	156
Documents	4393	Authors collaboration	
Annual growth rate %	6.3	Single-authored docs	229
Document average age	13.7	Co-authors per doc	6.41
Average citations per doc	29.36	International co-authorships %	17.07
References	55353	Document types	
Document contents		**Article**	3953
Keywords plus (ID)	4036	article; data paper	1
Author's keywords (DE)	4657	article; early access	2
		article; proceedings paper	110
		review	327

Table 2   Authors' local impact

Element	h_index	g_index	m_index	TC	NP	PY_start
Nolan JP	43	71	1,483	12920	71	1996
Perkıns GD	41	77	1,708	10354	77	2001
Berg RA	40	79	1,25	6371	87	1993
Soar J	38	56	1,9	10962	56	2005
Steen PA	32	43	0,97	3877	43	1992
Nadkarnı VM	31	55	1,292	3154	69	2001
Bossaert L	30	41	0,833	3724	41	1989
Deakın CD	30	43	1,034	7130	43	1996
Herlıtz J	30	49	1,034	3393	49	1996
Kern KB	30	59	0,732	3676	59	1984
Morrıson LJ	30	48	1,304	4046	48	2002
Koster RW	27	40	1	5812	40	1998
Wık L	27	50	0,871	2781	50	1994
Ewy GA	26	44	0,634	2037	44	1984
MA MHM	26	38	1,13	2447	38	2002
Nadkarnı V	26	38	0,684	4028	38	1987
ONG Meh	26	50	1,238	2542	51	2004
Callaway CW	25	45	0,962	2366	45	1999
Hazınskı MF	25	35	0,862	2568	35	1996
Sunde K	25	31	0,893	5816	31	1997

NP: Number of publications; TC: Total citations; TC/NP: Citations per paper; PY_start: Publication year starting

of papers not yet fully indexed, which could distort bibliometric indicators

(2) Conference abstracts, editorial materials, meeting reports, and other non-peer-reviewed content types

(3) uplicate records or retracted publications

This eligibility framework ensured that the final dataset reflected a coherent, peer-reviewed body of literature relevant to CPR in the EM domain. The systematic application of inclusion and exclusion criteria also enhanced the internal validity and replicability of the analysis, as recommended by bibliometric reporting standards.

3. Results

The data collection framework and workflow established for our analysis on CPR in EM are illustrated in figure 1.

3.1. Performance analysis

Figure 2 presents the top 20 categories of the 16,490 articles titled CPR in the WoS database. Among these categories, critical care medicine includes 4,811 articles, EM 4,393 articles, surgery 1,963 articles, medicine general internal 1,559 articles, and pediatrics 1,296 articles.

The figure highlights the 4,393 articles in the EM category, underscoring the vital role that CPR plays in this field and the ongoing research and development efforts. CPR is critically important in EM, and the high volume of research in this area demonstrates its significance in improving emergency response techniques, enhancing training programs, and improving patient outcomes.

Between 1980 and 2023, research on CPR in EM has spanned a wide array of topics and produced significant findings. The 4,393 publications from this period indicate intense research activity in the field, with an annual growth rate of 6.3%. The average citation count of 29.36 per article reflects the sub-

Table 3 Sources' local impact

Source	H-Index	G-Index	TC	NP	TC/NP	PY_start
Resuscitation	124	200	90411	2142	42,21	1980
Annals of Emergency Medicine	61	96	12992	302	43,02	1980
American Journal of Emergency Medicine	36	56	5698	367	15,53	1984
Academic Emergency Medicine	34	56	3458	93	37,18	1995
Emergency Medicine Journal	28	41	2236	108	20,7	2001
Scandinavian Journal of Trauma Resuscitation & Emergency Medicine	25	34	1897	126	15,06	2008
Injury Injury-international Journal of the care of the injured	23	34	1248	59	21,15	1981
Prehospital Emergency Care	23	34	1517	82	18,5	2006
Pediatric Emergency Care	20	33	1309	84	15,58	1992
Journal of Emergency Medicine	18	27	1110	91	12,2	1999
European Journal of Emergency Medicine	14	23	616	47	13,11	2006
Clinical and Experimental Emergency Medicine	13	17	388	40	9,7	2014
Emergency Medicine Australasia	13	19	449	39	11,51	2008
Journal of Emergency Nursing	12	21	466	24	19,42	2005
BMC Emergency Medicine	11	19	465	49	9,49	2007
World Journal of Emergency Medicine	11	15	277	33	8,394	2010
Canadian Journal of Emergency Medicine	10	22	505	29	17,41	2008
Emergency Medicine Clinics of North America	10	16	308	32	9,625	1998
European Journal of Trauma and Emergency Surgery	10	14	265	31	8,548	2009
International Journal of Emergency Medicine	10	15	296	33	8,97	2008

NP: Number of publications; TC: Total citations; TC/NP: Citations per paper; PY_start: Publication year starting

Table 4 Most local cited documents

Document	YP	LC	LC/YYP	GC	GC/YYP	LC/GC ratio%
Kramer-johansen J, 2006, Resuscitation	2006	144	8,000	409	22,72	35,21
Soar J, 2015, Resuscitation	2015	124	13,778	1100	122,22	11,27
Perkins gd, 2015, Resuscitation-a	2015	123	13,667	743	82,56	16,55
Vanhoeyweghen rj, 1993, Resuscitation	1993	121	3,903	338	10,90	35,80
Wik L, 1994, Resuscitation-a	1994	120	4,000	293	9,77	40,96
Handley AJ, 2005, Resuscitation	2005	97	5,105	361	19,00	26,87
Koster RW, 2010, Resuscitation	2010	94	6,714	415	29,64	22,65
Eisenberg MS, 1990, Ann Emerg Med	1990	91	2,676	590	17,35	15,42
Jacobs I, 2004, Resuscitation	2004	91	4,550	648	32,40	14,04
Deakin CD, 2010, Resuscitation-a	2010	91	6,500	775	55,36	11,74
Swor R, 2006, Acad Emerg Med	2006	90	5,000	297	16,50	30,30
Abella BS, 2007, Resuscitation	2007	87	5,118	279	16,41	31,18
Peberdy MA, 2003, Resuscitation	2003	84	4,000	884	42,10	9,50
Nolan JP, 2010, Resuscitation-a	2010	82	5,857	853	60,93	9,61
Monsieurs KG, 2015, Resuscitation	2015	76	8,444	693	77,00	10,97
Yeung J, 2009, Resuscitation	2009	71	4,733	275	18,33	25,82
Yannopoulos D, 2005, Resuscitation	2005	70	3,684	223	11,74	31,39
Becker LB, 1991, Ann Emerg Med	1991	69	2,091	428	12,97	16,12
Kramer-Johansen J, 2007, Resuscitation	2007	69	4,059	167	9,82	41,32
Nolan JP, 2005, Resuscitation	2005	68	3,579	631	33,21	10,78

YP: Year of publication; YYP: Year 2024-year of publication; GC: Global citations; LC: Local citations

stantial impact of studies in this area. Published across 58 different sources and supported by 55,353 references, these articles encompass a comprehensive literature review.

A total of 15,343 authors contributed to the research, with an average of 6.41 authors per article, highlighting the collaborative nature of CPR studies. Additionally, the international collaboration rate of 17.07% underscores the global importance of CPR and the support it receives through international research efforts. The majority of the articles (90%) are original research papers, while review and conference pa-

pers also hold significant value. These data demonstrate the depth and breadth of research in the CPR in EM field, attracting considerable interest and contributions from the scientific community. Statistical information is provided in table 1.

The annual quantities of scientific publications and average annual citations on CPR in EM produced between 1980 and 2023 were obtained using bibliometrix and are presented in figure 3.

