Original Article

ANATOLIAN CURRENT MEDICAL

DOI: 10.38053/acmj.1140398

Anatolian Curr Med J 2022; 4(4); 385-393

Hypothermia: what are the trends in recent studies? – a bibliometric analysis with global productivity

Emine Nilgün Zengin

Ministry of Health Ankara City Hospital, Department of Anesthesiology and Reanimation, Ankara, Turkey

Cite this article as: Zengin EN. Hypothermia: what are the trends in recent studies? – a bibliometric analysis with global productivity. Anatolian Curr Med J 2022; 4(4); 385-393.

ABSTRACT

Aim: Although the number of global studies on hypothermia, which plays an important role in morbidity and mortality in adults and newborns, has increased, there is still no bibliometric research on this subject in the literature. This study, it was aimed to determine trend topics and global productivity by using various statistical analyzes of scientific articles published on hypothermia.

Material and Method: Articles on hypothermia published between 1980 and 2021 were downloaded from the Web of Science (WoS) database and analyzed using various statistical and bibliometric methods. Spearman's correlation coefficient was used for correlation studies. Network visualization maps were used to identify effective studies, global collaborations, and trend topics with citation analyses.

Results: Out of a total of 14410 publications, 8157 articles were analyzed. The top 5 contributors to the literature are USA (n=2938, 36%), Japan (737, 9%), UK (641, 7.8%), Germany (576, 7%), and China (544, 6%). was. The first 3 journals that published the most articles were Resuscitation (n=296), Critical Care Medicine (146), Therapeutic Hypothermia, and Temperature Management (135). The top 3 most active institutions were League of European Research Universities (n=448), University of California System (274), and Pennsylvania Commonwealth System of Higher Education (221). The most active author was Marianne Thoresen (n=69).

Conclusion: The most studied trend topics in recent years are determined as hypoxic-ischemic encephalopathy, neonatal encephalopathy, out-of-hospital cardiac arrest, neonates, targeted management, therapeutic hypothermia, extracorporeal membrane oxygenation, perioperative hypothermia, emergency medicine, outcome, mortality, and perinatal asphyxia. This study will guide the authors who want to study in this area.

Keywords: Bibliometric analysis, hypothermia, therapeutic, neuroprotection, trends

INTRODUCTION

Hypothermia, an important issue in the history of medicine, is a decrease in core body temperature below 35°C (Mild hypothermia: 32°C to 35°C (90°F to 95°F), moderate hypothermia: 28°C to 32°C (82°F to 90°F), severe hypothermia: below 28°C (82°F)) and develops when the body's heat loss exceeds heat production (1,2). The temperature regulation center, which makes it possible to keep the core body temperature constant under changing environmental conditions, is located in the hypothalamus. If the body is exposed to cold, various mechanisms come into play to prevent heat loss and increase heat production. Death in hypothermia occurs by the mechanism of heart failure with asystole or ventricular fibrillation, which are factors that contribute to increased catecholamine levels, electrolyte disturbances, and cardiac oxygen depletion (2-4).

Although hypothermia is an emergency requiring immediate treatment, the therapeutic use of hypothermia is an important neuroprotection method. Therapeutic hypothermia is a promising neuroprotective intervention that has been shown to improve outcomes of nerve damage in humans. Until now, it has been proven that many neurological diseases such as stroke, traumatic brain injury, increased intracranial pressure, subarachnoid hemorrhage, spinal cord injury, hepatic encephalopathy, and neonatal peripartum encephalopathy are suppressed by therapeutic hypothermia (5). The neuroprotective role of hypothermia has been well established in cardiac arrest, hypoxic-ischemic encephalopathy, traumatic brain injury, and some other diseases (5-9).

Another special issue of hypothermia is neonatal hypothermia seen in newborns. According to the World

Corresponding Author: Emine Nilgün Zengin, nilbavullu@gmail.com

Received: 04.07.2022 **Accepted:** 24.08.2022

Health Organization (WHO), neonatal hypothermia is defined as a core body temperature of < 36.5°C or a skin temperature of <36°C (10).

Bibliometrics examines articles using various statistical methods (11-13). As a result of the analysis of the information obtained from thousands of articles in the literature with various statistical and bibliometric approaches, important information about a subject such as the most active countries, institutions, journals, authors, international collaborations, and past and future trends can be determined (14-16).

Although the number of global studies on hypothermia, which plays an important role in morbidity and mortality in adults and newborns, has increased, there is still no bibliometric research on this subject in the literature. This study, it was aimed to identify trend topics and reveal global productivity by holistically analyzing scientific articles on hypothermia published between 1980 and 2021 using various statistical methods and bibliometric approaches.

MATERIAL AND METHOD

Since our research article is a bibliometric study, there is no need for an ethics committee approval.

Search Strategy

Web of Science Core Collection (WoS by Clarivate Analytics) database was used for the literature review. The search process was determined as 1980 - 2021. All publications with the phrase hypothermia in the title were accessed. So that researchers can access similar documents reproducibility codes: Title "hypothermia", Timespan: 1980-2021 (search findings may vary depending on different access dates, access date: 1 May 2022). VOSviewer (Version 1.6.16, Leiden University's Center for Science and Technology Studies, Netherlands) package program was used to create bibliometric network visualizations as a result of clustering analyses, citation analyses, and trend topic determination analyses (17).

