

RESEARCH

Open Access



Global trends and hotspots in research on acupuncture for stroke: a bibliometric and visualization analysis

Jiale Zhang¹, Chenyang Ji², Xu Zhai^{3*}, Shuo Ren^{4*} and Hongxuan Tong^{1*}

Abstract

Acupuncture has been widely used in stroke and post-stroke rehabilitation (PSR), but there is no literature on the bibliometric analysis of acupuncture for stroke. This study aimed to characterize the global publications and analyze the trends of acupuncture for stroke in the past 40 years. We identified 1157 publications from the Web of Science Core Collection. The number of publications grew slowly in the first three decades from 1980 until it started to grow after 2010, with significant growth in 2011–2012 and 2019–2020. China, the USA, and South Korea are the top three countries in this field, and China has formed good internal cooperative relations. Early studies focused on the clinical efficacy of acupuncture for stroke. In the last five years, more emphasis has been placed on the effectiveness of acupuncture in treating sequelae and complications, combined with neuroimaging studies to explore the mechanisms of brain injury repair and neurological recovery. Acupuncture for stroke has a vast research potential, and researchers from different countries/regions and organizations still need to remove academic barriers to enhance communication and collaboration.

Highlights

- For the first time, we analyzed hotspots related to the field of acupuncture for stroke research using a bibliometric approach, focusing on the most critical indicators, including researchers, countries, research institutions, and journals.
- 1157 publications from 60 countries/regions contributed to this research theme. China is the main producer of acupuncture for stroke and has formed a cooperation cluster. It is worth noting that researchers from different countries/regions and organizations still need to remove academic barriers to enhance communication and collaboration.
- Future research trends are focused on providing high-quality clinical evidence, integrating neurological disciplines, exploring new models with multidisciplinary overlap, and exploring the development of artificially intelligent acupuncture robots. The integration of acupuncture with neuroscience and computational science, as well as deep learning and artificial intelligence, are hotspots in acupuncture for stroke.

Keywords Acupuncture, Stroke, Bibliometric analysis, Global trends, Brain disease

[†]Jiale Zhang and Chenyang Ji contributed equally to this work and share first authorship.

*Correspondence:

Xu Zhai

jameszhai34@163.com

Shuo Ren

renshuo_1982@163.com

Hongxuan Tong

thongxuan1@163.com

Full list of author information is available at the end of the article



© The Author(s) 2023. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

Introduction

Cerebral stroke is a common cerebrovascular disease, the onset of which is related to impaired blood circulation, vascular rupture, or obstruction of blood flow in cerebral blood vessels, including ischemic and hemorrhagic stroke [1, 2]. Studies [3, 4] showed that the age-standardized incidence rate (ASIR) was the highest for ischemic stroke in East Asia in 2019 and the most significant increase in the ASIR from 1990 to 2019. Globally, ischemic stroke incidence increases, especially in women aged 50 to 69 [5]. In 2019, there were 394 million new stroke cases in China, up by 86.0% compared to 1990 [6]. Contrary to the decreasing trend in developed countries, the incidence of stroke in China increased significantly, and the burden of stroke remains severe and is the primary cause of death [7, 8]. Therefore, the prevention and treatment of cerebral infarction are of great importance.

Acupuncture is widely used in stroke and post-stroke related complications, such as post-stroke impairments in motor function, cognitive function, and mental disorders [9–11]. Acupuncture can significantly improve neurobehavioral function and reduce animal brain infarct volume [12, 13]. Studies on the mechanism of acupuncture for stroke have focused on anti-apoptosis [14], autophagy promoting neural regeneration [15], anti-inflammatory [16], anti-oxidative stress [17], and improving cerebral circulation [18].

Bibliometrics can analyze the contributions of different authors, journals, institutions, and countries to a

research topic and discover trends and domain-specific hotspots [19]. Therefore, this study used two widely used bibliometric tools, CiteSpace and VOSviewer, based on the Web of Science core collection (WoSCC) from 1980 to 2022 publications. Our study is the first to describe the current situation and hotspots in acupuncture for stroke in the last 40 years. The objective of this research is threefold: (1) to identify articles and journals with high impact, prolific authors, institutions, and countries/regions with significant contributions; (2) to delineate the central research topics and currents of interest; and (3) to forecast the future trends of acupuncture for stroke.

Materials and methods

Search strategy

We conducted a systematic search through the Web of Science Core Collection (WoSCC) [20], which only included the Science Citation Index Expanded (SCI-E) literature included in the library. The retrieval type is TS=(acupuncture or Electroacupuncture or dry needling or acupoint injection) AND TS=(apoplexy or stroke or cerebral infarction). We excluded meeting abstract, letter, editorial material, proceeding paper, early access, correction, book chapters, retraction, news item, reprint, or retracted publication. Bibliometric analysis of acupuncture for stroke in the workflow is shown in Fig. 1. Two researchers (Jiale Zhang and Chenyang Ji) were assigned to search the database and filter the literature, while a

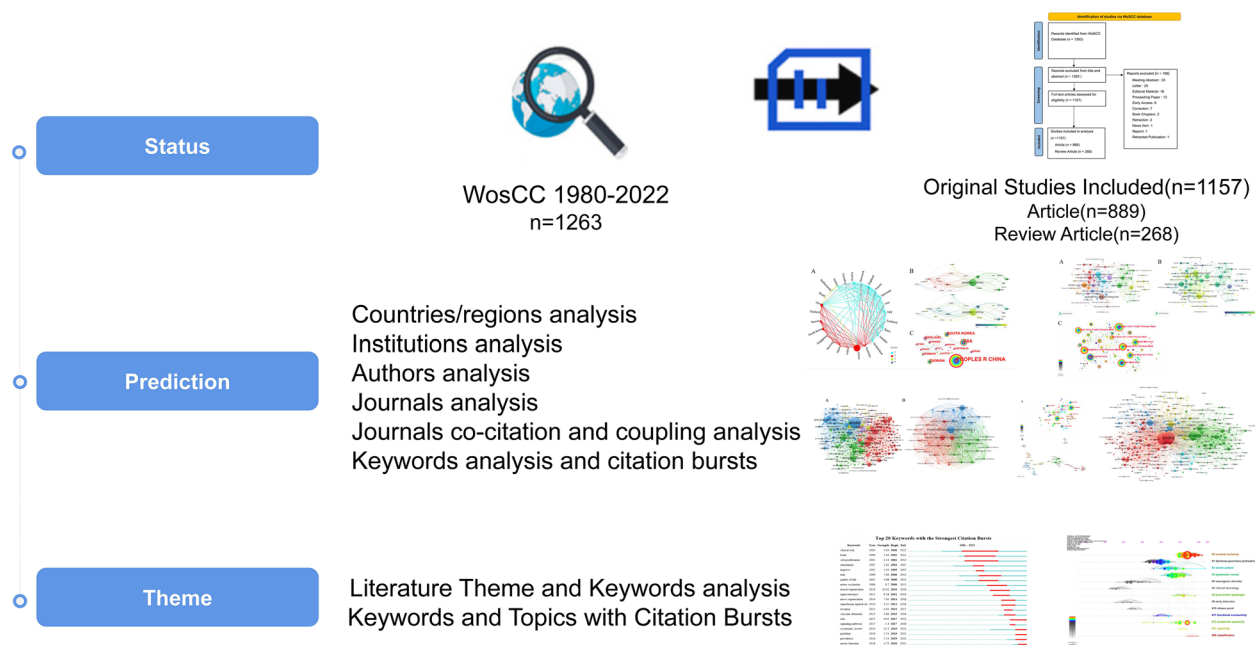


Fig. 1 Bibliometric analysis of acupuncture for stroke in the workflow

senior researcher (Hongxuan Tong) handled potential controversies and disagreements.

Data extraction and bibliometric analysis

The included literature was downloaded into Microsoft Excel 2019 for statistical analysis of basic information, including title, keywords, journal, publication date, and other essential information. VOSviewer was adopted to visualize countries/regions, institutions, authorship partnerships, and keyword co-occurrence journal coupling mapping. Among them, based on the countries/regions cooperation graph generated by VOSviewer, we use Scimago Graphica to develop a complex network graph of countries/regions associations, which can better present the cooperation relationship between countries/regions. CiteSpace is used to identify the keywords bursting to show the evolution of the research field. For the concepts mentioned in the study, journal coupling analysis originates from Professor M.M. Kessler in 1963 [21], which states that two journals are coupled if they cite the third journal together. Journal coupling analyzes the scholarly communication between journals and determines the journal’s position and the association between the disciplines. Journal co-citation [22] is a method to explore the association between journals through the external perception of journals. If one or more papers cite two (or more) papers simultaneously, the two are known to constitute a co-citation relationship. Journal coupling analysis the relationship between journals from the perspective of knowledge uptake, while journal co-citation analysis examines the association between journals from the perspective of knowledge output. More detailed instructions on the specific procedures can be found in Additional file 1.

Result

Basic analysis of the literature

As shown in Fig. 2, 1157 articles were included, with an overall increasing trend in the number of articles. From 1995 to 2005, the annual output of articles was approximately equal. The literature on acupuncture for stroke increased steadily from 2011 to 2012, indicating the beginning of interest in the treatment. The number of articles increased from 2019 to 2020, reaching 139 outputs by 2021. Based on Microsoft Excel worksheets, we predict that by 2025, the annual literature volume will exceed 200 articles.

Countries/regions analysis

In total, 60 countries or regions have published papers on treating stroke with acupuncture. Figure 3D shows the top 10 countries and regions with the highest yield. The most published papers were from the People’s Republic of China ($n=776$), followed by the USA ($n=151$) and South Korea ($n=98$). Figure 3A–C depicts the connectivity density among East Asian countries, North America, and some European countries. In total, four clusters were formed. Among the different countries, China ranks first in the number of publications. In terms of the timeline, as a typical representative, China started late, despite its size, and after 2015, studies in China began to increase gradually (Fig. 3B).