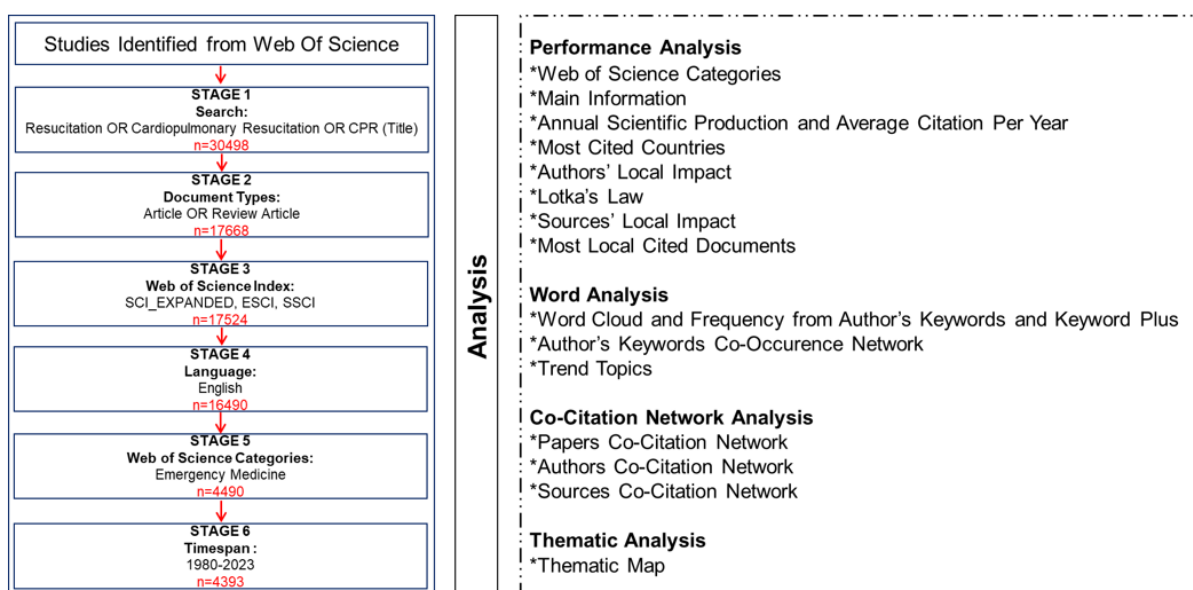A significant increase in the annual number of articles has

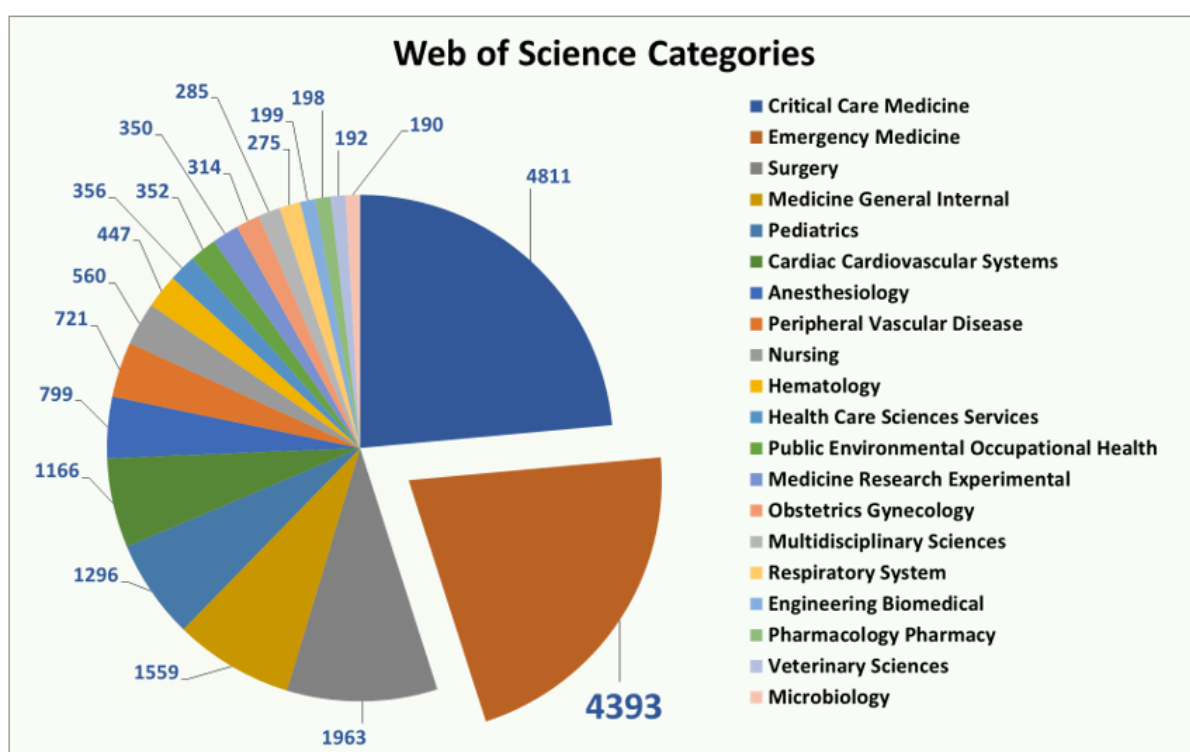**Figure 1** Workflow of science mapping


Figure 2 Web of Science categories

been observed since 1980. During the 1980s, an average of around 30 articles were published annually. This number rose to approximately 60-70 in the 2000s. The growth accelerated in the 2010s, with the annual number of articles exceeding 150, reaching a peak of 227 in 2020 and 284 in 2021. High production levels continued in 2022 and 2023, with 220 and 221 articles published, respectively. These data indicate a substantial increase in research activities in the field of CPR in EM in recent years.

Parallel to the increase in the number of articles, there has also been a general upward trend in annual citation counts. While articles in the 1980s had low citation rates (e.g., 0.1 in 1980), citation numbers began to rise in the mid-1990s. In the 2000s, articles received an average of 1.6-1.7 citations per year, and this rate exceeded 2 in the 2010s. A notable increase was seen in 2010, with an average of 3.5 citations per article. In 2015, articles received an average of 5.4 citations, indicating particularly high academic impact for CPR
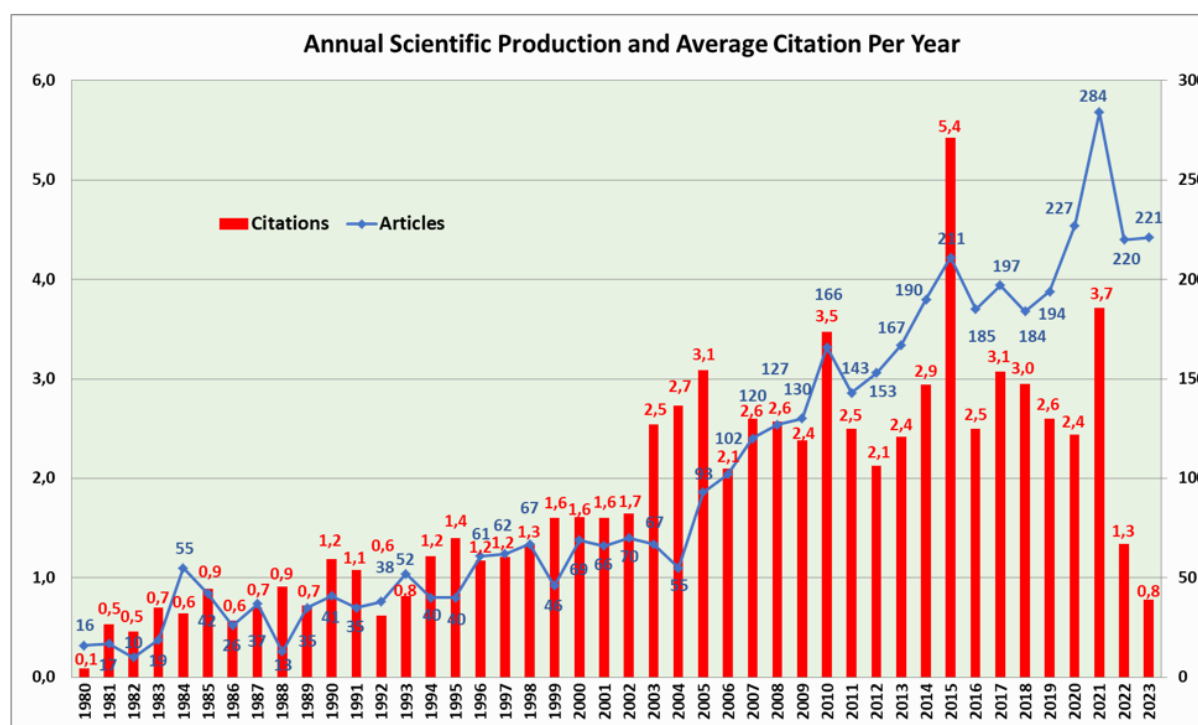
Figure 3 Annual scientific production and average citation per year
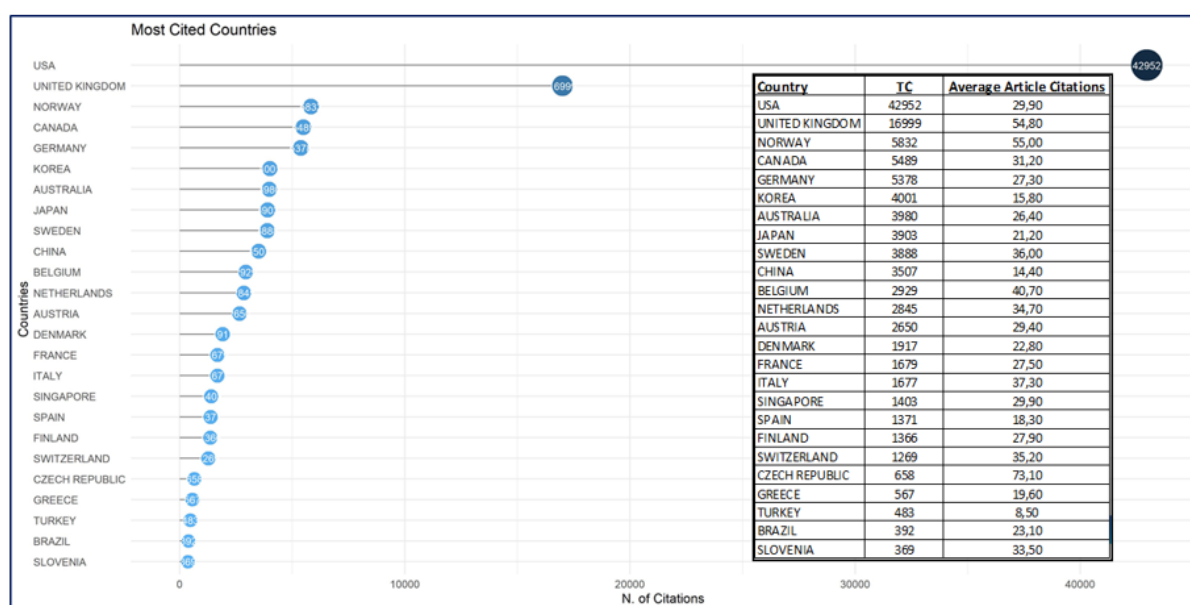
Figure 4 Most cited countries