Statistical Analysis

The website 'https://app.datawrapper.de' was used to create the world map showing the distribution of articles by country. The Exponential Smoothing estimator using seasonal smoothing was used in Microsoft Office Excel to estimate the number of articles that could be published in the next 5 years based on past publication trends. Statistical analyzes were performed with SPSS (Version 22.0, SPSS Inc., Chicago, IL, USA) package program. The normal distribution test of the data was analyzed with the Shapiro-Wilks test. Correlation analyzes were performed to determine whether some economic development indicators (Gross Domestic Product (GDP), Gross Domestic Product per capita (GDP per capita), Human Development Index (HDI)) of countries affected hypothermia (data were obtained from the world bank (18)). Correlation analyzes were analyzed using the Spearman correlation coefficient as the data were not normally distributed. $p<0.05$ was accepted for a statistically significant relationship.

RESULTS

As a result of the literature review, there were a total of 14410 publications on hypothermia published in all research areas in the WoS database during the 1980-2021 period. Of these publications, 56.6% (n=8157) were Articles, 22.7% (n=3275) Meeting Abstracts, 6.9% (n=1000) Letters, 4.3% (n=615) Proceedings Papers, 4.2% (n=602) were in Review Articles, and the remainder in other publication types (Notes, Corrections, Book Chapters, Early Access, News Items, Book Reviews, Discussions, Poetry, Biographical-Items, Data Papers). Bibliometric analyzes were carried out with 8157 articles published in the Article category out of a total of 14410 publications. 94.2% (n=7686) of these articles were in English and the remainder in other languages (German (156), French (90), Russian (84), Spanish (60), Japanese (23), Turkish (12), Portuguese (9), Czech (8), Polish (7), Italian (6), Korean (3), Serbian (3), Bulgarian (2), Ukrainian (2), Croatian (1), Hungarian (1), Norwegian (1), Serbo Croatian (1), Slovenian (1), Welsh (1)) (**Table 1**). The h-index of 8157 articles was 158, the average citations per article 25.8, and the sum of times cited 210.431 (without self-citations: 158,258) (**Table 1**). Most of the articles were scanned in SCI-Expanded (n=7671, 94%) and Emerging Sources Citation Index (ESCI) (n=424, 5.2%).

Table 1. Language distribution and citations

Language	Number of articles			
English	7686	Total 8157 articles	h- index	158
German	156			
French	90			
Russian	84		Average citations per article	25.8
Spanish	60			
Japanese	23			
Turkish	12			
Portuguese	9		Sum of times cited	210431
Czech	8			
Polish	7			
Italian	6			
Korean/Serbian	3		Without self-citations	158258
Bulgarian/Ukrainian	2			
Croatian/Hungarian/ Norwegian/ Serbo Croatian/Slovenian/Welsh	1			

Development of publications over the years

The distribution of the number of articles published on hypothermia by years is shown in **Figure 1**. The values

related to the results of the Exponential Smoothing estimation model, which takes into account the seasonal correction used to estimate the number of articles that can be published in the next 5 years, are shown in **Figure 1**. According to the estimation model results, it was predicted that 366 (Confidence Interval 95%: 320-412) articles will be published in 2022 and 394 (CI 95%: 300-489) articles will be published in 2026 (**Figure 1**).

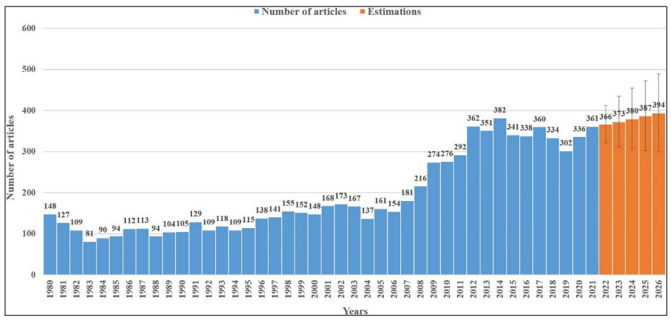

Figure 1. A bar chart illustrating the distribution of hypothermia articles published by year, as well as predictions for the number of articles to be published in the next five years.

Research Areas

The first 15 research areas with the most research on hypothermia are respectively; Neurosciences (1076, 13.2%), Critical Care Medicine (1073, 13.1%), Surgery (1034, 12.6%), Clinical Neurology (777, 9.5%), Pediatrics (755, 9.2%), Cardiac Cardiovascular Systems (726, 8.9 %), Anesthesiology (618, 7.5%), Emergency Medicine (610, 7.4%), Pharmacology Pharmacy (550, 6.7%), Medicine General Internal (494, 6%), Physiology (408, 5%), Peripheral Vascular Disease (339, 4.1%), Respiratory System (328, 4%), Medicine Research Experimental (283, 3.4%), Biochemistry Molecular Biology (206, 2.5%).