Institutions analysis

Altogether, there were 1,279 universities and institutes participating in the study (Fig. 4). Figure 4D shows the top 20 institutions. The top five institutions by publication count were GZUCM with 85 (7.35%) articles, BUCM with 70 (6.05%) articles, TUTCM with 64 (5.53%)

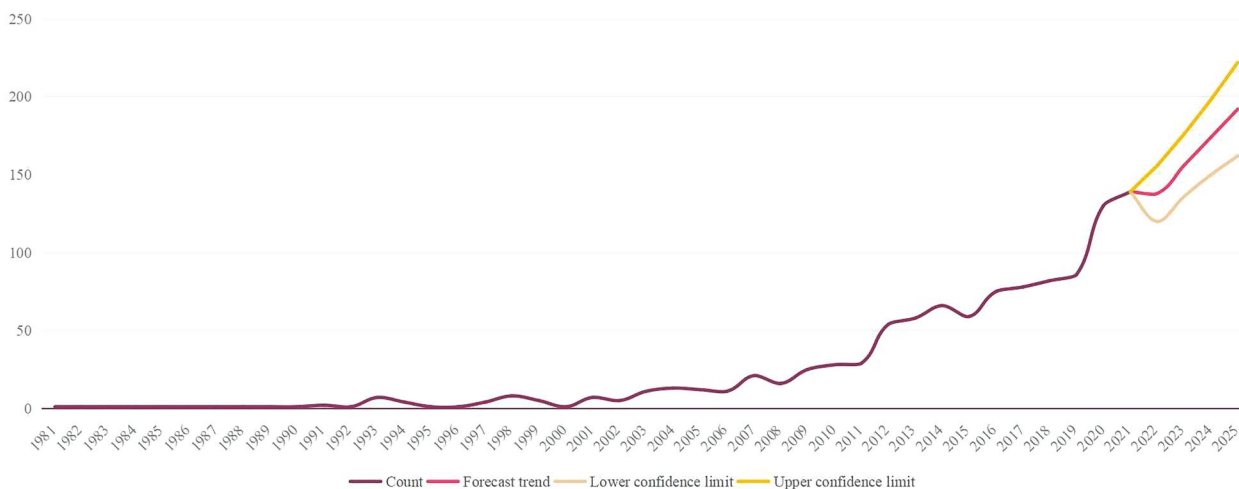


Fig. 2 Publication prediction diagram

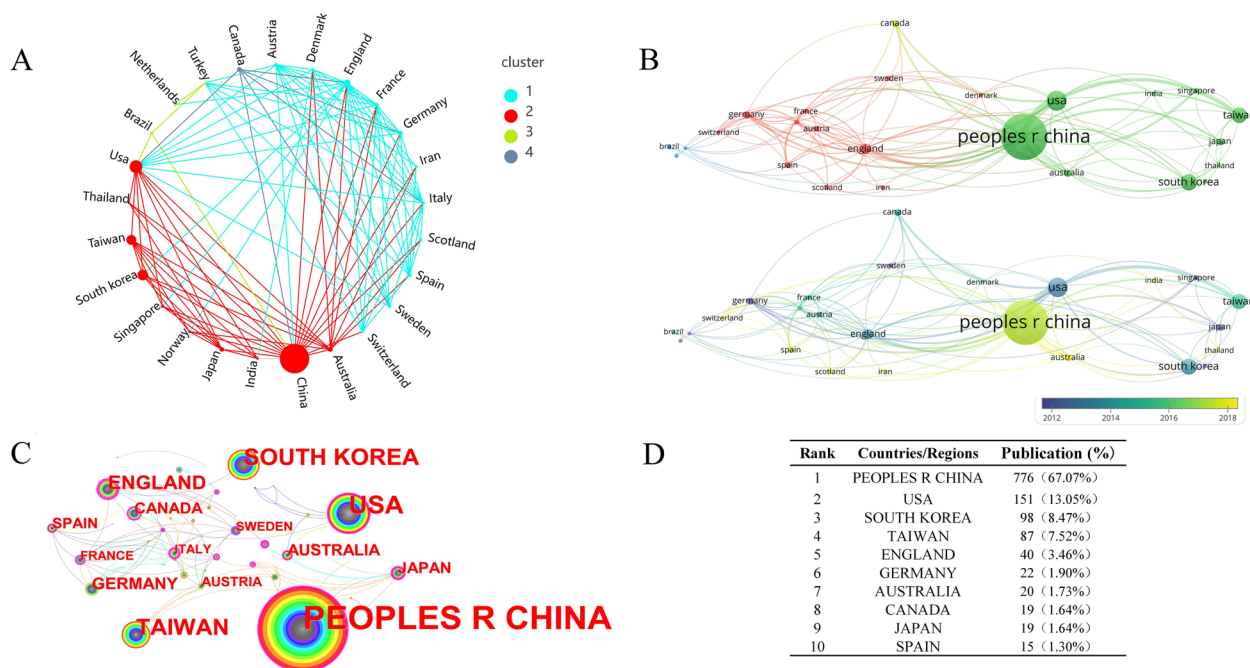


Fig. 3 Link density relationships between countries/regions and the top ten countries/regions. **A** The complex network of countries/ regions associations, forming four types of associations; **B** the four types of associations through the form of a map; **C** the intensity of cooperation between countries/ regions; **D** the top ten countries/regions. The most published papers were from the People’s Republic of China ($n = 776$), followed by the USA ($n = 151$) and South Korea ($n = 98$)

articles, FJTCM with 58 (5.01%) articles, and CMU with 55 (4.75%) articles. The graph of institutional partnerships and collaboration density shows that China has formed a network of collaborative relationships within the three TCM universities in tandem with comprehensive universities and local universities. In terms of the timeline, the research of China Medical University (Taiwan) and Kyung Hee University in South Korea formed a sizeable cluster centered on research until 2016. After 2016, Chinese research increased and gradually formed a large-scale, established research group.

Authors analysis

A total of 4,293 authors participated in studies on acupuncture for stroke. Chen Lidian was the prolific author with 44 publications, followed closely by Tao Jing ($n = 41$) and Huang Jia ($n = 25$). CiteSpace and VOSviewer visualize the cooperative network between authors. As shown in Fig. 5A, authors within the same country are closely connected, and scientific collaboration is relatively frequent, but the links between different countries and regions remain low.

Figure 5B shows the network diagram based on VOSviewer. The relational network of the author’s group collaboration also reflects the size of the study. Overall, five core groups of researchers have been formed in

China. Such as Chen Lidian, Liu Cunzhi, Shi Xuemin, Xu Nenggui, and Tang Chunzhi, Wang Qiang. In addition, through the CiteSpace analysis research team, there is also a research group formed in Korea, represented by Seung-Yeon Cho.

Journals analysis

Out of 1157 publications included, published in 313 different journals. Table 1 shows the top 20 journals. The top three journals are eCAM, *Medicine (IF/JCR = 1.817/Q3)*, *Neural Regen Res (IF/JCR = 6.058/Q1)*, and *Integrative & Complementary Medicine* accounted for 50% of the top 20 journals, followed by neuroscience or clinical neuroscience, accounting for 30% of the weight.

Journals co-citation and coupling analysis

In journal co-citation analysis, 7713 articles were extracted by VOSviewer, and we selected 370 papers with citation frequency more significant than 20 to the presentation (Fig. 6A). According to the total citation intensity analysis, the top-ranked journals are “Stroke, *Arch Phys Med Rehabil*, and eCAM”. In the journal coupling analysis, we set frequency five as the minimum coupling amount, and 48 of 312 journals reached the threshold, but one of the nodes was not associated with other nodes, so only 47 are shown in Fig. 6B. According

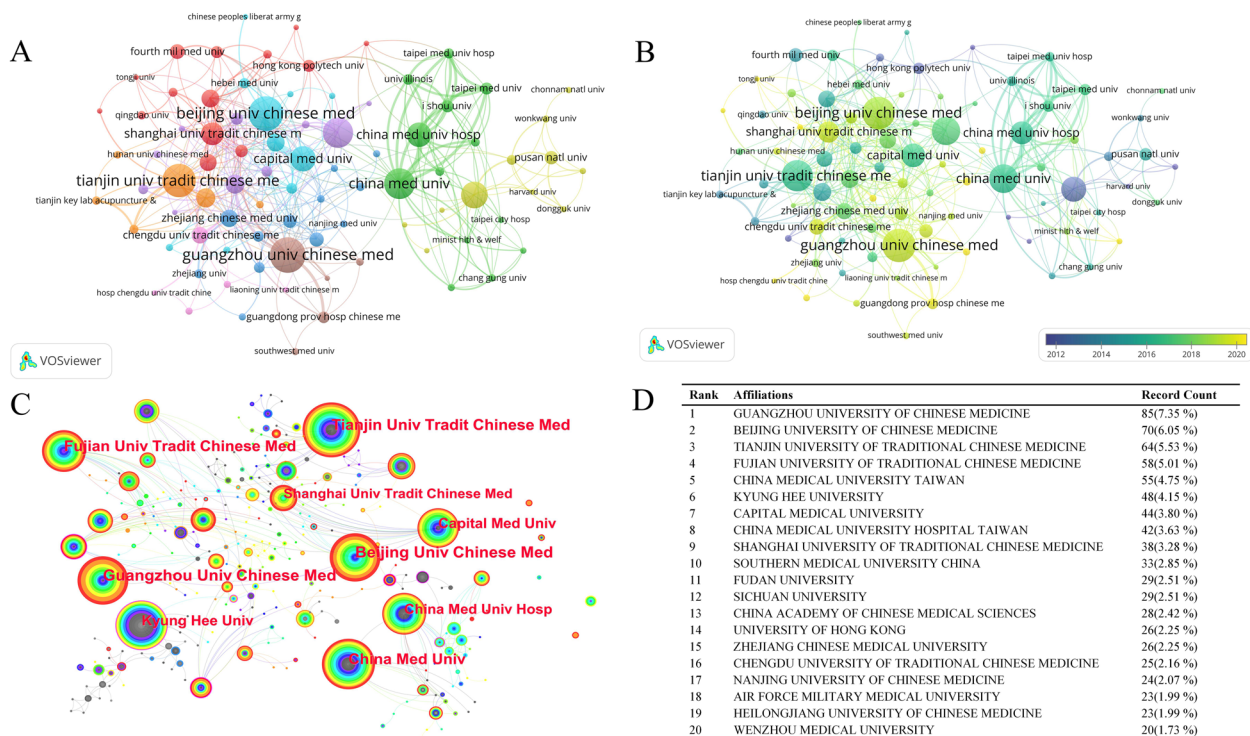


Fig. 4 Institutions relationship and collaboration density and the top 20 institutions. **A** The dense and complex lines between various research institutions in China indicate high correlation and close collaboration. **B** The edges with lighter colors (yellow) represent the period after 2016, during which more Chinese institutions were involved in the research. The darker-colored edges represent the earlier period when Chinese institutions were less involved. **C** The color depth represents the chronological order, with brighter colors indicating later periods. It can be observed that research from mainland China appeared later than that from other regions. The dense lines between South Korea and Taiwan represent a close collaboration. **D**. The top 20 institutions. GZUCM with the most publications of 85 (7.35%) articles, BUCM with 70 (6.05%) articles, and TUTCM with 64 (5.53%) articles

to the coupling strength, the top three stronger journals are “eCAM, Neural Regen Res, and Acupuncture in Medicine”.