studies during that period. The data demonstrate a continuous increase in scientific output in the field of CPR in EM over the years, highlighting the significant academic impact of studies in this area. The rising number of articles since the 1980s shows that research activities in this field have gained increasing importance. The increase in citation rates indicates that the quality of published studies and innovations in the field has resonated widely within the scientific community. The rapid rise in the number of articles and high citation rates in recent years underscore that CPR in EM is a dynamic research area that continues to evolve.

Figure 4 shows the top 25 countries with the highest citations in the field of CPR in EM. The figure, obtained from bibliometrix, ranks countries by total citations (TC) and shows the average citations per article. These data reveal the effectiveness and academic contributions of different countries in CPR research.

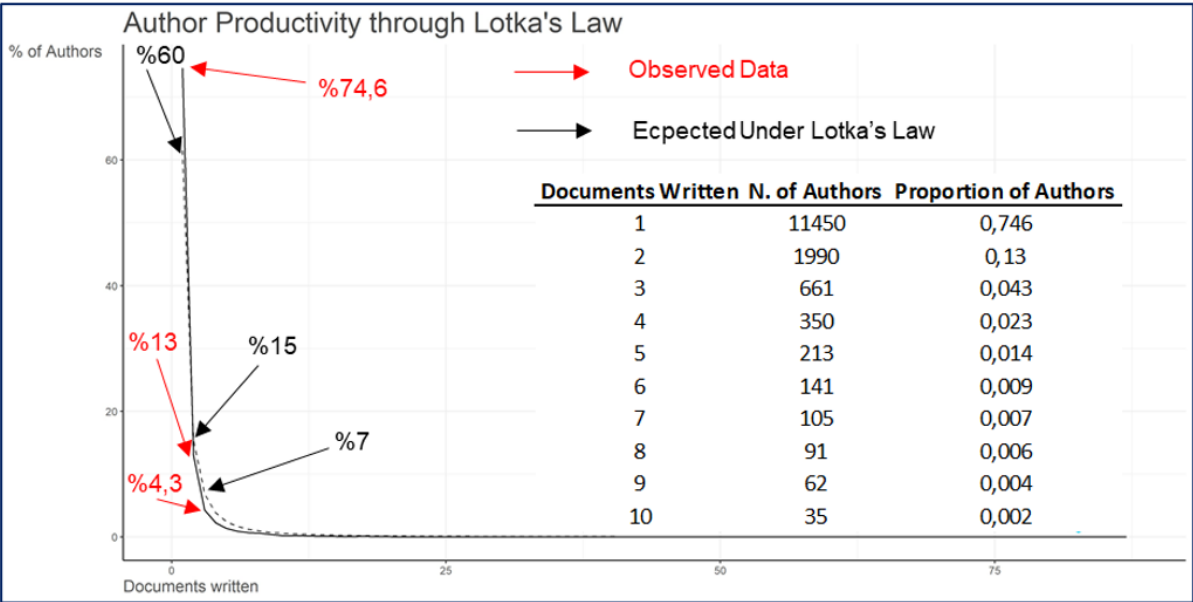The USA leads with 42,952 total citations, averaging 29.90 ci-

Figure 5 Lotka's law

Documents Written	N. of Authors	Proportion of Authors
1	11450	0,746
2	1990	0,13
3	661	0,043
4	350	0,023
5	213	0,014
6	141	0,009
7	105	0,007
8	91	0,006
9	62	0,004
10	35	0,002

| Author's Keyword		Keyword Plus	
Word	Frequency	Word	Frequency
cpr	2365	cpr	1373
cardiac arrest	925	survival	942
out-of-hospital cardiac arrest	294	hospital cardiac-arrest	834
emergency medical services	174	cardiac-arrest	512
education	164	quality	415
heart arrest	150	guidelines	367
chest compression	147	outcomes	358
outcome	135	basic life-support	322
survival	118	american-heart-association	312
ventricular fibrillation	118	care	294
training	115	life-support	287
basic life support	111	ventricular-fibrillation	225
trauma	94	association	209
bystander cpr	91	performance	208
defibrillation	86	council guidelines	190

Figure 6 Word cloud and frequency from author's keywords and keyword plus

tations per article, demonstrating its dominant position and broad academic impact in CPR research.

The UK and Norway follow with 16,999 and 5,832 total citations, respectively, and very high average citations per article (54.80 and 55.00, respectively). Despite publishing fewer articles, these countries have produced highly impactful studies. The Czech Republic, although having a lower total citation count of 658, boasts the highest average citation per article at 73.10, indicating highly influential research.