Active Countries

The distribution of the number of articles by country is shown in **Figure 2**. The first 21 countries that contributed the most to the literature by publishing more than 100 articles are respectively; USA (number of articles, n=2938, 36%), Japan (737, 9%), UK (641, 7.8%), Germany (576, 7%), China (544, 6%), Canada (482, 5.9%), France (304, 3.7%), Sweden (247, 3%), Netherlands (218, 2.6%), South Korea (208, 2.5%), Australia (194, 2.3%), Norway (182, 2.2) %), Italy (181, 2.2%), Austria (174, 2.1%), Spain (152, 1.8%), Turkey (147, 1.8%), Switzerland (144, 1.7%), Brazil (124, 1.5%) , Russia (115, 1.4%), India (103, 1.2%), and Poland (100, 1.2%) (**Figure 2**). Cluster analysis was performed among 60 countries that have published at least 5 articles from 110 countries that have published articles on hypothermia and whose authors have international cooperation, and it is shown in **Figure 3**a. According to the results of the clustering analysis, 10 different clusters related to international cooperation were formed (Colors for Cluster 1: red, Cluster 2: green, Cluster 3: blue, Cluster 4: yellow, Cluster 5: purple, Cluster 6: turquoise, Cluster 7: orange, Cluster 8: brown, Cluster 9: pink, Cluster 10: orange). In addition, the total link strength (international cooperation score) scores showing the cooperation power of 60 countries were calculated and the International cooperation density map created according to these scores was shown in **Figure 3**b (Highest scoring countries: USA (805), England in the UK (423), Germany (345), France (233), Austria (232), Italy (223), Sweden (215), Canada (214), Netherlands (207), Norway (201), Switzerland (201)).

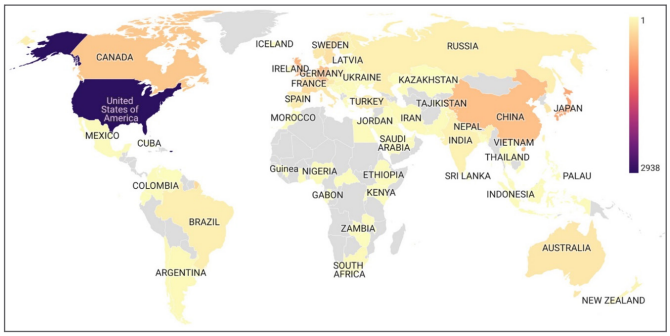

Figure 2. Global productivity world map showing the distribution of published articles on hypothermia by country

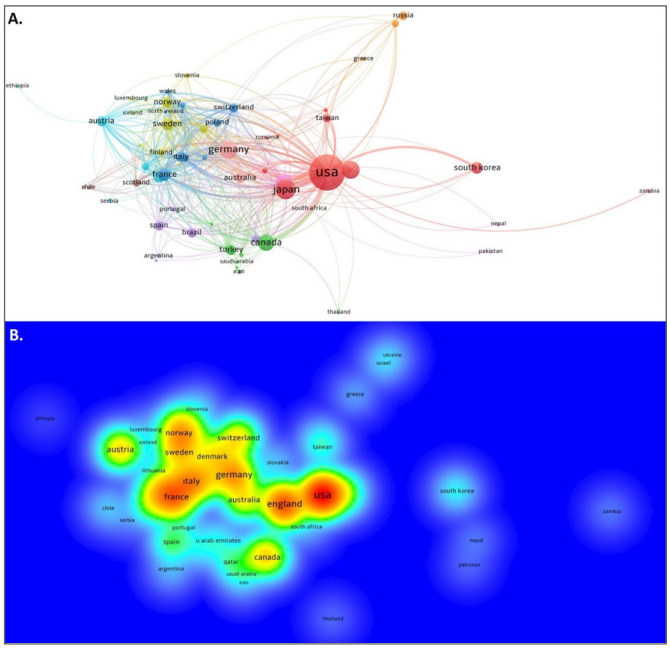

Figure 3. a. Network visualization map of results of cluster analysis showing international cooperation between countries on hypothermia Footnote: Each color denotes a distinct Cluster. The size of the circles representing the countries grows in proportion to the number of articles published by the countries. The lines indicate which countries they collaborate with. b. Density map showing the intensity of international cooperation of countries on hypothermia. Footnote: From blue to red (blue-green-yellow-red), the strength of international cooperation score increases.

Correlation Analysis

A positive moderate statistically significant correlation was found between the number of articles produced by countries on hypothermia and GDP, GDP per capita, and HDI values (respectively, r=0.709, p<0.001; r=0.702, p<0.001, r=0.666, p< 0.001).

Active Authors

The top 10 most active authors on hypothermia are respectively; Thoresen M. (69), Dietrich WD. (45), Kochanek PM. (43), Sterz F. (40), Schwab S. (38), Sessler DI. (37), Shankaran S. (34), Safar P. (32), Yenari MA. (32), Gunn AJ. (31).

Active Institutions

The 15 most active institutions on hypothermia are respectively; League of European Research Universities (448), University of California System (274), Pennsylvania Commonwealth System of Higher Education (221), University of Pittsburgh (178), University of London (142), University of Texas System (139), University of California San Francisco (128), Harvard University (126), Johns Hopkins University (121), Stanford University (111), University College London (109), US Department of Veterans Affairs (106), USA Veterans Health Administration (106), Imperial College London (104), University of Pennsylvania (98).

Active Journals

8157 articles published on hypothermia were published in 1794 different journals. The first 56 journals that contributed the most to the literature by publishing 25 or more articles from these journals, the total number of citations received by the journals and the average number of citations per article are presented in **Table 2**.

Citation Analysis

Among the 8157 articles reviewed, the first 20 articles with the highest number of citations according to the total number of citations are presented in **Table 3**. In the last column of **Table 3**, the average number of citations the articles received per year is given.