Literature theme and keywords analysis

The analysis of the literature reflects the trend of hot-spots and research topics. We did a set of cluster analyses and timeline evolution of the literature co-cited. For the analysis of keywords, we used VOSviewer to present a keywords network graph (Fig. 7), with the size of the circles representing the total link strength and the thickness of the lines representing the number of co-occurrences. Several clusters were formed based on the classification of keywords. The red cluster shows keywords related to clinical studies such as randomized controlled trial, double-blind, outcome, scale, guidelines, systematic review, bias, and epidemiology. In addition, above the red cluster, two types of clusters focus on clinical research on PSR, a blue cluster that focuses on quality of life improvement in PSR and a yellow cluster that emphasize the exploration of rehabilitation after stroke through neuroimaging. Below the red cluster is a small category of the light

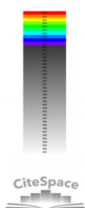
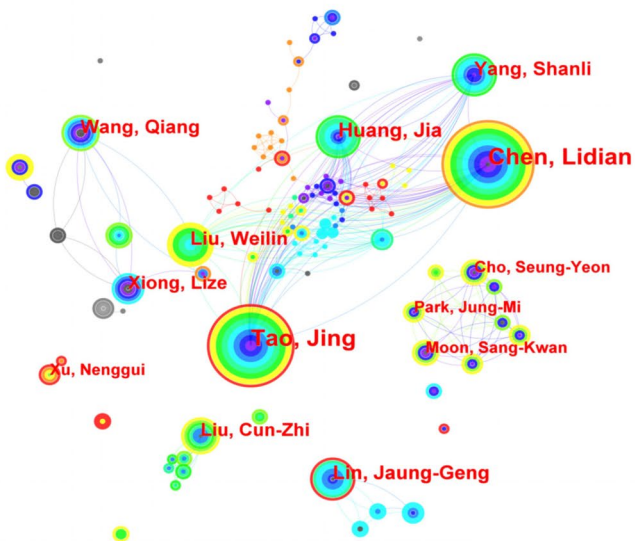
blue cluster, which focuses on stroke for neurological deficits, especially acupuncture interventions for cognitive impairment, vascular dementia, and other disease mechanisms and clinical research. On the right of the red cluster is another green cluster focused on animal experiments research, especially on EA for neurological deficits in animal models. Several relevant subject words, such as neurogenesis, activation, neurons, hippocampus, astrocytes, apoptosis, and rapid tolerance, are associated with exploring the mechanisms and targets of EA against stroke.

Keywords with the strongest citation bursts

We did a citation burst analysis of keywords (Fig. 8). Clinical research on acupuncture for stroke has been a long-standing hotspot. In the past three years, the focus has been on integrating evidence, including evaluating the reporting quality of randomized controlled trials (RCTs) and the functional recovery after stroke. Table 2 lists the randomized controlled trial (RCT) literature cited for high frequency. In addition, in animal models studies, attention has been paid to acupuncture

CiteSpace, v. 5.10.R3 (64-bit) Advanced
 October 16, 2022 at 8:47:45 AM CST
 WoS: D:\Desktop\data for mcridata
 Timespan: 1981-2022 (Slice Length=1)
 Selection Criteria: g-index (k=25), LRF=3.0, L/N=10, LBY=5, e=1.0
 Network: N=799, E=1589 (Density=0.005)
 Largest CC: 74 (9%)
 Nodes Labeled: 1.0%
 Pruning: None

A



B

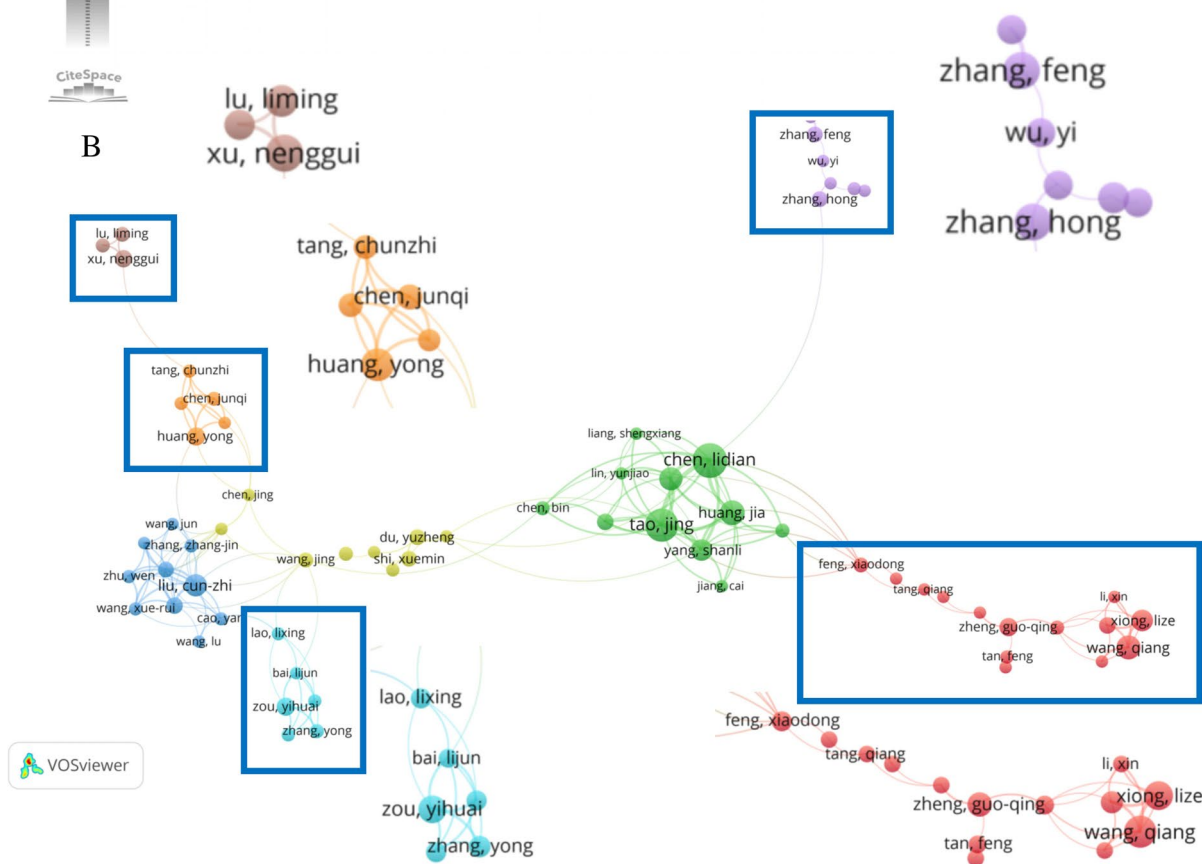


Fig. 5 Author collaboration network

Table 1 Information on the top 20 journals

Rank	Publication titles	Record count	Category	IF/JCR
1	Evidence-Based Complementary and Alternative Medicine	101(8.73%)	Integrative & Complementary Medicine	NA
2	Medicine	69(5.96%)	Medicine, General & Internal	1.817/Q3
3	Neural Regeneration Research	62(5.36%)	Neurosciences	6.058/Q1
4	Acupuncture in Medicine	44(3.80%)	Integrative & Complementary Medicine	1.976/Q3
5	Trials	34(2.94%)	Medicine, Research & Experimental	2.728/Q4
6	Journal of Traditional Chinese Medicine	28(2.42%)	Integrative & Complementary Medicine	2.547/Q3
7	Journal of Alternative and Complementary Medicine	27(2.33%)	Integrative & Complementary Medicine	2.381/Q3
8	BMC Complementary and Alternative Medicine	24(2.07%)	Integrative & Complementary Medicine	4.782/Q1
9	ACUPUNCTURE & ELECTRO-THERAPEUTICS RESEARCH	20(1.73%)	Neurosciences	0.684/Q4
10	Cochrane Database of Systematic Reviews	20(1.73%)	Medicine, General & Internal	12.008/Q1
11	Frontiers in Neurology	20(1.73%)	Integrative & Complementary Medicine	4.086/Q2
12	American Journal of Chinese Medicine	19(1.64%)	Integrative & Complementary Medicine	6.005/Q1
13	Chinese Journal of integrative Medicine	18(1.56%)	Multidisciplinary Sciences	2.626/Q3
14	PLoS One	18(1.56%)	Integrative & Complementary Medicine	3.752/Q2
15	Neural Plasticity	17(1.47%)	Neurosciences	3.144/Q3
16	Stroke	17(1.47%)	Clinical Neurology	10.170/Q1
17	Neurological Research	16(1.38%)	Clinical Neurology	2.529/Q3
18	Complementary Therapies in Medicine	15(1.30%)	Integrative & Complementary Medicine	3.335/Q2
19	Neuroscience Letters	14(1.21%)	Neurosciences	3.197/Q3
20	European Journal of Integrative Medicine	13(1.12%)	Integrative & Complementary Medicine	1.813/Q4