Sweden, Belgium, Switzerland, and the Netherlands also ex-
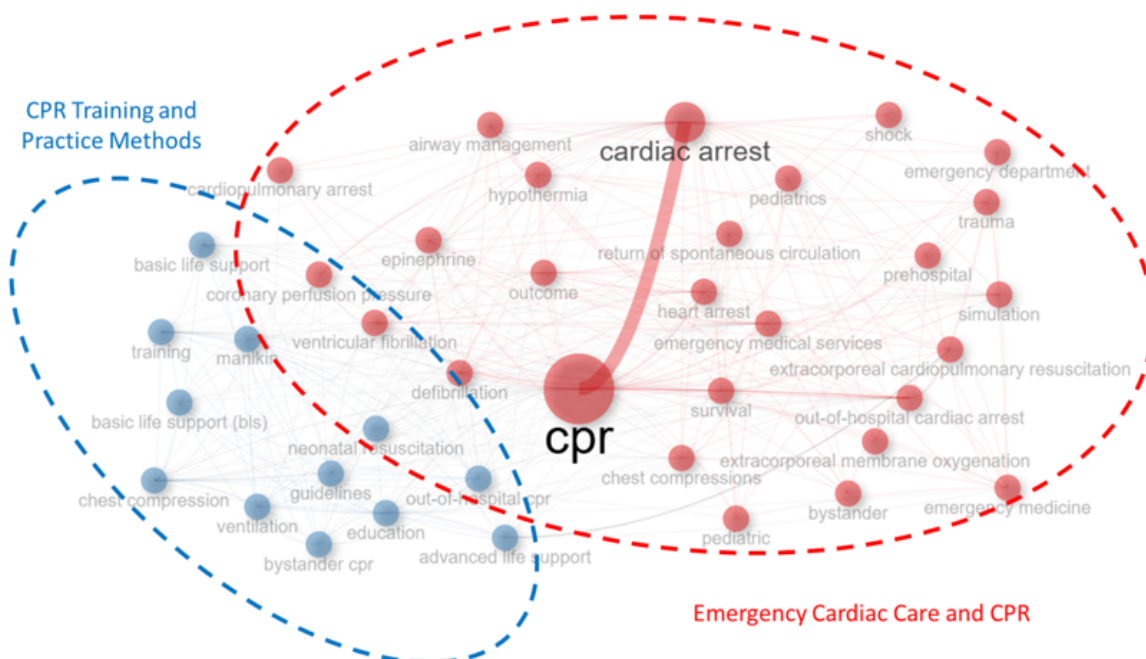
Figure 7 Authors' keywords co-occurence network
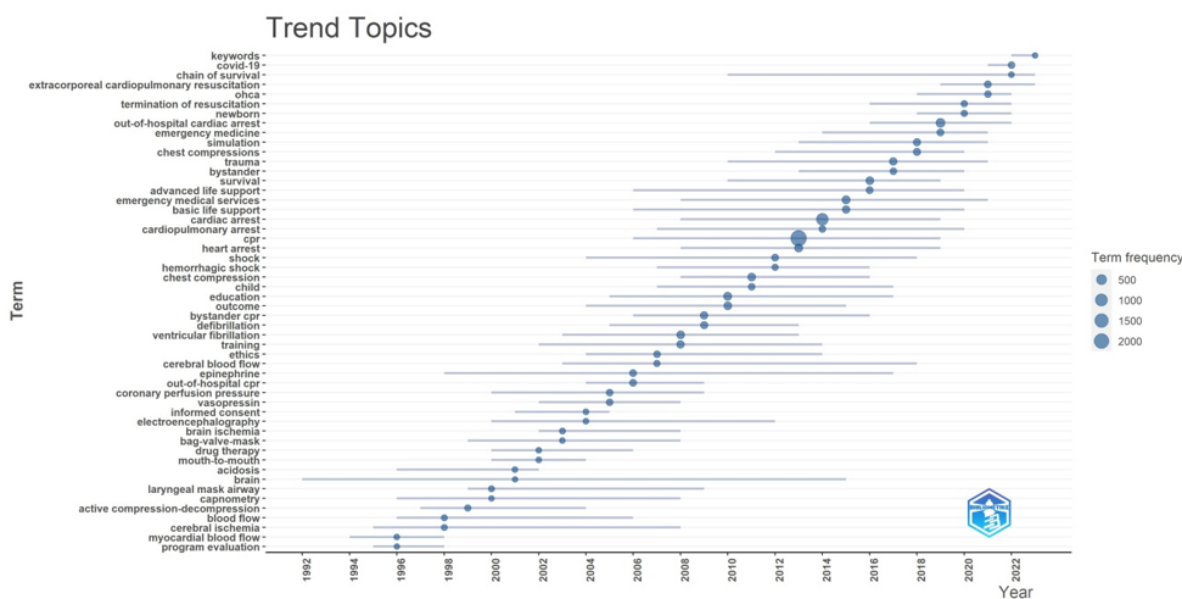
Figure 8 Trend topics

hibit high average citation values (36.00; 40.70; 35.20; and 34.70, respectively), contributing significantly to CPR research with widely recognized work.

Germany, Canada, France, Italy, and Finland show both high total citations and notable average citations per article (27.30; 31.20; 27.50; 37.30; and 27.90, respectively), reflecting their significant research activities in the CPR field.

South Korea, China, Spain, Turkey, and Brazil have lower average citations per article (15.80; 14.40; 18.30; 8.50; and 23.10, respectively). Notably, Turkey's average of 8.50 citations per article suggests a comparatively lower impact in CPR research.

These data illustrate the contributions and academic impacts of various countries in the field of CPR in EM. Countries like the USA, UK, Norway, and the Czech Republic stand out with high citation rates, while European countries generally show a strong presence in this field. Countries like Turkey, with lower citation rates, indicate a lesser impact in CPR research compared to others. This figure serves as a valuable reference for understanding the global distribution and country-specific academic influence of CPR research.

Statistics of the top 20 most influential authors in the field of
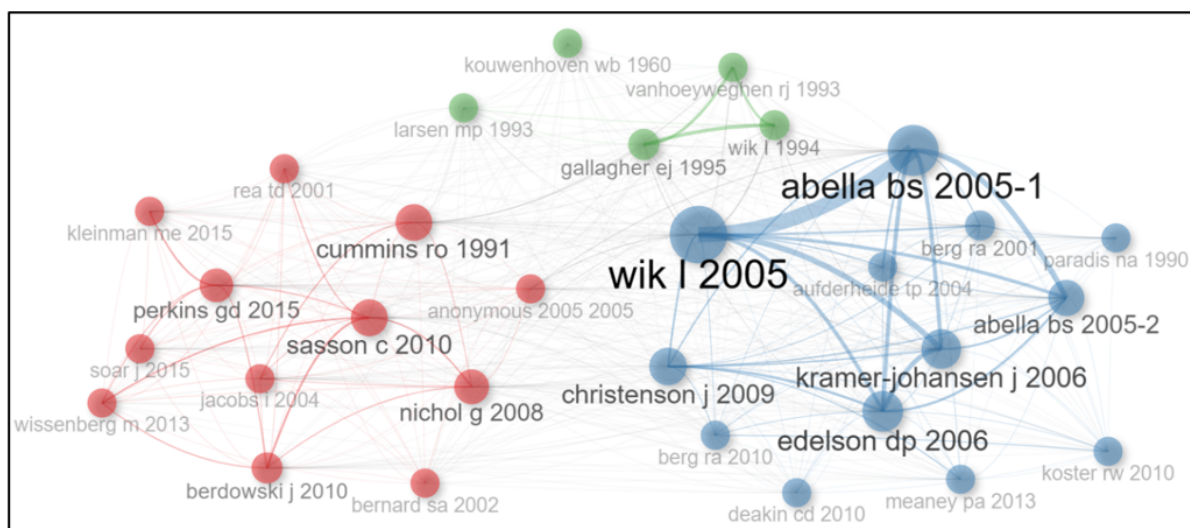
Figure 9 Papers co-citation network
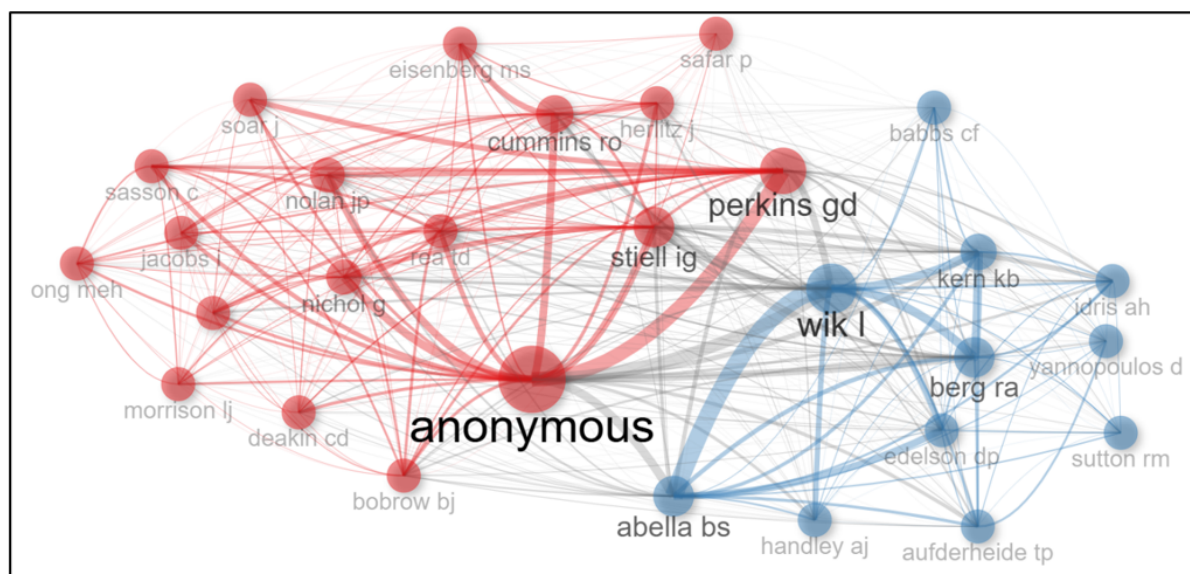
Figure 10 Authors co-citation network

CPR in EM are presented in table 2. The table is based on the h-index values. The h-index, g-index, m-index, total citations (TC), total number of publications (NP), and the year of commencement of their publishing career were analyzed.