Table 2. The 56 most active journals that have published 25 or more articles on hypothermia

Journals	RC	C	AC	Journals	RC	C	AC
Resuscitation	296	12056	40.7	Journal of Applied Physiology	41	1055	25.7
Critical Care Medicine	146	8457	57.9	Journal of Maternal-Fetal & Neonatal Medicine	37	306	8.3
Therapeutic Hypothermia and Temperature Management	135	760	5.6	Life Sciences	37	774	20.9
Brain Research	117	4202	35.9	Acta Paediatrica	36	599	16.6
Annals of Thoracic Surgery	97	2432	25.1	Critical Care	36	1578	43.8
Plos One	92	1444	15.7	Neurological Research	36	702	19.5
Journal of Thoracic and Cardiovascular Surgery	91	3306	36.3	Shock	36	811	22.5
Journal of Neurotrauma	87	3958	45.5	Journal of Neurosurgical Anesthesiology	35	854	24.4
Anesthesia and Analgesia	86	2669	31.0	Journal of Thermal Biology	35	195	5.6
Stroke	85	8541	100.5	American Journal of Physiology-Regulatory Integrative and Comparative Physiology	34	924	27.2
Anesthesiology	81	5673	70.0	Anaesthesia	34	834	24.5
Journal of Cerebral Blood Flow and Metabolism	79	5901	74.7	Archives of Disease in Childhood-Fetal and Neonatal Edition	34	934	27.5
Acta Anaesthesiologica Scandinavica	76	2393	31.5	Neurosurgery	34	2080	61.2
American Journal of Emergency Medicine	75	785	10.5	American Journal of Perinatology	33	290	8.8
Journal of Trauma-Injury Infection and Critical Care	69	4465	64.7	Circulation	33	2621	79.4
Pediatric Research	68	2600	38.2	Anaesthesist	32	194	6.1
Cryobiology	63	979	15.5	Pediatric Critical Care Medicine	30	685	22.8
Pharmacology Biochemistry and Behavior	62	1034	16.7	Scandinavian Journal of Trauma Resuscitation & Emergency Medicine	30	561	18.7
European Journal of Pharmacology	54	1439	26.6	British Journal of Anaesthesia	29	839	28.9
Neuroscience Letters	49	1218	24.9	Experimental Neurology	29	1116	38.5
Journal of Perinatology	48	853	17.8	Intensive Care Medicine	29	1409	48.6
Journal of Surgical Research	47	786	16.7	Neonatology	28	489	17.5
Journal of Pediatrics	46	1920	41.7	Neuroscience	28	928	33.1
Bulletin of Experimental Biology and Medicine	45	26	0.6	Pediatrics	28	2746	98.1
Journal of Neurosurgery	44	3818	86.8	Annals of Emergency Medicine	27	1134	42.0
Neurocritical Care	42	1243	29.6	Neuropharmacology	26	555	21.3
Scientific Reports	42	555	13.2	Psychopharmacology	26	780	30.0
European Journal of Cardio-Thoracic Surgery	41	1072	26.1	Pediatric Neurology	25	965	38.6

C: Record count, C: Number of citation, AC: Average citation per document

Table 3. The top 20 most cited articles on hypothermia

No	Article	Author	Journal	PY	TC	AC
1	Treatment of comatose survivors of out-of-hospital cardiac arrest with induced hypothermia	Bernard SA. et al.	New England Journal of Medicine	2002	3687	175.5
2	Mild therapeutic hypothermia to improve the neurologic outcome after cardiac arrest	Holzer M. et al.	New England Journal of Medicine	2002	3426	163.1
3	Whole-body hypothermia for neonates with hypoxic-ischemic encephalopathy	Shankaran S. et al.	New England Journal of Medicine	2005	1787	99.2
4	Selective head cooling with mild systemic hypothermia after neonatal encephalopathy: multicentre randomised trial	Gluckman PD. et al.	Lancet	2005	1531	85
5	Moderate Hypothermia to Treat Perinatal Asphyxial Encephalopathy.	Azzopardi DV. et al.	New England Journal of Medicine	2009	1117	79.7
6	Defense strategies against hypoxia and hypothermia	Hochachka PW.	Science	1986	968	26.1
7	Treatment of traumatic brain injury with moderate hypothermia	Marion DW. et al.	New England Journal of Medicine	1997	934	35.9
8	Effect of mild hypothermia on ischemia-induced release of neurotransmitters and free fatty-acids in rat-brain	Busto R. et al.	Stroke	1989	925	27.2
9	Lack of effect of induction of hypothermia after acute brain injury.	Clifton GL. et al.	New England Journal of Medicine	2001	904	41
10	Mild hypothermia increases blood loss and transfusion requirements during total hip arthroplasty	Schmied H. et al.	Lancet	1996	613	22.7
11	Neurological outcomes at 18 months of age after moderate hypothermia for perinatal hypoxic ischaemic encephalopathy: synthesis and meta-analysis of trial data	Edwards AD. et al.	BMJ-British Medical Journal	2010	601	46.2
12	Hypothermia but not the n-methyl-d-aspartate antagonist, mk-801, attenuates neuronal damage in gerbils subjected to transient global-ischemia	Buchan A. and pulsinelli WA.	Journal of Neuroscience	1990	547	16.5
13	Deep hypothermia with circulatory arrest - determinants of stroke and early mortality in 656 patients	Svensson LG. et al.	Journal of Thoracic and Cardiovascular Surgery	1993	477	15.9
14	Moderate hypothermia in the treatment of patients with severe middle cerebral artery infarction	Schwab S. et al.	Stroke	1998	473	18.9
15	Glutamate release and free-radical production following brain injury - effects of posttraumatic hypothermia	Globus MYT. et al.	Journal of Neurochemistry	1995	453	16.1
16	Prognostication after cardiac arrest and hypothermia a prospective Study	Rossetti AO. et al.	Annals of Neurology	2010	444	34.1
17	Hypothermia in trauma victims - an ominous predictor of survival	Jurkovich GJ. et al.	Journal of Trauma-Injury Infection and Critical Care	1987	444	12.3
18	Effect of hypothermia on the coagulation cascade	Rohrer MJ. and natalie AM.	Critical Care Medicine	1992	438	14.1
19	Childhood Outcomes after Hypothermia for Neonatal Encephalopathy	Shankaran S. et al.	New England Journal of Medicine	2012	436	39.6
20	The effects of mild perioperative hypothermia on blood loss and transfusion requirement	Rajagopal.an S. et al.	Anesthesiology	2008	431	28.7