All impact factors are the latest impact factors published by Clarivate in 2021

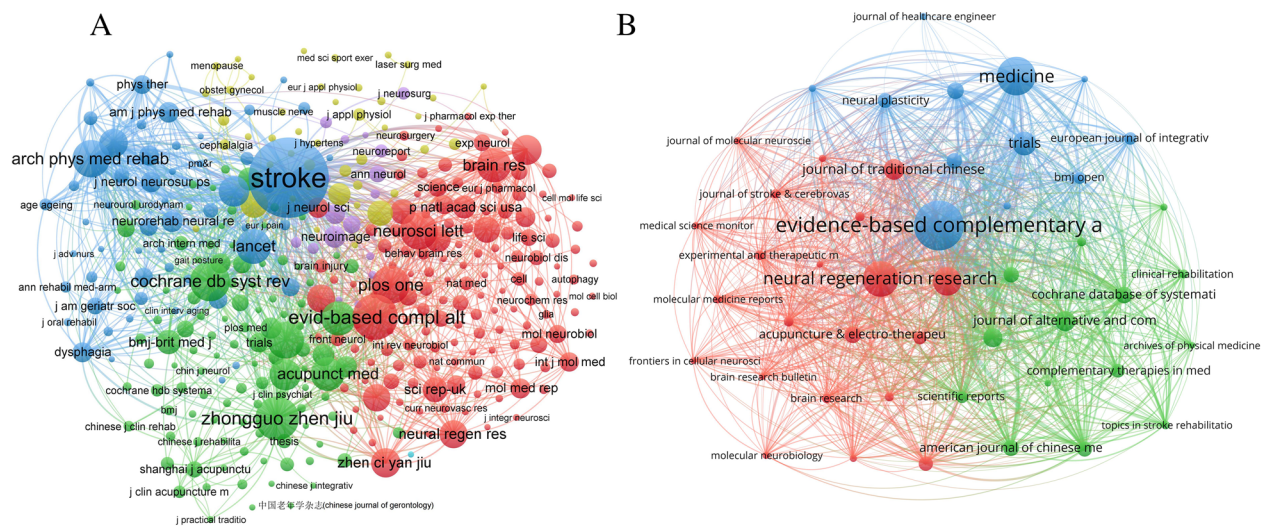


Fig. 6 Journal co-citation and journal coupling

intervention in neuronal apoptosis in cerebral infarction rats to improve motor ability, learning memory, and neurological function, primarily through signaling pathways such as NF-Kb [23], PI3K/Akt [24], to reduce cerebral ischemic injury and neuroinflammation.

Discussion

In recent years, research surrounding acupuncture for stroke has become increasingly extensive [25–28], especially after 2010, with a faster growth rate. Acupuncture has received increasing attention as a method of complementary and alternative medicine. Although early clinical

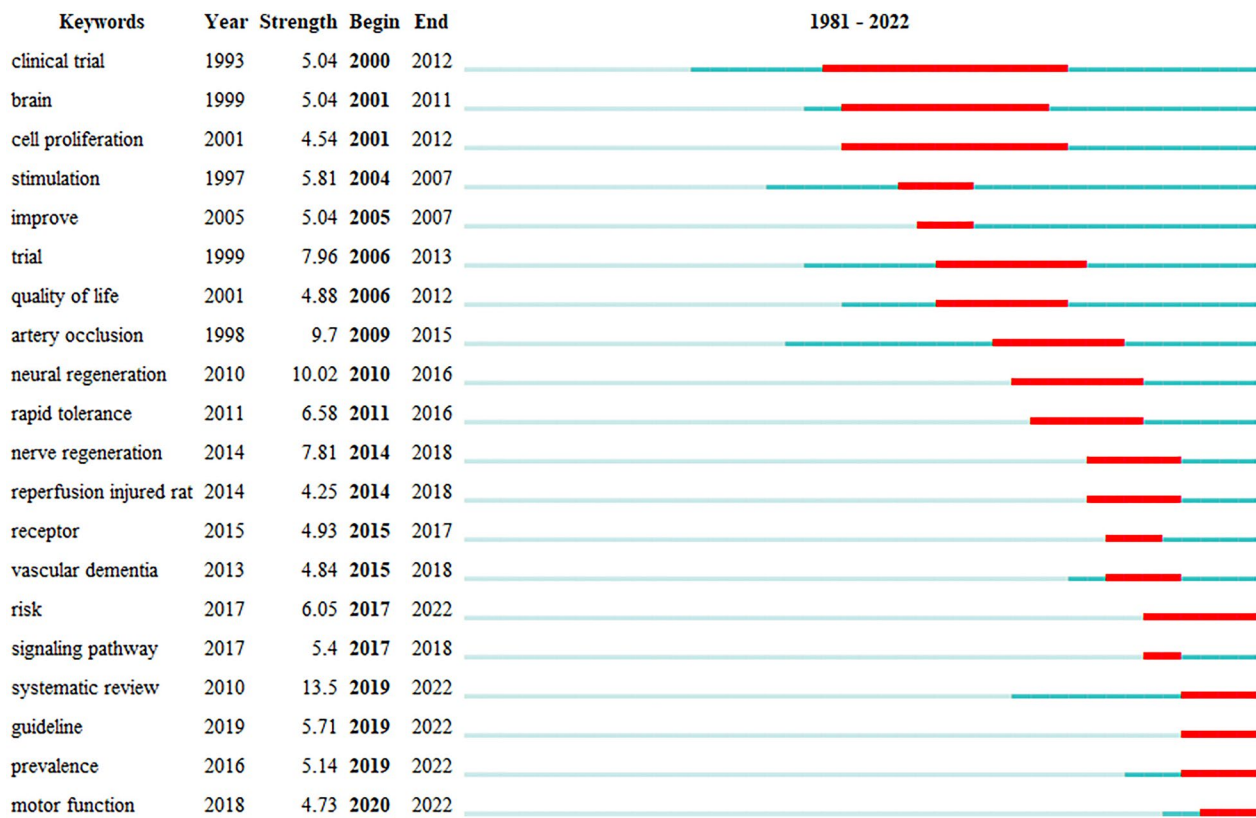


Fig. 8 Keywords with the strongest citation bursts

of clinical guideline recommendation” [38] mentioned that although clinical practice and treatment guidelines increasingly mention acupuncture as a therapeutic option for post-stroke care, most guidelines indicate a lack of sufficient basis for recommending acupuncture as a treatment option for PSR.

Recent evidence published in 2022 suggests that interactive dynamic scalp acupuncture [39–41] is effective in cognitive function, motor function, and gait of lower limbs after stroke, where acupuncture improves cognitive function but reduces anxiety, depression and ultimately promotes the patient’s ability of daily activity. In another study evaluating the role of acupuncture in ischemic stroke rehabilitation [42], after treatment, the acupuncture group had lower NIHSS scores ($P=0.017$) compared to the traditional training group. The acupuncture was more effective than the traditional training on the Basel Index ($P=0.016$).

In addition, another category of clinical research focuses on the acupuncture of PSR from the perspective of neuroimaging [43]. Resting-State fMRI before and after acupuncture in stroke patients was found to increase the intrinsically reduced functional connectivity between bilateral primary motor cortices. Thus, further

understanding the neuroplasticity mechanism of acupuncture on motor function recovery in stroke is crucial [44].

Topic 2: Mechanistic studies to explore the action of acupuncture for stroke and its sequelae

In mechanistic studies, acupuncture significantly reduced cerebral infarct volume, improved neurological function, and inhibited neuronal apoptosis [45]. EA modulates endoplasmic reticulum stress in rats with acute ischemic stroke, which significantly increased the mRNA expression level of GRP78, and decreased the expression levels of pro-apoptotic proteins (CHOP / GADD153, p-eIF2 α and caspase 12). The mechanism suggesting that EA protects cells from cerebral ischemia/reperfusion injury neuronal damage may involve the inhibition of endoplasmic reticulum stress [46]. A study [47] on EA intervention in middle cerebral artery occlusion (MCAO) rats from cerebral ischemia–reperfusion injury showed that EA decreased the pro-apoptotic proteins Bax and caspase-3, increased the anti-apoptotic protein Bcl-2, inhibited the transcriptional activity of NF- κ B and TRPV1 expression. EA plays an anti-apoptosis role by inhibiting the NF- κ B to protect rats from ischemia–reperfusion injury.