The h-index, introduced by Jorge E. Hirsch, is a metric used to measure a researcher's scientific productivity and impact (14,15). The g-index, introduced by Leo Egghe in 2006, gives more weight to highly cited papers (16). The m-index, also developed by Hirsch, aims to compare researchers with different lengths of academic careers. Dividing the h-index by the number of years a scientist has been active is considered a reasonable method for such comparisons (17). These metrics help us evaluate the academic impact and contributions of the authors.

Nolan JP is the researcher with the highest total citations (12,920) and has an h-index of 43 and a g-index of 71. He

began his publishing career in 1996 and has published a total of 71 papers.

Perkins GD stands out with an h-index of 41 and a g-index of 77, having received a total of 10,354 citations and published 77 papers. His m-index is 1.708, indicating a rapid achievement of high academic impact.

Berg RA has an h-index of 40 and a g-index of 79, with a significant number of citations (6,371) and a total of 87 publications. His publishing career started in 1993, making a broad impact over the years.

Soar J is notable for his high h-index (38) and total citations (10,962). He started publishing in 2005 and has produced impactful research in a short period.

Steen PA has an h-index of 32 and a g-index of 43, with a substantial number of citations (3,877) and 43 publications. He began his publishing career in 1992 and is a recognized re-
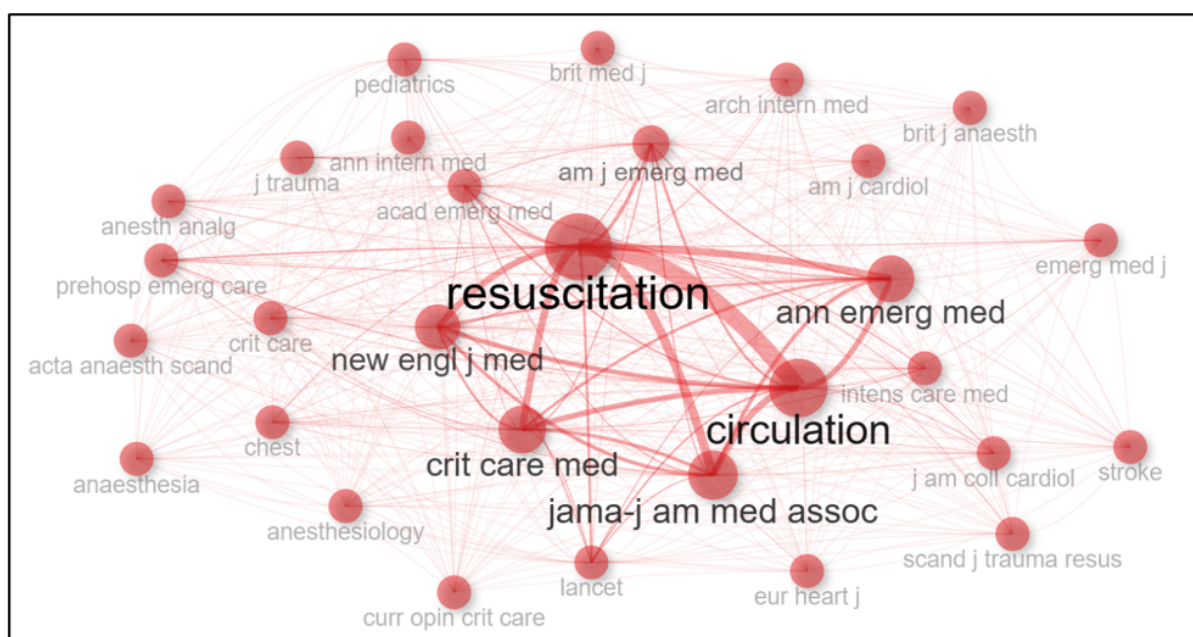
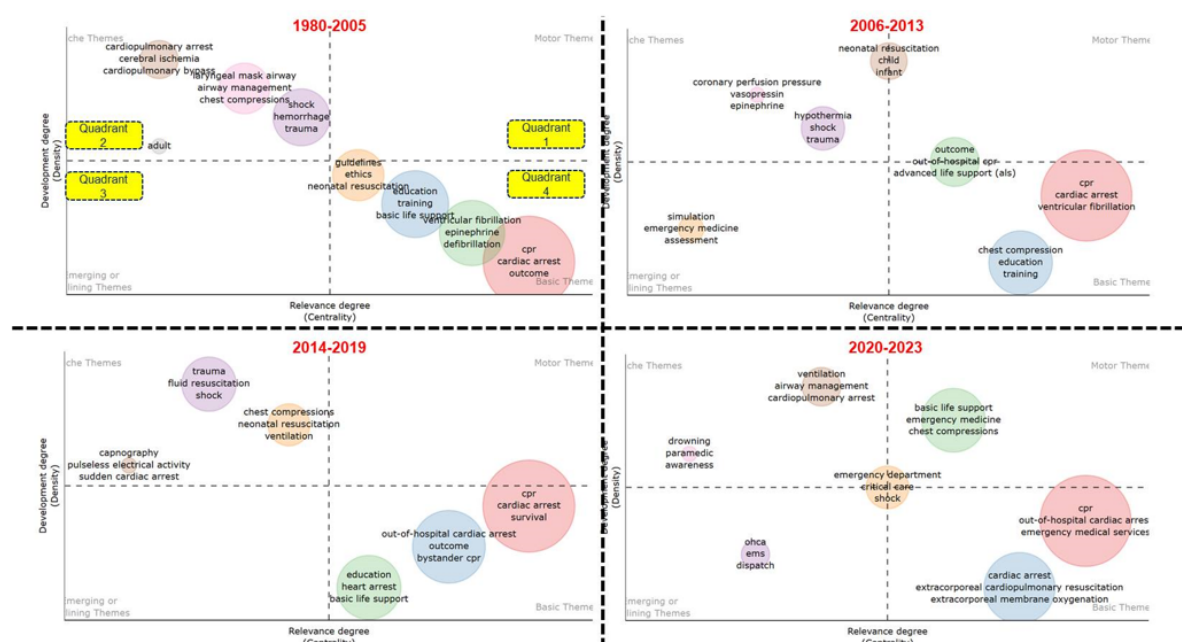**Figure 11** Sources co-citation network

Figure 12 Thematic map

searcher in the field of CPR.

Nadkarni VM, with an h-index of 31 and a g-index of 55, has published a high number of papers (69) that have been widely cited. Bossaert L, with an h-index of 30 and a g-index of 41, has been active in CPR research for a long time, starting in 1989, and has accumulated a total of 3,724 citations.

Deakin CD, with an h-index of 30 and a g-index of 43, has a high citation count (7,130) and 43 publications, making significant contributions to CPR in EM since 1996. Herlitz J, with

an h-index of 30 and a g-index of 49, is consistently cited and has a notable h-index.

Overall, the table details the academic impacts and contributions of leading researchers in the field of CPR in EM. High h-index and g-index values indicate that these researchers' works are widely referenced and have significant impact. The m-index values show that these researchers have maintained their academic influence from the beginning of their publishing careers. These data highlight the critical roles these

researchers have played in the development of CPR research. The publications of authors working in the field of CPR in EM according to Lotka's Law are presented in figure 5. According to Lotka's Law, 60% of authors contribute to a research field with one article, 15% with two articles, and 7% with three articles (18).

When examining articles and authors within the framework of Lotka's Law, it is found that in the CPR in EM field, 74.6% of the authors contributed with one article, 13% with two articles, 4.3% with three articles, 2.3% with four articles, and 1.4% with five articles. It is evident that the author distribution of articles in the CPR in EM field does not conform to Lotka's Law. Despite this, it can be accepted that authors with more than five publications have deepened their expertise in the CPR in EM field and should be considered core authors.

Table 3 shows the top 20 journals (source local impact) publishing on CPR in EM, ranked by h-index. These top 20 journals have published 86.75% (3811/4393) of the total articles. The table displays the h-index, g-index, TC) total NP, citation per article (TC/NP), and the year they began publication (PY_start) for these significant journals in CPR in EM. These data allow us to evaluate the academic impact and contributions of these journals in the field.

Resuscitation stands out as the journal with the highest h-index (124), g-index (200), and total citations (90,411). Published since 1980, this journal has a substantial impact in the field with 2,142 articles. The high citation rate per article (42.21) underscores the quality and academic influence of the journal, establishing Resuscitation as one of the most effective and prestigious publications in CPR research.

Annals of Emergency Medicine, with an h-index of 61 and a total of 12,992 citations, has been published since 1980 and has made a significant impact in CPR research with 302 articles. The citation rate per article (43.02) reflects the high quality and influence of the journal in the field, providing a crucial platform for CPR studies.