PY: Publication year, TC: Total citation, AC: Average citations per year

Co-citation Analysis

There were a total of 116544 studies cited in the references section of all 8157 articles published on hypothermia. Among these studies, the 7 most influential studies with more than 350 citations and the most co-citations are respectively; Bernard et al. (2002) (Number of co-citations: NC=1079), Holzer et al. (2002) (NC=979), Shankaran et al. (2005) (NC=625), Gluckman et al. (2005) (NC=501), Azzopardi et al. (2009) (NC=388), Busto et al. (1989) (NC=386), and Busto et al. (1987) (NC=383) (19-25).

Keyword Analysis and Trend Topics

In all of the 8157 articles published on hypothermia, 9330 different keywords were used. Among these keywords, 105 different keywords used in at least 20 different articles are shown in **Table 4**. The cluster network visualization map showing the results of the clustering analysis performed between these keywords is shown in **Figure 4**. As a result of the cluster analysis, it was seen that hypothermia subjects were divided into 7 different clusters (Colors for Cluster 1: red, Cluster 2: green, Cluster 3: blue, Cluster 4: yellow, Cluster 5: purple, Cluster 6: turquoise, Cluster 7: orange). The trend network visualization map performed to identify trend topics is shown in **Figure 5**, and the citation network visualization map performed to reveal the most cited topics is shown in **Figure 6**.

Table 4. The 105 most frequently used keywords in articles on hypothermia

Keywords	Number of uses	Keywords	Number of uses	Keywords	Number of uses
hypothermia	2747	cooling	56	core temperature	29
therapeutic hypothermia	564	oxidative stress	54	hemorrhagic shock	29
cardiac arrest	524	cerebral blood flow	50	hibernation	29
neuroprotection	242	hyperthermia	48	shivering	29
hypoxic-ischemic (or ischaemic) encephalopathy	225	intracranial pressure	47	subarachnoid hemorrhage	29
rat (s)	215	magnetic resonance imaging	46	metabolism	28
temperature	181	nitric oxide	46	coma	27
cardiopulmonary resuscitation	173	glutamate	45	electroencephalography	27
mild hypothermia	172	hippocampus	45	microglia	27
resuscitation	162	out-of-hospital cardiac arrest	45	critical care	26
body temperature	148	brain injury	44	microdialysis	26
ischemia	143	encephalopathy	44	induced	25
traumatic brain injury	143	moderate hypothermia	44	lactate	25
outcome (s)	140	reperfusion	44	mitochondria	25
cerebral ischemia	135	sepsis	42	coagulopathy	24
stroke	123	survival	42	ethanol	24
newborn	117	targeted temperature management	42	head injury	24
neonate (s)	114	brain edema	41	reactive oxygen species	24
rewarming	110	cytokines	41	infant	23
apoptosis	109	hypoxia-ischemia	40	liver	23
inflammation	97	myocardial infarction	39	perioperative hypothermia	23
thermoregulation	94	anesthesia	38	circulatory arrest	22
accidental hypothermia	92	extracorporeal circulation	35	emergency medicine	22
induced hypothermia	90	neurological outcome	33	hypothalamus	22
asphyxia	88	shock	33	lipopolysaccharide	22
heart arrest	88	children	32	blood-brain barrier	21
cardiopulmonary bypass	80	mild therapeutic hypothermia	32	brain temperature	21
trauma	77	pharmacokinetics	32	mri	21
perinatal asphyxia	74	fever	31	pediatric	21
brain	71	hemorrhage	31	brain ischemia	20
mortality	71	reperfusion injury	31	dopamine	20
ventricular fibrillation	67	spinal cord injury	31	heart	20
prognosis	65	extracorporeal membrane oxygenation	30	kidney	20
neonatal encephalopathy	64	surgery	30	microcirculation	20
hypoxia	59	birth asphyxia	29	normothermia	20