Table 2 Top 20 literature of randomized controlled trials

Title	Authors (top five)	Journal title	Impact factor	Year	DOI	Citation
Acupuncture and transcutaneous nerve stimulation in stroke rehabilitation—A randomized, controlled trial	Johansson, BB; Haker, E; von Arbin, M; Britton, M; Langstrom, G; et al	Stroke	10.170/Q1	2001	10.1161/01.STR.32.3.707	118
Clinical trial of electrical acupuncture on hemiplegic stroke patients	Wong, AMK; Su, TY; Tang, FT; Cheng, PT; Liaw, MY	American Journal of Physical Medicine & Rehabilitation	3.412/Q1	1999	10.1097/00002060-199903000-00006	92
A randomized controlled trial on the treatment for acute partial ischemic stroke with acupuncture	HU, HH; CHUNG, C; LIU, TJ; CHEN, RC; CHEN, CH; et al	Neuroepidemiology	5.393/Q1	1993	10.1159/000110308	76
Acupuncture efficacy on ischemic stroke recovery multicenter randomized controlled trial in China	Zhang, Shihong; Wu, Bo; Liu, Ming; Li, Ning; Zeng, Xianrong; et al	Stroke	10.170/Q1	2015	10.1161/STROKEAHA.114.007659	70
Acupuncture for subacute stroke rehabilitation—A sham-controlled, subject- and assessor-blind, randomized trial	Park, J; White, AR; James, MA; Hemsley, AG; Johnson, P; et al	JAMA internal medicine (formerly the Archives of Internal Medicine) ^a	44.409/Q1	2005	10.1001/archinte.165.17.2026	64
Transcutaneous electrical stimulation on acupuncture points improves muscle function in subjects after acute stroke: A randomized controlled trial	Yan, Tiebin; Hui-Chan, Christina W. Y	Journal of Rehabilitation Medicine	3.959/Q1	2009	10.2340/16501977-0325	52
Intradermal acupuncture on Shenmen and Nei-kuan acupoints improves insomnia in stroke patients by reducing the sympathetic nervous activity: A randomized clinical trial	Lee, Seung Yeop; Baek, Yong Hyeon; Park, Seong Uk; Moon, Sang Kwan; Park, Jung Mi; et al	American Journal of Chinese Medicine	6.005/Q1	2009	10.1142/S0192415X09007624	48
Efficacy and safety assessment of acupuncture and nimodipine to treat mild cognitive impairment after cerebral infarction: A randomized controlled trial	Wang, Shuhua; Yang, Hongling; Zhang, Jie; Zhang, Bin; Liu, Tao; et al	BMC Complementary and Alternative Medicine	4.782/Q1	2016	10.1186/s12906-016-1337-0	36
A pilot controlled trial of a combination of dense cranial electroacupuncture stimulation and body acupuncture for post-stroke depression	Man, Sui-Cheung; Hung, Ben H. B.; Ng, Roger M. K.; Yu, Xiao-Chun; Cheung, Hobby; et al	BMC Complementary and Alternative Medicine	4.782/Q1	2014	10.1186/1472-6882-14-255	36
Effects of dry needling on post-stroke spasticity, motor function and stability limits: A randomized clinical trial	Sanchez-Milla, Zacarias; Salom-Moreno, Jaime; Fernandez-de-las-Penas, Cesar	Acupuncture in Medicine	1.976/Q3	2018	10.1136/acupmed-2017-011568	33
Clinical efficacy of acupuncture treatment in combination with rehabcom cognitive training for improving cognitive function in stroke: A 2 x 2 factorial design randomized controlled trial	Jiang, Cai; Yang, Shanli; Tao, Jing; Huang, Jia; Li, Yinyan; et al	Journal of the American Medical Directors Association	7.802/Q1	2016	10.1016/j.jamda.2016.07.021	33

Table 2 (continued)

Title	Authors (top five)	Journal title	Impact factor	Year	DOI	Citation
Additional effects of acupuncture on early comprehensive rehabilitation in patients with mild to moderate acute ischemic stroke: A multicenter randomized controlled trial	Chen, Lifang; Fang, Jianqiao; Ma, Ruijie; Gu, Xudong; Chen, Lina; et al	BMC Complementary and Alternative Medicine	4.782/Q1	2016	10.1186/s12906-016-1193-y	30
Clinical effects of scalp electrical acupuncture in stroke: A sham-controlled randomized clinical trial	Hsing, Wu Tu; Imamura, Marta; Weaver, Kayleen; Fregni, Felipe; Azevedo Neto, Raymundo S	Journal of Alternative and Complementary Medicine	2.381/Q3	2012	10.1089/acm.2011.0131	28
Bee venom acupuncture point injection for central post stroke pain: A preliminary single-blind randomized controlled trial	Cho, Seung-Yeon; Park, Joo-Young; Jung, Woo-Sang; Moon, Sang-Kwan; Park, Jung-Mi; et al	Complementary Therapies in Medicine	3.335/Q2	2013	10.1016/j.ctim.2013.02.001	25
Therapeutic effect of acupuncture and massage for shoulder-hand syndrome in hemiplegia patients: A clinical two-center randomized controlled trial	Li, Ning; Tian, Fengwei; Wang, Chengwei; Yu, Pengming; Zhou, Xi; et al	Journal of Traditional Chinese Medicine	2.547/Q3	2012	10.1016/S0254-6272(13)60035-7	20
The effects of acupuncture on cerebral blood flow in post-stroke patients: A randomized controlled trial	Ratmanský, Mottl; Levy, Adi; Messinger, Aviv; Birg, Alla; Front, Lilach; et al	Journal of Alternative and Complementary Medicine	2.381/Q3	2016	10.1089/acm.2015.0066	19
Efficacy of integrated rehabilitation techniques of traditional Chinese medicine for ischemic stroke: A randomized controlled trial	Zhang, Yong; Jin, He; Ma, Dayong; Fu, Yuanbo; Xie, Yanming; et al	American Journal of Chinese Medicine	6.005/Q1	2013	10.1142/S0192415X13500651	18
Effectiveness of acupuncture for vascular cognitive impairment no dementia: A randomized controlled trial	Yang, Jing-Wen; Shi, Guang-Xia; Zhang, Shuai; Tu, Jian-Feng; Wang, Li-Qiong; et al	Clinical Rehabilitation	2.884/Q2	2019	10.1177/0269215518819050	17
Traditional Chinese acupuncture for poststroke depression: A single-blind double-simulated randomized controlled trial	Qian, Xiaolu; Zhou, Xuan; You, Yanli; Shu, Shi; Fang, Fanfu; et al	Journal of Alternative and Complementary Medicine	2.381/Q3	2015	10.1089/acm.2015.0084	15
Efficacy and safety of transcutaneous electrical acupoint stimulation to treat muscle spasticity following brain injury: A double-blinded, multicenter, randomized controlled trial	Zhao, Wenli; Wang, Chao; Li, Zhongzheng; Chen, Lei; Li, Jianbo; et al	PLoS One	3.752/Q2	2015	10.1371/journal.pone.0116976	14

^a JAMA Internal Medicine, formerly known as the Archives of Internal Medicine
All Impact Factor are the latest impact factors published by Clarivate in 2021

As to the neurovascular unit repair, acupuncture plays a vital role by activating the phosphatidylinositol 3-hydroxy kinase/protein kinase B signaling pathway, which has facilitated rehabilitation after cerebral infarction in rats [48].

The combined intervention of mesenchymal stem cell (MSC) transplantation and EA is a neuroprotection strategy for intracerebral hemorrhage (ICH) [49]. The combination of two methods, by relieving cerebral edema and glial scar, promotes neuronal and oligodendrocyte survival, activates mammalian target of rapamycin (mTOR) / 70 kDa ribosomal protein S6 kinase (p70S6K) proteins signaling, and enhances synaptic plasticity [50]. Relevant evidence suggests that the effect of acupuncture in ICH may be related to the modification of microglia polarization via the miR-34a-5p/Krüppel-like factor 4 (Klf4) signaling pathway [51].

On complications and functional recovery, it has been shown that EA is protective against post-stroke depression (PSD). EA reversed depression-like behavior in PSD rats and was better than fluoxetine. The mechanism of action [52] may be related to the activation of the expression of brain-derived neurotrophic factor (BDNF) and its receptor tyrosine kinase receptor B (TrkB) gene. The improvement of depression by EA may be achieved by activating the tissue plasminogen activator (tPA)/BDNF/TrkB pathway [53]. EA attenuates cognitive impairment in stroke rats by regulating endogenous melatonin secretion through synthesizing the aralkylamine N-acetyltransferase gene in the pineal gland. Meanwhile, EA exerts neuroprotective effects and ameliorates cognitive impairment by regulating mitochondrial autophagy-related proteins through melatonin and inhibiting reactive oxygen species induced NLRP3 inflammasome activation [54]. In improving motor function, acupuncture of the MCAO rat model can improve spastic muscle structure partly by enhancing γ -aminobutyric acid and other signaling pathways in the brainstem of spasticity after stroke rats [55]. It was shown that [56] EA at Quchi (LI 11) and Tsusanli (ST 36) enhances motor functional connectivity in brain regions, such as the motor cortex in rats. EA showed high therapeutic microtubule-associated protein 2 expression and motor function recovery after combined rehabilitation training [57]. In the early post-stroke period, EA stimulation can increase the high expression of irisin in the blood and peri-lesion cortex, promote motor function recovery and reduce neuronal death after ischemic stroke in post-ischemic rats [58]. In improving learning and memory, it was shown [59] that nerve growth factor (NGF) entry into the brain promotes learning and memory and inhibits apoptosis of hippocampal neurons in rats. EA enhances the permeability of the blood-brain barrier in the prefrontal cortex and

induces NGF uptake by prefrontal neurons, and stimulates NGF into the brain for its therapeutic effects. EA increases intracellular calcium concentration regulated by N-methyl-D-aspartic acid (NMDA) receptor activation. Thus, the hippocampus's 5-HT_{1A} receptor-mediated PKA kinase and NMDA receptors may contribute to improved learning and memory during recovery from EA interventions after ischemic stroke [60]. EA may enhance learning and memory in MCAO-induced cognitive deficit rats by increasing functional connectivity between the retrosplenial cortex and the hippocampus, cingulate gyrus, and midbrain [61].

Future research trends are focused on the following three points.

They are:

1. Producing high-quality clinical evidence.
2. Integrating neurological disciplines and exploring new models of multidisciplinary overlapping.
3. Exploring the development of PSR acupuncture robots.