American Journal of Emergency Medicine holds an h-index of 36 and a total of 5,698 citations. Since its inception in 1984, the journal has contributed 367 articles to CPR research. The citation rate per article (15.53) illustrates the journal's influence, making it a valuable resource for CPR-related studies.

Academic Emergency Medicine, with an h-index of 34 and a total of 3,458 citations, has been published since 1995 and has 93 articles in the field. The citation rate per article (37.18) indicates the journal's high quality and academic impact, establishing it as a significant source for CPR research.

Emergency Medicine Journal has an h-index of 28 and a total of 2,236 citations. Published since 2001, this journal has provided valuable contributions with 108 articles in the field. The citation rate per article (20.7) underscores the journal's influence.

Other notable journals include the Scandinavian Journal of Trauma, Resuscitation & Emergency Medicine, Injury-International Journal of the Care of the Injured, Prehospital Emergency Care, Pediatric Emergency Care, and Journal of Emergency Medicine. These journals contribute significantly to CPR research with their h-index and citation rates per article. Specifically, the Scandinavian Journal of Trauma, Resuscitation & Emergency Medicine, despite being a relatively new journal, has demonstrated significant academic impact. Overall, the table details the academic impacts and contributions of the leading journals in the field of CPR in EM. High h-index and citation rates per article demonstrate the quality and influence of these journals. Resuscitation and Annals of Emergency Medicine stand out as the most effective journals in CPR research. Other journals also provide various levels of academic contributions. These data highlight the critical role these journals play in the development of CPR in EM research.

Citation analysis has been conducted to identify the most cited articles and the connections between them in the field of CPR in EM. Citation analyses are generally used to explore the intellectual structure and development dynamics within a field of study. The top 20 most cited publications in the CPR in EM review area are presented in table 4, ranked in descending order according to their local citation (LC) counts. The table shows the ranking of important articles in the field of CPR in EM according to their local (LC) and global (GC) citation counts. These data allow us to evaluate the academic impact and citation trends of the articles.

The 2006 article by Kramer-Johansen J stands out as the most highly cited article locally, with 144 LC. The article's annual local citation rate (LC/Y) is 8.000, and it has received 409 GC. The global citation rate (GC/Y) is 22.72, and the ratio of local to global citations (LC/GC ratio) is 35.21%. This high LC/GC ratio indicates that the article has a strong impact in the local domain.

The 2015 article by Soar J is ranked second with 124 LC. Its annual local citation rate (LC/Y) is 13.778, and it has received 1100 GC. The global citation rate (GC/Y) is 122.22, with an LC/GC ratio of 11.27%. This shows that the article is highly cited both locally and globally.

The 2015 article by Perkins GD is ranked third with 123 LC. Its annual local citation rate (LC/Y) is 13.667, and it has received 743 GC. The global citation rate (GC/Y) is 82.56, and the LC/GC ratio is 16.55%. The article has significant academic impact in the field of CPR.

The older 1993 article by Vanhoeyweghen RJ stands out with 121 LC and 338 GC. The LC/Y rate is 3.903, the GC/Y rate is 10.90, and the LC/GC ratio is 35.80%. This article has been consistently cited over the years and has a higher local impact compared to its global impact.

The 1994 article by Wik L is notable with 120 LC and 293 GC. The LC/Y rate is 4.000, the GC/Y rate is 9.77, and the LC/GC ratio is 40.96%. This high LC/GC ratio indicates a very strong local influence.

More recent articles, such as those by Soar J (2015), Perkins GD (2015), and Monsieurs KG (2015), stand out with high local and global citation counts. These articles provide significant and current contributions to CPR in EM research.

Older articles, such as those by Eisenberg MS (1990) and Becker LB (1991), have received substantial local and global citations over many years and have made fundamental contributions to the core literature in the CPR field.

The table clearly details the local and global academic impacts of important articles in CPR in EM. Local citation rates show how influential the articles are within a specific geographic region or community, while global citation rates reflect their worldwide impact. The LC/GC ratio indicates the proportion of an article's local impact relative to its global impact. These data highlight which studies stand out and are widely recognized in CPR in EM research.

3.2. Word analysis

Authors select specific keywords to describe their articles. These keywords are important for analyzing and identifying current topics and themes in a field of study, as they are thought to reflect the content of the article (19).

The keyword frequencies (number of occurrences) in the field of CPR in EM were obtained using bibliometrix. The word cloud created from these keywords graphically represents the most current concepts in CPR in EM.

A word cloud helps identify overlapping areas and analyze the popular keywords over the years (20). In the word cloud, the larger the keyword appears, the more frequently it has been used in the data set. The statistics of author-selected keywords and source keywords are presented in figure 6 as a word cloud and a frequency table. The word cloud displays the top 50 keywords, while the frequency table lists the top 15 keywords.

The table shows the frequency of author keywords and source keywords used in CPR in EM research. These data help determine the prevalence and focus areas of research topics.

The most frequently used author keyword is CPR (2365 times), indicating that CPR is a central topic in the research literature. The second most common keyword is cardiac arrest (925 times), highlighting the importance of cardiac arrest cases within CPR studies. Keywords such as out-of-hospital cardiac arrest (294 times) and Emergency Medical Services (174 times) reflect interest in the applications of CPR in emergency medical services and out-of-hospital cardiac arrests.

Other significant keywords include education (164 times) and training (115 times), demonstrating a high interest in CPR education and the training of healthcare professionals. Terms like heart arrest (150 times) and chest compression (147 times) indicate a focus on the technical components and applications of CPR. Additionally, keywords such as survival (118 times) and outcome (135 times) represent studies investigating the impact of CPR on survival rates and outcomes.

Among source keywords, the highest frequency is recorded for CPR (1373 times). This is followed by Survival (942 times) and hospital cardiac-arrest (834 times), showing that in-hospital cardiac arrests and survival rates hold significant places in research. The keyword cardiac-arrest (512 times) is

consistent with author keywords, confirming that cardiac arrests are frequently examined in CPR research.

Keywords like quality (415 times) and guidelines (367 times) emphasize the focus on the quality of CPR practices and guideline principles. Terms such as outcomes (358 times) and basic life-support (322 times) reflect research on CPR outcomes and basic life support. Keywords such as American Heart Association (312 times) and Care (294 times) indicate important organizations and care standards associated with CPR studies. Both sets of keywords show a focus on various aspects of CPR, including emergency medical interventions, education, and guidelines. Author keywords tend to include more specific terms, while source keywords reflect broader concepts. This indicates that CPR research focuses on both specific technical and educational issues as well as general practices and outcomes. These insights help us understand the focus areas of CPR in EM research and identify where further studies may be needed.

In figure 7, the co-occurrence network of author keywords representing articles on CPR in EM is presented. The co-occurrence network of the top 40 keywords has been analyzed. To clearly visualize the co-occurrence networks of author keywords, word merging has been applied. It can be observed that the author keywords are clustered into two groups, red and blue, with the red cluster being the larger one.

The red cluster is represented by the keyword CPR. This cluster includes other related terms such as cardiac arrest, emergency medical services, and survival, which suggests a broader context that can be identified as the emergency cardiac care and CPR cluster. CPR is the central concept in all metrics and stands out as the core component of the cluster. Other terms included in this cluster encompass emergency cardiac conditions and treatment methods directly associated with CPR. These terms include cardiac arrest, out-of-hospital cardiac arrest, emergency medical services, and defibrillation. The term emergency highlights the importance of these terms in the context of emergency medicine and urgent interventions.

The second cluster is the blue cluster. This cluster's central concept is education, encompassing training and practice methods related to CPR. Therefore, it is logical to define this cluster as CPR training and practice methods. The high centrality values of the education and training nodes indicate that education is the core component of this cluster. Terms like chest compression, basic life support, bystander CPR, and ventilation represent the practice methods and training content of CPR. More specific educational topics such as advanced life support, neonatal resuscitation, and guidelines can also be grouped under this general name.

Figure 8 shows a graph illustrating the popularity of keywords selected by authors over the years. The graph visualizes keywords that were used at least five times in any given year. In the field of CPR in EM, keywords like program evaluation, myocardial blood flow, cerebral ischemia, blood flow,

active compression decompression, and capnometry were more commonly used in the 2000s. In contrast, more recent years have seen increased usage of keywords like coronavirus disease of 2019 (Covid-19), chain of survival, extracorporeal cardiopulmonary resuscitation (ECPR), out-of-hospital cardiac arrest (OHCA), termination of resuscitation, newborn, and out-of-hospital cardiac arrest. The keyword CPR was most frequently used in 2013, with 2,364 instances, while the keyword cardiac arrest peaked in 2014 with 925 instances.