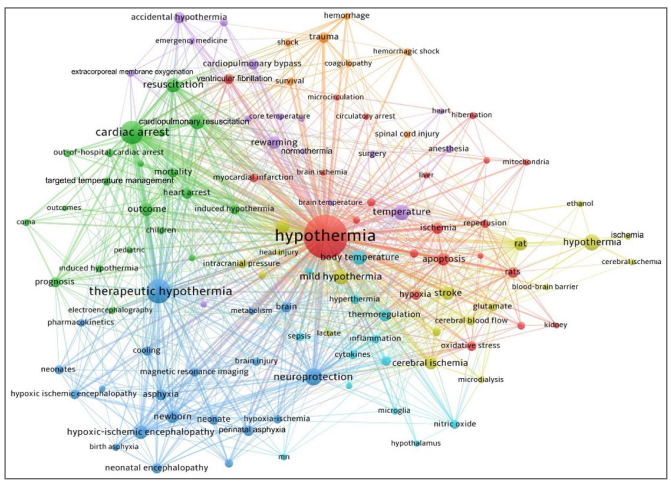

Figure 4. Network visualization map for cluster analysis based on keyword analysis performed to identify clustering of hypothermia. Footnote: Each color denotes a distinct cluster. The color of keywords in the same cluster is the same. The circle represents the number of times the keyword is used in articles. The larger the circle represents the number of times the keyword is used in articles.

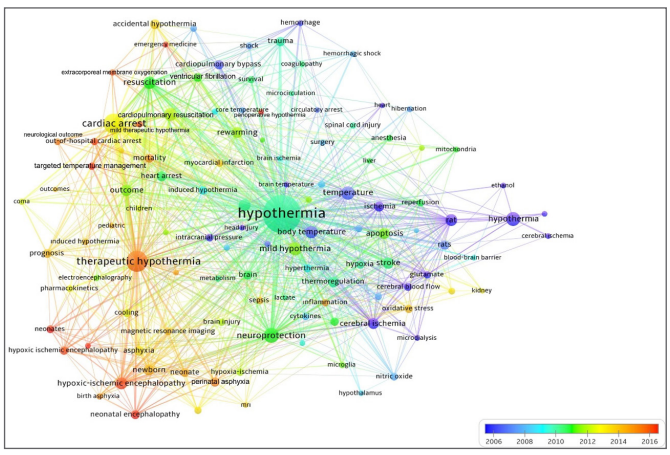

Figure 5. Network visualization map based on keyword analysis to identify past and current trends on hypothermia. Footnote: The article's topicality increases from blue to red as indicated by the indicator in the lower right corner of the figure (blue-green-yellow-red). The circle represents the number of times the keyword is used in articles. The larger the circle represents the number of times the keyword is used in articles.

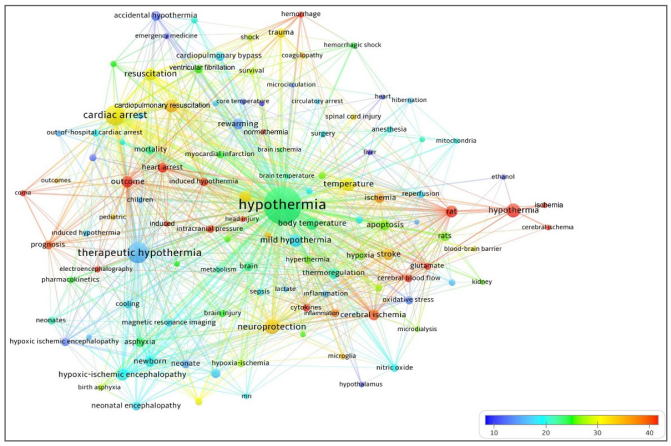

Figure 6. Network visualization map based on keyword analysis performed to identify the most cited topics on hypothermia. Footnote: The number of citations received by the subject increases from blue to red in the indicator in the lower right corner of the figure (blue-green-yellow-red). The circle represents the number of times the keyword is used in articles. The larger the circle represents the number of times the keyword is used in articles.

DISCUSSION

This study, in which the subject of hypothermia was evaluated, showed that the studies on hypothermia mainly focused on the neuroprotective effect of therapeutic hypothermia. This shows that therapeutic hypothermia is an important research topic. In addition, the increase in the annual average number of publications, especially in the 2008-2021 period, is higher than in previous periods. This may be related to both the development of technologies on hypothermia and the fact that therapeutic hypothermia applications are an important treatment method that keeps up to date.

Heart disease is still one of the main universal reasons for death. Acute myocardial infarction is one of the most common diseases in the world. (26,27). For this reason, millions of people lose their lives every year (28). This situation continues to be a global health problem despite all the precautions and developments in treatment strategies. Management of ischemic brain injury, especially due to late intervention after myocardial infarction, is a very difficult health problem. There are promising results regarding therapeutic hypothermia, which has been increasingly used in recent years in order to eliminate the morbidity and mortality that may occur after this situation (19,29,30). In this bibliometric analysis, although most of the studies involving therapeutic hypothermia applications are associated with ischemic encephalopathy, it is observed that this condition is predominantly associated with a prolonged cardiac arrest that develops after myocardial infarction. Another interesting result is that the broadcasts peaked especially with the COVID-19 pandemic. This situation can be evaluated as a result of the reflection of the therapeutic hypothermia applied to patients due to the increased frequency of severe hypoxia due to COVID-19 pneumonia and subsequent hypoxic encephalopathy in the publications.