The quality of RCT reporting in clinical acupuncture studies still needs to be standardized more. Although the statement of CONSORT 2010 [62] has been published for more than a decade, with the STRICTA 2010 checklist [63] as a specification for reporting acupuncture interventions, it has not yet been widely used in clinical RCT of acupuncture. In the future, clinical studies of acupuncture for stroke will also need to report basic entries according to the study specifications. Since 2015, Chinese scholars have published strong evidence for acupuncture in high-impact journals such as *Annals of Internal Medicine* [64], *JAMA* [65], *JAMA Internal Medicine* [66], and *BMJ* [67]. Still, high-level evidence for acupuncture for stroke remains to be further studied. In 2020, the NIHR published design methods for optimizing surgically invasive interventions to guide invasive placebo control interventions [68]. These include “Deconstruct (treatment intervention); Identify (critical intervention elements); Take out (critical elements); Think (feasibility and risk of placebo); Optimize (ensure effective blinding)”, a methodological framework (DITTO) to standardize invasive placebo. Studying and learning from the DITTO standardized methodological framework will help to conduct studies on the setting of simulated acupuncture controls and optimize the design of acupuncture placebo interventions for RCT. Evidence-based medicine emphasizes evidence-based scientific decision-making. Regarding evidence translation, some clinical guidelines [69–72] have now incorporated evidence-level recommendations for acupuncture for stroke, such as the Brazilian Practice

Guidelines for Stroke Rehabilitation [72], which suggest that acupuncture and EA are recommended to treat post-stroke spasticity. Despite the low level of evidence, there is a need to promote the generation of high-quality evidence so that the most recent evidence can be translated into clinical practice [73] to support clinical decision-making rapidly.

The intersection of acupuncture combined with neuroscience and computational science will be an important development in acupuncture for stroke. Several studies [74–76] have shown that integrating complex central nerves may be the key to acupuncture. Network neuroscience and traditional functional connectivity computing rely on a node-centric network model. Recently the concept of ‘edge-centric’ [77] has been proposed, focusing on analyzing the relationships between the edges constituted by brain regions. The combined use of several techniques, such as brain waves combined with functional magnetic resonance imaging or machine learning techniques for predicting the efficacy of acupuncture, can be carried out in the future. Chinese research teams have recently proposed the concept of computational acupuncture [78], with features such as histology, mathematical modeling, and high-performance computing. Through data mining and knowledge discovery, hypotheses are formed by extracting the hidden patterns behind a large amount of acupuncture data. After hypotheses are formed, mathematical models are built, and computer simulations are used to test the hypotheses and provide predicted results for further in vivo and in vitro experimental studies. This original concept organically links "Discovery Science" and "Hypothesis-Driven Science", which may be helpful for future research.

Acupuncture combined with deep learning and artificial intelligence rehabilitation robots is also the hotspot of future research [79]. The existing clinical research on acupuncture revolves around acupuncture methods such as EA and dry needling and focuses on the rehabilitation of stroke sequelae, mainly by manual manipulation and supplemented by tools. With the COVID-19 pandemic not yet fully over, combining material technology with engineering to explore the development of acupuncture robots of artificial intelligence. It may contribute to rehabilitating neurological and motor functions in patients with post-stroke sequelae. Currently, there are upper limb exoskeleton robots [80, 81], including the design and development of remote rehabilitation robots [82]. The acupuncture robots will be equipped with various sensors, such as mechanical and electrical sensors, to reduce the pain of needle injections. Furthermore, the design included a study protocol [83, 84] for acupoint positioning, mechanical stimulation, and detection of deqi, for which strategies have been developed.

Limitation

First, our study was based on a WoSCC search of papers on acupuncture for stroke. Although WoSCC is the most authoritative database, other critical databases are also widely accepted by researchers. Still, the core libraries we selected, especially SCI-E, represent the current status and trends. Second, the citation count of review and original research has the advantage of ensuring the accuracy and quality of the study and can extract high-quality research content. However, including articles in the quantitative analysis may raise concerns about validity due to potential bias. Despite this, our study provides a balanced and informative overview of the evidence base for acupuncture treatment for stroke. In the presentation of the figure, we emphasized the prominent and significantly changed nodes in the results. However, this does not imply that other nodes are unimportant. Furthermore, regarding Table 1, as only the top 20 targets were selected for analysis without considering the remaining research targets, the total percentage does not exceed 100%. Therefore, we must acknowledge this potential limitation to avoid any potential controversy. Last, it is worth noting that the first and corresponding authors in research collaborations are crucial, and simple counts of co-authorships may not fully reflect their contributions. However, we focused on analyzing author collaborations based on co-authorship networks to identify scientific collaboration patterns. Future studies may consider new methods, such as descriptive, diagnostic, predictive, and prescriptive analytics [85, 86].

Conclusion

This bibliometric analysis summarizes information on countries, institutions, authors, and journals and maps the knowledge network of acupuncture for stroke. Further directions can be considered: (1) focus on the latest evidence-based medical research methods and use the new techniques to guide clinical practice. (2) Strengthen cooperation between researchers, and institutions in acupuncture for stroke, especially between China and other countries, to integrate acupuncture in the brain and neurological disciplines. (3) Develop more acupuncture rehabilitation equipment and standardized acupuncture rehabilitation tools.

Abbreviations

PSR	Post-stroke rehabilitation
EA	Electroacupuncture
ASIR	Age-standardized incidence rate
WoSCC	Web of Science core collection
SCI-E	Science Citation Index Expanded
GZUCM	Guangzhou University of Chinese Medicine
BUICM	Beijing University of Chinese Medicine
TUTCM	Tianjin University of Traditional Chinese Medicine
FJTMC	Fujian University of Traditional Chinese Medicine

CMU	China Medical University (Taiwan)
eCAM	Evidence-based complementary and alternative medicine
Neural Regen Res	Neural regeneration research
Arch Phys Med Rehabil	Archives of Physical Medicine and Rehabilitation
RCTs	Randomized controlled trials
RCT	Randomized controlled trial
NIHSS	National Institutes of Health Stroke Scale
fMRI	Functional magnetic resonance imaging
MCAO	Middle cerebral artery occlusion
PSD	Post-stroke depression
BDNF	Brain-derived neurotrophic factor

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s40001-023-01253-w>.

Additional file 1. The emergence of bibliometrics: a workflow of six steps.

Author contributions

XZ and HT contributed to the conception of this research idea. JZ and CJ conducted the bibliographic search, and JZ wrote the manuscript. CJ carried out software operation and figure drawing. SR contributed to the final version. All authors reviewed the final manuscript and helped perform the analysis with constructive discussions.

Funding

The work was supported by the Scientific and technological innovation project of the China Academy of Chinese Medical Sciences (CI2021A00307) and the Fundamental Research Funds for the Central Public Welfare Research Institutes (ZZ140518, YZ-2021042) and the innovation and entrepreneurship training program for college students of Jiangxi University of Traditional Chinese Medicine (202210412593, 202210412587, 202210412588).

Data availability

Data are available on request from the authors.

Declarations

Ethics approval and consent to participate

Not applicable.

Competing interests

All the authors declare that they have no conflict of interest.

Author details

¹Institute of Basic Theory for Chinese Medicine, China Academy of Chinese Medical Sciences, Beijing 100700, China. ²Science and Technology College of Jiangxi, University of Traditional Chinese Medicine, Nanchang 330004, China. ³Wangjing Hospital of China Academy of Chinese Medical Sciences, Beijing 100102, China. ⁴Affiliated Hospital of Shandong University of Traditional Chinese Medicine, Jinan 250011, China.

Received: 10 January 2023 Accepted: 29 July 2023

Published online: 21 September 2023

References

- Emsley HC, Hopkins SJ. Acute ischaemic stroke and infection: recent and emerging concepts. *The Lancet Neurology*. 2008;7(4):341–53.
- Dong Y, Cao W, Cheng X, Fang K, Zhang X, Gu Y, Leng B, Dong Q. Risk factors and stroke characteristic in patients with postoperative strokes. *J Stroke Cerebrovasc Dis*. 2017;26(7):1635–40.
- Ding Q, Liu S, Yao Y, Liu H, Cai T, Han L. Global, regional, and national burden of ischemic stroke, 1990–2019. *Neurology*. 2022;98(3):e279–90.
- Chin YY, Sakinah H, Aryati A, Hassan BM. Prevalence, risk factors and secondary prevention of stroke recurrence in eight countries from south, east and southeast asia: a scoping review. *Med J Malaysia*. 2018;73(2):90–9.
- Saini V, Guada L, Yavagal DR. Global epidemiology of stroke and access to acute ischemic stroke interventions. *Neurology*. 2021;97(20 Suppl 2):S6–s16.
- Ma Q, Li R, Wang L, Yin P, Wang Y, Yan C, Ren Y, Qian Z, Vaughn MG, McMillin SE, et al. Temporal trend and attributable risk factors of stroke burden in China, 1990–2019: an analysis for the Global Burden of Disease Study 2019. *The Lancet Public health*. 2021;6(12):e897–906.
- Wu S, Wu B, Liu M, Chen Z, Wang W, Anderson CS, Sandercock P, Wang Y, Huang Y, Cui L, et al. Stroke in China: advances and challenges in epidemiology, prevention, and management. *The Lancet Neurology*. 2019;18(4):394–405.
- Wang W, Jiang B, Sun H, Ru X, Sun D, Wang L, Wang L, Jiang Y, Li Y, Wang Y, et al. Prevalence, incidence, and mortality of stroke in China: results from a nationwide population-based survey of 480 687 adults. *Circulation*. 2017;135(8):759–71.
- Wijeratne T, Sales C, Wijeratne C. A narrative review on the non-pharmacologic interventions in post-stroke depression. *Psychol Res Behav Manag*. 2022;15:1689–706.
- Li L, Yang L, Luo B, Deng L, Zhong Y, Gan D, Wu X, Feng P, Zhu F. Acupuncture for post-stroke cognitive impairment: an overview of systematic reviews. *Int J Gen Med*. 2022;15:7249–64.
- Kong JC, Lee MS, Shin BC, Song YS, Ernst E. Acupuncture for functional recovery after stroke: a systematic review of sham-controlled randomized clinical trials. *CMAJ*. 2010;182(16):1723–9.
- Wang Q, Wang F, Li X, Yang Q, Li X, Xu N, Huang Y, Zhang Q, Gou X, Chen S, et al. Electroacupuncture pretreatment attenuates cerebral ischemic injury through $\alpha 7$ nicotinic acetylcholine receptor-mediated inhibition of high-mobility group box 1 release in rats. *J Neuroinflammation*. 2012;9:24.
- Jung YS, Lee SW, Park JH, Seo HB, Choi BT, Shin HK. Electroacupuncture preconditioning reduces ROS generation with NOX4 down-regulation and ameliorates blood-brain barrier disruption after ischemic stroke. *J Biomed Sci*. 2016;23:32.
- Wang Q, Li X, Chen Y, Wang F, Yang Q, Chen S, Min Y, Li X, Xiong L. Activation of epsilon protein kinase C-mediated anti-apoptosis is involved in rapid tolerance induced by electroacupuncture pretreatment through cannabinoid receptor type 1. *Stroke*. 2011;42(2):389–96.
- Cao BQ, Tan F, Zhan J, Lai PH. Mechanism underlying treatment of ischemic stroke using acupuncture: transmission and regulation. *Neural Regen Res*. 2021;16(5):944–54.
- Zhan J, Qin W, Zhang Y, Jiang J, Ma H, Li Q, Luo Y. Upregulation of neuronal zinc finger protein A20 expression is required for electroacupuncture to attenuate the cerebral inflammatory injury mediated by the nuclear factor- κ B signaling pathway in cerebral ischemia/reperfusion rats. *J Neuroinflammation*. 2016;13(1):258.
- Su XT, Wang L, Ma SM, Cao Y, Yang NN, Lin LL, Fisher M, Yang JW, Liu CZ. Mechanisms of acupuncture in the regulation of oxidative stress in treating ischemic stroke. *Oxid Med Cell Longev*. 2020;2020:7875396.
- Zhang B, Shi H, Cao S, Xie L, Ren P, Wang J, Shi B. Revealing the magic of acupuncture based on biological mechanisms: a literature review. *Biosci Trends*. 2022;16(1):73–90.
- Hood WW, Wilson CS. The literature of bibliometrics, scientometrics, and informetrics. *Scientometrics*. 2001;52(2):291–314.
- Mongeon P, Paul-Hus A. The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics*. 2016;106(1):213–28.
- Kessler MM. Bibliographic coupling between scientific papers. *Am Doc*. 1963. <https://doi.org/10.1002/asi.5090140103>.
- Gmur M. Co-citation analysis and the search for invisible colleges: a methodological evaluation. *Scientometrics*. 2003;57(1):27–57.
- Xu H, Wang Y, Luo Y. OTULIN is a new target of EA treatment in the alleviation of brain injury and glial cell activation via suppression of the NF- κ B signalling pathway in acute ischaemic stroke rats. *Mol Med (Cambridge, Mass)*. 2021;27(1):37.
- Wang HL, Liu FL, Li RQ, Wan MY, Li JY, Shi J, Wu ML, Chen JH, Sun WJ, Feng HX, et al. Electroacupuncture improves learning and memory functions in a rat cerebral ischemia/reperfusion injury model through PI3K/Akt signaling pathway activation. *Neural Regen Res*. 2021;16(6):1011–6.
- Wang L, Chi X, Lyu J, Xu Z, Fu G, Liu Y, Liu S, Qiu W, Liu H, Liang X, et al. An overview of the evidence to guide decision-making in acupuncture