This shift reflects how the focus of CPR applications and research in EM has evolved. In the 2000s, there was a greater emphasis on the biological effects and specific techniques of CPR. However, in recent years, broader systemic approaches and public health measures have come to the forefront, influenced significantly by the Covid-19 pandemic. The impact of Covid-19 has made the application of CPR in the context of infection control a critical topic. Additionally, concepts like the chain of survival emphasize the importance of societal awareness and training in improving survival rates.

Advanced technological interventions such as extracorporeal cardiopulmonary resuscitation and criteria for out-of-hospital interventions also reflect the current research focus. These trends indicate that CPR is not only viewed as an individual intervention but also requires a systematic and community-wide approach.

3.3. Co-citation network analysis

A paper co-citation network analysis was conducted by examining the co-citations of publications in the CPR in EM literature. The Louvain algorithm was used to analyze the top 30 articles. As shown in figure 9, the co-citation network is divided into three node clusters represented by blue, red, and green circles. Each circle in the clusters represents an article. The presence of a connecting line between the circles indicates a relationship between the articles. The thicker the line, the stronger the relationship.

The blue cluster consists of 13 articles, the red cluster contains 12 articles, and the green cluster comprises 5 articles. The blue cluster has the most articles. Articles with the most co-citations with other articles are represented by larger circles. The blue cluster is represented by the article Wik L 2005. In the blue cluster, the articles following Wik L 2005 in terms of co-citations are Abella BS 2005-1, Edelson DP 2006, Kramer-Johansen J 2006, Christenson J 2009, and Abella BS 2005-2. In the red cluster, the most co-cited articles are Sasson C 2010, Nichol G 2008, Cummins RO 1991, and Perkins GD 2015. In the green cluster, the article Gallagher EJ 2005 has the most co-citations.

Examining the thickness of the lines between them, the pairs of articles most frequently cited together by subsequent articles are Wik L 2005 - Abella BS 2005-1, Wik L 2005 - Kramer-Johansen J 2006, Abella BS 2005-1 - Abella BS 2005-2, and Edelson DP 2006 - Kramer-Johansen J 2006. An author co-citation network analysis was conducted to examine the co-citations of authors of CPR in EM articles. As shown in figure

10, the co-citation network is divided into two node clusters composed of circles.

The red cluster is the larger cluster, consisting of 18 authors, while the blue cluster comprises 11 authors. In the red cluster, the author labeled anonymous, representing publications by official institutions without central authors, has the most citations. When examining the WOS database, it is noted that publications without author names in the references are entered under the name anonymous. Other highly co-cited authors in the red cluster include Perkins GD, Steil IG, and Cummins RO.

The blue cluster is represented by Wik L. Other highly co-cited authors in the blue cluster are Berg RA, Abella BS, and Kern KB. The pairs of authors most frequently cited together are Wik L - Abella BS, Anonymous - Perkins GD, Anonymous - Wik L, Wik L - Berg RA, and Anonymous - Abella BS.

A sources co-citation network analysis was conducted to examine the co-citations of sources of CPR in EM articles. As shown in figure 11, the co-citation network is divided into a single node cluster composed of circles. Each circle in the cluster represents a source.

The red cluster contains 29 journals, with Resuscitation at its center. Following Resuscitation, the most highly cited journals are Circulation, JAMA (Journal of the American Medical Association), Critical Care Medicine, Annals of Emergency Medicine, and the New England Journal of Medicine.

The thickness of the lines between the journals indicates that the highest co-citations are among Resuscitation and Circulation, Resuscitation and JAMA (Journal of the American Medical Association), and Resuscitation and Annals of Emergency Medicine.

3.4. Thematic analysis

Each sub-period of CPR in EM research, created using bibliometrix with the top 250 author keywords repeated at least five times, is presented in figure 12 as a strategic diagram. The most frequently used keywords are grouped into thematic clusters, with each cluster represented by the three most frequently recurring keywords. The size of the circles is proportional to the frequency of keyword usage. Through thematic mapping, it has been possible to visualize and identify the dynamics of research themes across different time periods (21).

The strategic diagram reflects the interactions of factors within the studied topic over time. This diagram provides a static description of the network structure within a field of study (22). The thematic diagram is divided into four quadrants, each interpreted based on centrality and density parameters. Density is represented on the y-axis, while centrality is on the x-axis. The more central a theme is, the more important it is considered; the more developed it is, the denser it is (23).

The thematic development of CPR in EM research from 1980 to 2023 has been analyzed from a dynamic perspective. The research period (1980-2023) has been divided into four sub-

periods based on the number of documents and time span. The first sub-period covers 26 years (1980-2005) due to the limited number of early publications, the second sub-period covers 8 years (2006-2013), the third sub-period covers 6 years (2014-2019), and the fourth sub-period covers 4 years (2020-2023).

The first quadrant in the upper right corner of the thematic map includes motor themes with high density and centrality. These themes have been the subject of detailed research and are well-developed. The second quadrant in the upper left corner includes niche themes with high density but low centrality; these themes have not been the main research focus but have been explored in specialized studies. The third quadrant in the lower left corner includes emerging or declining Themes with low density and centrality; these themes have not yet received significant attention or importance. The fourth quadrant in the lower right corner includes basic themes with high centrality but low density; these themes are central to the study area but have not been sufficiently researched (24).

Motor themes have undergone detailed research and matured due to their high centrality and density. Niche themes, due to their low centrality and high density, have not become the main research focus but have been concentrated on specialized studies. Emerging or declining themes have not garnered sufficient attention as they lack centrality and density. Basic themes, despite their high centrality, have low density, indicating they are central to the study area but have not been sufficiently researched. Our main focus in CPR in EM research is on these themes.

When examining the basic themes, which are our research focus in CPR in EM:

• From 1980 to 2005, the first theme includes keywords such as CPR, cardiac arrest, outcome; the second theme includes ventricular fibrillation, epinephrine, defibrillation; the third theme includes education, training, basic life support; the fourth theme includes guidelines, ethics, neonatal resuscitation.

• From 2006 to 2013, the first theme includes CPR, cardiac arrest, ventricular fibrillation; the second theme includes chest compression, education, training; the third theme includes outcome, out of hospital CPR, advanced life support.

• From 2014 to 2019, the first theme includes CPR, cardiac arrest, survival; the second theme includes out of hospital cardiac arrest, outcomes, bystander CPR; the third theme includes education, heart arrest, basic life support.

• From 2020 to 2023, the first theme includes CPR, out of hospital cardiac arrest, emergency medical services; the second theme includes cardiac arrest, extracorporeal cardiopulmonary resuscitation, extracorporeal membrane oxygenation.

From 1980 to 2005, research primarily focused on CPR, cardiac arrest, and patient outcomes; topics such as ventricular fibrillation, epinephrine use, and defibrillation were also intensely studied during this period. Education and basic life support gained importance to enhance the effectiveness of CPR, while guidelines, ethical issues, and neonatal resuscitation were other significant themes of the period.

From 2006 to 2013, while themes of CPR and cardiac arrest continued, chest compression and education became prominent; out-of-hospital CPR applications and advanced life support along with patient outcomes became notable research areas.

From 2014 to 2019, research focused on survival rates post-cardiac arrest, with increased studies on out-of-hospital cardiac arrest cases and CPR performed by bystanders. Education and basic life support related to cardiac arrest remained important research areas.

From 2020 to 2023, the focus shifted to out-of-hospital cardiac arrest and emergency medical services, with advanced techniques such as extracorporeal cardiopulmonary resuscitation and extracorporeal membrane oxygenation coming to the forefront. Overall, these shifts demonstrate how innovations and developments in CPR and EM have impacted patient care and how continuous improvement efforts are ongoing.

Based on the basic themes of the thematic map, the likely research topics in the field of CPR in EM for the coming years, considering the evolution of past research themes and current trends, are as follows:

• CPR optimization with artificial intelligence and machine learning: the integration of AI and machine learning-based systems in applying correct techniques and decisions during CPR will increase. These technologies aim to provide real-time guidance to healthcare personnel to improve patient outcomes.

• Wearable technologies and biosensors: wearable devices and biosensors will be developed to detect cardiac arrest early and enable rapid intervention in emergencies. These technologies can continuously monitor heart rhythm and other vital signs to predict sudden cardiac events in advance.

• Telemedicine and distance CPR training: telemedicine applications will be more widely used in CPR and EM training. Remote training and simulation technologies will enable broader reach and ensure that both healthcare professionals and the public gain competence in CPR.