When the articles were examined and the number of studies of the countries was evaluated, it was seen that particularly developed countries were at the forefront. This situation does not come as a surprise when we evaluate the economic power of an application that requires advanced technology such as therapeutic hypothermia and the pioneers in the production of these devices. In addition, the cooperation scores of the countries in the studies on these issues were again at the forefront in the developed countries.

When the co-authorship cooperation of countries on hypothermia is evaluated, although some international global collaborations have been observed, it is thought that regional international collaborations based on the geographical neighborhood are common in article production. When the journals that publish the most articles on hypothermia are evaluated, it is seen that therapeutic hypothermia comes to the fore. In addition, it was observed that the studies focused on neurology, anesthesia, and emergency journals. We can recommend that authors who want to publish on hypothermia consider these journals first.

When the analyzed articles were evaluated according to the total number of citations they received and the average number of citations received per year, it was observed that the studies on hypothermia were predominantly post-cardiopulmonary arrest, followed by neonatal encephalopathy. Studies have been published showing that hypothermia treatment applied after post-cardiopulmonary arrest and neonatal encephalopathy has positive clinical results. (19,20,23) These results suggest that therapeutic hypothermia applications will intensify in an increasing trend, especially in these subjects. In addition, it is not surprising that similar results are obtained when citation analysis is performed.

Neonatal hypothermia is one of the most important issues in hypothermia. According to the World Health Organization (WHO), neonatal hypothermia is defined as a core body temperature of < 36.5 °C or a skin temperature of < 36 °C (10). Neonatal hypothermia is a global health problem and is still an important risk factor for neonatal morbidity and mortality, especially in low- and middle-income countries (31). In a meta-analysis study conducted for East Africa with 20911 participants (a total of 12 potential studies), the prevalence of neonatal hypothermia was found to be 57.2% (95%CI; 39.5–75.0) (32). Awareness of neonatal hypothermia is still low in some African populations. Risk factors for neonatal hypothermia in the region include poverty, preterm

birth, night birth, home birth, low birth weight, early bathing of newborns, late initiation of breastfeeding, and inadequate knowledge among health workers (31,32). Ironically, neonatal hypothermia, which is frequently encountered in underdeveloped regions such as African countries, is reflected in the publications as a condition that needs to be treated, while in developed countries, it gains weight in publications where hypothermia is used for therapeutic purposes (33). In addition, the limited number of studies on neonatal hypothermia may be associated with less sensitivity in underdeveloped populations and ignorance of the diagnosis of neonatal hypothermia.

As a result of our literature review, we did not find any bibliometric study on hypothermia. It can be said as the advantage of our study is that our research is the first bibliometric study on this subject. In addition, the use of many statistical approaches such as international cooperation analysis, citation analysis, trend keyword analysis, and correlation analysis can be said to be the other superior aspects of our study. A limitation of the study is that we used only the WoS database in the literature review. However, citation analyzes cannot be performed in the PubMed database. In addition, the WoS database indexes the articles published in more effective journals (SCI-expanded, ESCI, and SSCI-indexed journals) compared to the Scopus database (34).

CONCLUSION

In this comprehensive bibliometric research, conducted on hypothermia, it was shared the statistical analysis information of 8157 articles published from the past to the present. The most researched trend topics in recent years were determined as hypoxic-ischemic encephalopathy, neonatal encephalopathy, neonates, targeted management, therapeutic hypothermia, out-of-hospital cardiac arrest, extracorporeal membrane oxygenation, perioperative hypothermia, emergency medicine, outcome, mortality, perinatal asphyxia. Developed countries with large economies had a say in global productivity and international cooperation. This study will guide the authors who want to study in this area.

ETHICAL DECLARATIONS

Ethics Committee Approval: Since our research article is a bibliometric study, there is no need for an ethics committee approval.

Informed Consent: For this type of study, formal consent is not required.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper and that they have approved the final version.

REFERENCES

1. De Robertis E, Kozek-Langenecker SA, Tufano R, Romano GM, Piazza O, Zito Marinosci G. Coagulopathy induced by acidosis, hypothermia and hypocalcaemia in severe bleeding. Minerva Anestesiol 2015; 81: 65-75.
2. Turk EE. Hypothermia. Forensic Sci Med Pathol 2010; 6: 106-15.
3. Aasum E, Larsen TS. Pyruvate reverses fatty-acid-induced depression of ventricular function and calcium overload after hypothermia in guinea pig hearts. Cardiovasc Res 1997; 33: 370-7.
4. Hildebrand F, Giannoudis PV, van Griensven M, Chawda M, Pape HC. Pathophysiologic changes and effects of hypothermia on outcome in elective surgery and trauma patients. Am J Surg 2004; 187: 363-71.
5. Sun YJ, Zhang ZY, Fan B, Li GY. Neuroprotection by therapeutic hypothermia. Front Neurosci 2019; 13: 586.
6. Hakim SM, Ammar MA, Reyad MS. Effect of therapeutic hypothermia on survival and neurological outcome in adults suffering cardiac arrest: a systematic review and meta-analysis. Minerva Anestesiol. 2018; 84: 720-30.
7. Yum SK, Seo YM, Kwun Y, Moon CJ, Youn YA, Sung IK. Therapeutic hypothermia in infants with hypoxic-ischemic encephalopathy and reversible persistent pulmonary hypertension: short-term hospital outcomes. J Matern Fetal Neonatal Med 2018; 31: 3108-14.
8. Leng L. Hypothermia therapy after traumatic brain injury: a systematic review and meta-analysis. Turk Neurosurg 2018; 28: 703-9.
9. Zhu J, Wang B, Lee JH, et al. Additive neuroprotection of a 20-HETE inhibitor with delayed therapeutic hypothermia after hypoxia-ischemia in neonatal piglets. Dev Neurosci 2015; 37: 376-89.
10. World Health Organization (WHO). Thermal control of the newborn: a practical guide. Geneva: World Health Organization; 1993.
11. Zengin M, Karcioglu AM. Do not invade, just support. Bratisl Lek Listy 2022; 123: 218-26.
12. Baldemir R, Ülger G. A holistic investigation of the global outcomes of spontaneous pneumothorax during 1980-2021, including the COVID-19 pandemic a bibliometric approach. Medicine (Baltimore) 2022; 18; 101: e29113.
13. Zengin M, Karaca O. A bibliometric analysis of academic publications about intoxication in the period from 1975 to 2020: A global and medical view. Osmangazi J Med 2022; 44: 148-61.
14. Ülger G, Baldemir R. Analysis of global publications on tracheostomy between 1980 and 2021, including the impact of COVID-19: a bibliometric overview. J Med Palliat Care 2022; 3: 103-10.
15. Zengin M, Baldemir R. Investigation of the global outcomes of acute respiratory distress syndrome with the effect of COVID-19 in publications: a bibliometric analysis between 1980 and 2020. Kırıkkale Üniversitesi Tıp Fakültesi Derg 2021; 23; 279-92.

16. Doğan G, Karaca O. Análise bibliométrica no campo da anestesiologia no período de 2009-2018 [A bibliometric analysis of the field of anesthesia during 2009-2018]. Braz J Anesthesiol 2020; 70: 140-52.
17. van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics 2010; 84: 523-38.
18. The World Bank (2022). Website https://data.worldbank.org/indicator/NY.GDP.MKTP.CD, [accessed 1 February 2022]
19. Bernard SA, Gray TW, Buist MD, et al. Treatment of comatose survivors of out-of-hospital cardiac arrest with induced hypothermia. N Engl J Med 2002; 346: 557-63.
20. Hypothermia after Cardiac Arrest Study Group. Mild therapeutic hypothermia to improve the neurologic outcome after cardiac arrest. N Engl J Med 2002; 346: 549-56. Erratum in: N Engl J Med 2002; 346: 1756.
21. Shankaran S, Laptook AR, Ehrenkranz RA, et al. Whole-body hypothermia for neonates with hypoxic-ischemic encephalopathy. N Engl J Med 2005; 353: 1574-84.
22. Gluckman PD, Wyatt JS, Azzopardi D, et al. Selective head cooling with mild systemic hypothermia after neonatal encephalopathy: multicentre randomised trial. Lancet 2005; 365: 663-70.
23. Azzopardi DV, Strohm B, Edwards AD, et al. Moderate hypothermia to treat perinatal asphyxial encephalopathy. N Engl J Med 2009; 361: 1349-58.
24. Busto R, Globus MY, Dietrich WD, Martinez E, Valdés I, Ginsberg MD. Effect of mild hypothermia on ischemia-induced release of neurotransmitters and free fatty acids in rat brain. Stroke 1989; 20: 904-10.
25. Busto R, Dietrich WD, Globus MY, Valdés I, Scheinberg P, Ginsberg MD. Small differences in intraischemic brain temperature critically determine the extent of ischemic neuronal injury. J Cereb Blood Flow Metab 1987; 7: 729-38.
26. Babini G, Ameloot K, Skrifvars MB. Cardiac function after cardiac arrest: what do we know? Minerva Anestesiol 2021; 87: 358-67.
27. Rathore V, Singh N, Mahat RK, et al. Risk factors for acute myocardial infarction: a review. EJMI 2018; 2; 1-7.
28. El Farissi M, Mast TP, van de Kar MRD, et al. Hypothermia for cardioprotection in patients with st-elevation myocardial infarction: do not give it the cold shoulder yet! J Clin Med 2022; 11: 1082.
29. Lascarrou JB, Merdji H, Le Gouge A, et al. Targeted temperature management for cardiac arrest with nonshockable rhythm. N Engl J Med 2019; 381: 2327-37.
30. Dankiewicz J, Cronberg T, Lilja G, et al. Hypothermia versus normothermia after out-of-hospital cardiac arrest. N Engl J Med 2021; 384: 2283-94.
31. Onalo R. Neonatal hypothermia in sub-Saharan Africa: a review. Niger J Clin Pract 2013; 16: 129-38.
32. Beletew B, Mengesha A, Wudu M, Abate M. Prevalence of neonatal hypothermia and its associated factors in East Africa: a systematic review and meta-analysis. BMC Pediatr 2020; 20: 148.
33. Karpuz D, Celik Y, Giray D, Tasdelen B, Hallioglu O. Therapeutic hypothermia and myocardium in perinatal asphyxia: a microvolt T-wave alternans and Doppler echocardiography study. Bratisl Lek Listy 2017; 118; 765-71.
34. Demir E, Akmeşe ÖF, Erbay H, Taylan-Özkan A, Mumcuoğlu KY. Bibliometric analysis of publications on house dust mites during 1980-2018. Allergol Immunopathol (Madr) 2020; 48: 374-83.