- therapies for early recovery after acute ischemic stroke. *Front Neurol.* 2022;13:1005819.
26. Chavez LM, Huang SS, MacDonald I, Lin JG, Lee YC, Chen YH. Mechanisms of acupuncture therapy in ischemic stroke rehabilitation: a literature review of basic studies. *Int J Mol Sci.* 2017. <https://doi.org/10.3390/ijms18112270>.
 27. Lee SH, Lim SM. Acupuncture for insomnia after stroke: a systematic review and meta-analysis. *BMC Complement Altern Med.* 2016;16:228.
 28. Zhang J, Lu C, Wu X, Nie D, Yu H. Neuroplasticity of acupuncture for stroke: an evidence-based review of MRI. *Neural Plast.* 2021;2021:2662585.
 29. Johansson BB, Haker E, von Arbin M, Britton M, Långström G, Terént A, Ursing D, Asplund K. Acupuncture and transcutaneous nerve stimulation in stroke rehabilitation: a randomized, controlled trial. *Stroke.* 2001;32(3):707–13.
 30. Ratmanský M, Levy A, Messinger A, Birg A, Front L, Treger I. The effects of acupuncture on cerebral blood flow in post-stroke patients: a randomized controlled trial. *J Altern Complement Med.* 2016;22(1):33–7.
 31. Lu L, Zhang Y, Tang X, Ge S, Wen H, Zeng J, Wang L, Zeng Z, Rada G, Ávila C, et al. Evidence on acupuncture therapies is underused in clinical practice and health policy. *BMJ (Clinical research ed).* 2022;376:e067475.
 32. Li Q, Ma Q, Li D, Liu N, Yang J, Sun C, Cheng C, Jia X, Wang J, Zeng Y. Statistics and analysis on acupuncture and moxibustion projects of the National Natural Science Foundation of China of traditional Chinese medicine universities and colleges in recent 10 years: taking the General Program and National Science Fund for Young Scholars as examples. *Zhongguo Zhen Jiu.* 2018;38(3):325–30.
 33. Yang J. Acupuncture treatment for post-stroke insomnia: a systematic review and meta-analysis of randomized controlled trials. *Complement Ther Clin Pract.* 2021;44: 101396.
 34. Lu CY, Huang HC, Chang HH, Yang TH, Chang CJ, Chang SW, Chen PC. Acupuncture therapy and incidence of depression after stroke. *Stroke.* 2017;48(6):1682–4.
 35. Du XZ, Bao CL, Dong GR, Yang XM. Immediate effects of scalp acupuncture with twirling reinforcing manipulation on hemiplegia following acute ischemic stroke: a hidden association study. *Neural Regen Res.* 2016;11(5):758–64.
 36. Wu HM, Tang JL, Lin XP, Lau J, Leung PC, Woo J, Li YP. Acupuncture for stroke rehabilitation. *Cochrane Database Syst Rev.* 2006;3:CD004131.
 37. Yang A, Wu HM, Tang JL, Xu L, Yang M, Liu GJ. Acupuncture for stroke rehabilitation. *Cochrane Database Syst Rev.* 2016;2016(8):CD004131.
 38. Birch S, Robinson N. Acupuncture as a post-stroke treatment option: a narrative review of clinical guideline recommendations. *Phytomedicine.* 2022;104: 154297.
 39. Zhang SH, Wang YL, Zhang CX, Zhang CP, Xiao P, Li QF, Liang WR, Pan XH, Zhou MC. Effect of interactive dynamic scalp acupuncture on post-stroke cognitive function, depression, and anxiety: a multicenter, randomized, controlled trial. *Chin J Integr Med.* 2022;28(2):106–15.
 40. Zhang SH, Wang YL, Zhang CX, Zhang CP, Xiao P, Li QF, Liang WR, Pan XH, Zhou MC. Effects of interactive dynamic scalp acupuncture on motor function and gait of lower limbs after stroke: a multicenter, randomized, controlled clinical trial. *Chin J Integr Med.* 2022;28(6):483–91.
 41. Wang J, Pei J, Cui X, Sun K, Ni H, Zhou C, Wu J, Huang M, Ji L. Interactive dynamic scalp acupuncture combined with occupational therapy for upper limb motor impairment in stroke: a randomized controlled trial. *Zhongguo Zhen Jiu.* 2015;35(10):983–9.
 42. Li L, Zhu W, Lin G, Chen C, Tang D, Lin S, Weng X, Xie L, Lu L, Li W. Effects of acupuncture in ischemic stroke rehabilitation: a randomized controlled trial. *Front Neurol.* 2022;13: 897078.
 43. Li SS, Xing XX, Hua XY, Zhang YW, Wu JJ, Shan CL, Zheng MX, Wang H, Xu JG. Alteration of brain functional networks induced by electroacupuncture stimulation in rats with ischemia-reperfusion: an independent component analysis. *Front Neurosci.* 2022;16: 958804.
 44. Ning Y, Li K, Fu C, Ren Y, Zhang Y, Liu H, Cui F, Zou Y. Enhanced functional connectivity between the bilateral primary motor cortices after acupuncture at yanglingquan (GB34) in right-hemispheric subcortical stroke patients: a resting-state fMRI study. *Front Hum Neurosci.* 2017;11:178.
 45. Wang WW, Xie CL, Lu L, Zheng GQ. A systematic review and meta-analysis of Baihui (GV20)-based scalp acupuncture in experimental ischemic stroke. *Sci Rep.* 2014;4:3981.
 46. Zhang YM, Xu H, Chen SH, Sun H. Electroacupuncture regulates endoplasmic reticulum stress and ameliorates neuronal injury in rats with acute ischemic stroke. *eCAM.* 2021;2021:9912325.
 47. Long M, Wang ZG, Shao LY, Bi J, Chen ZB, Yin NN. Electroacupuncture pretreatment attenuates cerebral ischemia-reperfusion injury in rats through transient receptor potential vanilloid 1-mediated anti-apoptosis via inhibiting NF- κ B signaling pathway. *Neuroscience.* 2022;482:100–15.
 48. Wei LL, Zeng KX, Gai JJ, Zhou FX, Wei ZL, Bao QH. Effect of acupuncture on neurovascular units after cerebral infarction in rats through PI3K/AKT signaling pathway. *Clin Hemorheol Microcirc.* 2020;75(4):387–97.
 49. Tang H, Guo Y, Zhao Y, Wang S, Wang J, Li W, Qin S, Gong Y, Fan W, Chen Z, et al. Effects and mechanisms of acupuncture combined with mesenchymal stem cell transplantation on neural recovery after spinal cord injury: progress and prospects. *Neural Plast.* 2020;2020:8890655.
 50. Yang GQ, Zhu JY, Zhan GW, Fan GB, Deng L, Tang HJ, Jiang XQ, Chen B, Yang CX. Mesenchymal stem cell-derived neuron-like cell transplantation combined with electroacupuncture improves synaptic plasticity in rats with intracerebral hemorrhage via mTOR/p70S6K signaling. *Stem Cells Int.* 2022. <https://doi.org/10.1155/2022/6450527>.
 51. Li D, Zhao YH, Bai P, Li Y, Wan SQ, Zhu X, Liu MY. Baihui (DU20)-penetrating-Qubin (GB7) acupuncture regulates microglia polarization through miR-34a-5p/Klf4 signaling in intracerebral hemorrhage rats. *Exp Anim.* 2021;70(4):469–78.
 52. Kang Z, Ye HM, Chen T, Zhang P. Effect of electroacupuncture at siguan acupoints on expression of BDNF and TrkB proteins in the hippocampus of post-stroke depression rats. *J Mol Neurosci.* 2021;71(10):2165–71.
 53. Dong H, Qin YQ, Sun YC, Yao HJ, Cheng XK, Yu Y, Lu SS. Electroacupuncture ameliorates depressive-like behaviors in poststroke rats via activating the tPA/BDNF/TrkB pathway. *Neuropsychiatric Disease Treat.* 2021;17:1057–67.
 54. Zhong X, Chen B, Li Z, Lin R, Ruan S, Wang F, Liang H, Tao J. Electroacupuncture ameliorates cognitive impairment through the inhibition of NLRP3 inflammasome activation by regulating melatonin-mediated mitophagy in stroke rats. *Neurochem Res.* 2022;47(7):1917–30.
 55. Sun TY, Ma LX, Mu JD, Zhang Z, Yu WY, Qian X, Tian Y, Zhang YD, Wang JX. Acupuncture improves the structure of spastic muscle and decreases spasticity by enhancing GABA, KCC2, and GABA $\text{A}\alpha 2$ in the brainstem in rats after ischemic stroke. *NeuroReport.* 2022;33(9):399–407.
 56. Li Z, Yang M, Lin Y, Liang S, Liu W, Chen B, Huang S, Li J, Tao J, Chen L. Electroacupuncture promotes motor function and functional connectivity in rats with ischemic stroke: an animal resting-state functional magnetic resonance imaging study. *Acupunct Med.* 2021;39(2):146–55.
 57. Yu Q, Li X, Li Y, Fu J, Xiao Z. Effects of combined electroacupuncture and exercise training on motor function and microtubule-associated protein 2 expression in the middle and late stages of cerebral infarction in rats. *Acupunct Med.* 2020;38(3):175–80.
 58. Liu L, Zhang Q, Li M, Wang N, Li C, Song D, Shen X, Luo L, Fan Y, Xie H, et al. Early post-stroke electroacupuncture promotes motor function recovery in post-ischemic rats by increasing the blood and brain iris. *Neuropsychiatr Dis Treat.* 2021;17:695–702.
 59. Zhao Y, Mao X, Wang H, Gan L, Zhang S, Gong P, Lin X. The influence of electronic acupuncture at a specific frequency in facilitating the passage of NGF through the blood-brain barrier and its effect on learning and memory in MCAO/R rats. *J Integr Neurosci.* 2022;21(3):79.
 60. Wang Z, Lin B, Liu W, Peng H, Song C, Huang J, Li Z, Chen L, Tao J. Electroacupuncture ameliorates learning and memory deficits via hippocampal 5-HT 1A receptors and the PKA signaling pathway in rats with ischemic stroke. *Metab Brain Dis.* 2020;35(3):549–58.
 61. Zhang Q, Li J, Huang S, Yang M, Liang S, Liu W, Chen L, Tao J. Functional connectivity of the retrosplenial cortex in rats with ischemic stroke is improved by electroacupuncture. *Acupunct Med.* 2021;39(3):200–7.
 62. Moher D, Hopewell S, Schulz KF, Montori V, Gøtzsche PC, Devereaux PJ, Elbourne D, Egger M, Altman DG. CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials. *BMJ (Clin Res Ed).* 2010;340: c869.
 63. MacPherson H, Altman DG, Hammerschlag R, Youping L, Taixiang W, White A, Moher D. Revised standards for reporting interventions in clinical trials of acupuncture (STRICTA): extending the CONSORT statement. *PLoS Med.* 2010;7(6): e1000261.