• Development and use of extracorporeal technologies: efforts will be made to make advanced life support technologies such as ECPR (extracorporeal cardiopulmonary resuscitation) and ECMO (extracorporeal membrane oxygenation) more effective and accessible. Optimizing usage protocols and developing new devices for these technologies will play a crucial role in improving patient outcomes.

• Increasing community participation and bystander CPR: campaigns and educational programs will intensify to make the community more aware and active in performing CPR. Efforts will focus on reducing public hesitations about performing CPR and increasing intervention rates.

• Continuous update of guides and protocols: CPR and cardiac arrest management guidelines and protocols will be

continuously updated based on new research findings. This ensures the use of the most current and effective intervention methods.

• Genetic and molecular research: studies on the genetic and molecular biology of cardiac arrest will increase. This will make it possible to better understand individuals' risks of cardiac arrest and develop preventive measures.

• Post-CPR rehabilitation and long-term care: there will be an increase in studies focusing on the rehabilitation processes of patients who survive CPR. Optimizing long-term care and recovery processes will enhance patient quality of life.

These topics have the potential to be the focus of future research and applications in the field of CPR in EM.

4. Discussion

Our findings align with and extend previous bibliometric insights presented by Jia et al. (10), who demonstrated a growing scholarly emphasis on therapeutic hypothermia, extracorporeal membrane oxygenation (ECMO), and post-cardiac arrest care within CPR research between 2010 and 2019. Consistent with their results, our study confirms the sustained prominence of these topics. However, our analysis—spanning a broader temporal range (1980–2023) and focusing specifically on the EM category—reveals a notable shift in research attention toward neurological prognostication, artificial intelligence-assisted training modalities, and the ethical dimensions of resuscitation practices such as palliative integration. These findings suggest an ongoing thematic evolution in CPR research, from acute clinical intervention to long-term patient outcomes and system-level preparedness.

From a methodological standpoint, this study contributes to the maturing landscape of bibliometric research by incorporating the recently published biblio checklist (11), which provides the first formal guidance for the transparent reporting of bibliometric reviews in biomedical sciences. Unlike earlier CPR-focused bibliometric studies that lacked standardized reporting structures, our application of the biblio framework ensured a methodologically robust and reproducible process. Key aspects of this include the explicit documentation of eligibility criteria, the systematic use of bibliometric tools (e.g., bibliometrix), structured keyword clustering, and quantification of author impact metrics. While the biblio guideline remains in its early adoption phase, its structured approach has demonstrably enhanced the clarity and transparency of our analytical workflow.

In doing so, this study not only synthesizes evolving research themes in CPR but also models a reporting structure that aligns with the emerging standards in bibliometric science. We encourage further bibliometric analyses in EM and adjacent fields to adopt similar reporting frameworks to enhance consistency, methodological comparability, and scholarly rigor across future research outputs.

5. Conclusion

In this study, a bibliometric analysis of academic articles on CPR was conducted. The analysis aimed to understand the importance of CPR in EM, the scope of research in this field, and its contributions to the scientific literature. A total of 4,393 articles published between 1980 and 2023 in the WoS database were examined. Various metrics such as publication counts, citation rates, leading countries and institutions, prominent researchers, and most-cited studies were analyzed.

Significant research activity on CPR has been observed between 1980 and 2023. Especially since the 2000s, there has been a noticeable increase in the number of publications. By the 2020s, the annual number of articles peaked, indicating the growing importance of CPR in EM and the expanding knowledge base in this field. The average of 29.36 citations per article underscores the impact and value of these studies on the scientific community.

The United States leads in CPR research, with the highest number of publications and citations. Other countries, such as the United Kingdom, Norway, and Germany, also make significant contributions. Notably, European countries have a strong presence in this field. Major medical schools and research centers are among the most prolific institutions. Their support of CPR research through international collaborations has facilitated increased scientific contributions and knowledge sharing.

Prominent researchers in the field of CPR include Nolan JP, Perkins GD, and Berg RA, who have conducted significant studies on the clinical efficacy, educational methods, and technical improvements of CPR. The most-cited articles emphasize findings and recommendations aimed at enhancing CPR techniques, thereby strengthening the scientific foundation of CPR practices and contributing significantly to clinical practice. The bibliometric analysis revealed trends and evolving topics in CPR research over time. While the 2000s focused more on the biological effects and specific techniques of CPR, more recent research, influenced by the pandemic, emphasizes broader systemic approaches and public health measures. The impact of COVID-19 has highlighted the importance of applying CPR in the context of infection control. Concepts like the chain of survival emphasize the importance of societal awareness and training in improving survival rates. Advanced technological interventions such as extracorporeal cardiopulmonary resuscitation (ECPR) and out-of-hospital intervention criteria reflect current research focuses.

Thematic analysis showed the main themes of CPR research and their evolution over time. While early research focused on fundamental issues like CPR, cardiac arrest, and patient outcomes, more recent studies have emphasized education, out-of-hospital cardiac arrest, and advanced life support technologies. Future research in CPR in EM is expected to focus on areas such as:

• CPR optimization with artificial intelligence and machine

learning: the integration of AI and machine learning-based systems in applying correct techniques and decisions during CPR will increase. These technologies aim to provide real-time guidance to healthcare personnel to improve patient outcomes.

• Wearable technologies and biosensors: wearable devices and biosensors will be developed to detect cardiac arrest early and enable rapid intervention in emergencies. These technologies can continuously monitor heart rhythm and other vital signs to predict sudden cardiac events in advance.

• Telemedicine and distance CPR training: telemedicine applications will be more widely used in CPR and emergency medicine training. Remote training and simulation technologies will enable broader reach and ensure that both healthcare professionals and the public gain competence in CPR.

• Development and use of extracorporeal technologies: efforts will be made to make advanced life support technologies such as ECPR and ECMO more effective and accessible. Optimizing usage protocols and developing new devices for these technologies will play a crucial role in improving patient outcomes.

• Increasing community participation and bystander CPR: campaigns and educational programs will intensify to make the community more aware and active in performing CPR. Efforts will focus on reducing public hesitations about performing CPR and increasing intervention rates.

• Continuous update of guides and protocols: CPR and cardiac arrest management guidelines and protocols will be continuously updated based on new research findings. This ensures the use of the most current and effective intervention methods.

• Genetic and molecular research: studies on the genetic and molecular biology of cardiac arrest will increase. This will make it possible to better understand individuals' risks of cardiac arrest and develop preventive measures.

• Post-CPR rehabilitation and long-term care: there will be an increase in studies focusing on the rehabilitation processes of patients who survive CPR. Optimizing long-term care and recovery processes will enhance patient quality of life.

These findings highlight the critical role of CPR in EM and the importance of research in this field. The expansion and deepening of CPR research enhance the effectiveness of this vital intervention and improve patient outcomes. Bibliometric analysis provides a valuable tool for understanding the current state and future directions of CPR research.

To further advance CPR research and increase the knowledge base in this field, some recommendations can be made. Integrating AI and advanced technologies into CPR applications will enhance clinical effectiveness and improve patient outcomes. Expanding CPR training programs and raising public awareness are crucial; educational campaigns should be organized to reduce public hesitations about performing CPR and increase intervention rates. Increasing international collaborations will enhance the quality and impact of CPR re-

search; knowledge and experience sharing among different countries and institutions should be encouraged. Additionally, focusing on new research areas such as wearable technologies, genetics and molecular biology, and post-CPR rehabilitation will further enhance the effectiveness of CPR. In conclusion, better understanding the position and importance of CPR research in the scientific literature will contribute to more effective and widespread application of this vital intervention. The findings of this study provide important insights into the development and future directions of CPR research in EM.

6. Declarations

6.1. Acknowledgement

None.

6.2. Authors' contribution

Writing – original draft, methodology: EB; Analysis, general considerations: AT.

6.3. Conflict of interest

None.

6.4. Funding

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

6.5. Ethics statement

This study did not require ethical approval.

6.6. Use of artificial intelligence

The authors declare that artificial intelligence (AI) tools, specifically OpenAI's ChatGPT, were used solely for the purpose of linguistic editing and refinement of the manuscript. No AI technologies were employed in the design, execution, data analysis, or interpretation of the research findings. The intellectual content, scientific reasoning, and conclusions presented in this study are entirely the product of the authors.

6.7. Data availability

The data supporting the findings of this study were obtained from the Web of Science™ Core Collection. Due to licensing restrictions, these data are not publicly available. However, they can be made available by the corresponding author upon reasonable request for academic and non-commercial purposes.

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