64. Yang JW, Wang LQ, Zou X, Yan SY, Wang Y, Zhao JJ, Tu JF, Wang J, Shi GX, Hu H, et al. Effect of acupuncture for postprandial distress syndrome: a randomized clinical trial. *Ann Intern Med.* 2020;172(12):777–85.
65. Liu Z, Liu Y, Xu H, He L, Chen Y, Fu L, Li N, Lu Y, Su T, Sun J, et al. Effect of electroacupuncture on urinary leakage among women with stress urinary incontinence: a randomized clinical trial. *JAMA.* 2017;317(24):2493–501.
66. Zhao L, Chen J, Li Y, Sun X, Chang X, Zheng H, Gong B, Huang Y, Yang M, Wu X, et al. The long-term effect of acupuncture for migraine prophylaxis: a randomized clinical trial. *JAMA Intern Med.* 2017;177(4):508–15.
67. Xu S, Yu L, Luo X, Wang M, Chen G, Zhang Q, Liu W, Zhou Z, Song J, Jing H, et al. Manual acupuncture versus sham acupuncture and usual care for prophylaxis of episodic migraine without aura: multicentre, randomised clinical trial. *BMJ (Clin Res Ed).* 2020;368: m697.
68. Cousins S, Blencowe NS, Tsang C, Chalmers K, Mardanpour A, Carr AJ, Campbell MK, Cook JA, Beard DJ, Blazeby JM. Optimizing the design of invasive placebo interventions in randomized controlled trials. *Br J Surg.* 2020;107(9):1114–22.
69. Zhong LLD, Kun W, Shi N, Ziea TC, Ng BFL, Gao Y, Bian Z, Lu A. Evidence-based Chinese medicine clinical practice guideline for stroke in Hong Kong. *Chinese medicine.* 2020;15(1):116.
70. Ni X, Lin H, Li H, Liao W, Luo X, Wu D, Chen Y, Cai Y. Evidence-based practice guideline on integrative medicine for stroke 2019. *J Evid Based Med.* 2020;13(2):137–52.
71. Zhang T, Zhao J, Li X, Bai Y, Wang B, Qu Y, Li B, Zhao S. Chinese Stroke Association guidelines for clinical management of cerebrovascular disorders: executive summary and 2019 update of clinical management of stroke rehabilitation. *Stroke Vasc Neurol.* 2020;5(3):250–9.
72. Minelli C, Luvizutto GJ, Cacho RO, Neves LO, Magalhães S, Pedatella MTA, Mendonça LIZ, Ortiz KZ, Lange MC, Ribeiro PW, et al. Brazilian practice guidelines for stroke rehabilitation: Part II. *Arq Neuropsiquiatr.* 2022;80(7):741–58.
73. Zhang YQ, Jing X, Guyatt G. Improving acupuncture research: progress, guidance, and future directions. *BMJ (Clin Res Ed).* 2022;376: o487.
74. Li K, Wang J, Li S, Deng B, Yu H. Latent characteristics and neural manifold of brain functional network under acupuncture. *IEEE Trans Neural Syst Rehabil Eng.* 2022;30:758–69.
75. Chae Y, Chang DS, Lee SH, Jung WM, Lee IS, Jackson S, Kong J, Lee H, Park HJ, Lee H, et al. Inserting needles into the body: a meta-analysis of brain activity associated with acupuncture needle stimulation. *J Pain.* 2013;14(3):215–22.
76. Hui KK, Marina O, Liu J, Rosen BR, Kwong KK. Acupuncture, the limbic system, and the anticorrelated networks of the brain. *Auton Neurosci.* 2010;157(1–2):81–90.
77. Jo Y, Zamani Esfahlani F, Faskowitz J, Chumin EJ, Sporns O, Betzel RF. The diversity and multiplexity of edge communities within and between brain systems. *Cell Rep.* 2021;37(7): 110032.
78. Guo Y, Wang J, Chen B, Deng B, Liu Y, Guo Y, Zhao X, Li N. Computational acupuncture. *China J Tradit Chin Med Pharm.* 2020;35(11):5394–8.
79. Wang Y, Shi X, Efferth T, Shang D. Artificial intelligence-directed acupuncture: a review. *Chinese medicine.* 2022;17(1):80.
80. Graser JV, Prospero L, Liesch M, Keller U, van Hedel HJA. Test-retest reliability of upper limb robotic exoskeleton assessments in children and youths with brain lesions. *Sci Rep.* 2022;12(1):16685.
81. Hsu HY, Yang KC, Yeh CH, Lin YC, Lin KR, Su FC, Kuo LC. A Tenodesis-Induced-Grip exoskeleton robot (TIGER) for assisting upper extremity functions in stroke patients: a randomized control study. *Disabil Rehabil.* 2021. <https://doi.org/10.1080/09638288.2021.1980915>.
82. Kuo LC, Yang KC, Lin YC, Lin YC, Yeh CH, Su FC, Hsu HY. Internet of things (IoT) enables robot-assisted therapy as a home program for training upper limb functions in chronic stroke: a randomized control crossover study. *Arch Phys Med Rehabil.* 2022. <https://doi.org/10.1016/j.apmr.2022.08.976>.
83. Xu T, Xia Y. Guidance for acupuncture robot with potentially utilizing medical robotic technologies. *eCAM.* 2021;2021:8883598.
84. Lan KC, Litscher G. Robot-controlled acupuncture—an innovative step towards modernization of the ancient traditional medical treatment method. *Medicines (Basel, Switzerland).* 2019;6(3):87.
85. Hung CC, Tu MY, Chien TW, Lin CY, Chow JC, Chou W. The model of descriptive, diagnostic, predictive, and prescriptive analytics on 100

- top-cited articles of nasopharyngeal carcinoma from 2013 to 2022: Bibliometric analysis. *Medicine.* 2023;102(6): e32824.
86. Juang SJ, Lin CY, Chien TW, Chou W, Lai FJ. Using temporal heatmaps to identify worthwhile articles on immune checkpoint blockade for melanoma (ICBM) in Mainland China, Hong Kong, and Taiwan since 2000: a bibliometric analysis. *Medicine.* 2023;102(5): e32797.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions

