

**BMJ** Group

# Stroke research in China

A spotlight on the  
CHANCE trials



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# Foreword

Stroke continues to be one of the leading causes of mortality and long-term disability worldwide, posing a profound challenge to individuals, health systems, and economies. The increasing burden, particularly in rapidly developing nations like China, highlights the need for innovative research, evidence-based clinical practice, and global collaboration. This report captures an important and timely evolution: how China, once primarily known for the scale of its public health challenges, has become a vital contributor to global stroke research and clinical innovation.

The progress documented here shows how China is emerging as a global leader in stroke research and innovation with an ever-growing influence of research on international health guidelines and policies. It also underscores the critical role of institutions such as Beijing Tiantan Hospital and Capital Medical University, and researchers like Professor Yongjun Wang, whose work exemplifies excellence, perseverance, and impact.

This report not only celebrates China's achievements in advancing stroke prevention and care but also serves as a call to action: to sustain investment in research, foster international partnerships, and prioritise the translation of scientific discoveries into real-world health improvements.

**Stroke is a global challenge, and China's experience offers valuable lessons for us all.**

# Summary

This report examines the global impact of stroke research originating from China, highlighting the country's transformation into a major contributor to international stroke prevention, treatment and management. It explores the scale of the stroke burden globally and within China, setting the context for why research innovation has been both necessary and urgent. It explores how Chinese stroke research, particularly through landmark studies like the CHANCE trials, has contributed to shaping evidence-based clinical practice, influenced international policy, and improved health outcomes globally.

## Key findings include:

- ◆ A dramatic rise in China's stroke research output, with increasing publication in high-impact international journals and a corresponding growth in citations within global clinical guidelines and policy documents.
- ◆ The central role of leading institutions such as Beijing Tiantan Hospital and Capital Medical University, and the contributions of top researchers, particularly Professor Yongjun Wang, whose work has shaped both national and international stroke care strategies.
- ◆ The landmark CHANCE series of clinical trials, which have advanced understanding of antiplatelet therapies and personalised medicine approaches to stroke prevention, with results directly influencing health policy across multiple countries.
- ◆ Evidence that Chinese stroke research is increasingly cited by major organisations such as the Association of Scientific Medical Societies (AWMF) in Germany, the American Academy of Neurology, National Institute for Health and Care Excellence (NICE), and the World Health Organization (WHO), reflecting its broad global reach and relevance.
- ◆ The report concludes that continued investment in research and international collaboration, are critical to sustaining and building on this progress. China's experience demonstrates how research excellence, when effectively translated into practice, can significantly improve population health outcomes both domestically and globally.

# Global prevalence of stroke

According to the World Health Organization (WHO), approximately 15 million people across the globe suffer a stroke each year. Of these individuals, 5 million tragically lose their lives, while another 5 million survive but are left with long-term, often permanent disabilities. These disabilities can range from difficulties with mobility and speech to cognitive impairments and emotional challenges, profoundly affecting not only the survivors themselves but also their families, caregivers, and wider communities<sup>i</sup>. The physical, emotional, and financial toll of stroke-related disabilities creates a lasting impact that reverberates through society and healthcare systems worldwide.

The Global Burden of Disease (GBD) 2021 study has firmly established stroke as one of the most pressing global health challenges. Stroke is now recognised as the second leading cause of death among non-communicable diseases (NCDs), following closely behind ischemic heart disease. The GBD's extensive epidemiological analysis has revealed a concerning trend: from 1990 to 2021<sup>ii</sup>, there has been a marked global increase in stroke incidence, mortality, and long-term disability rates.

This rising burden is closely linked to the growing prevalence of key risk factors such as hypertension, obesity, diabetes, sedentary lifestyles, and unhealthy diets<sup>iii</sup>. Considering these findings, the need for a coordinated, global response is more urgent than ever. To effectively reduce this burden, it is vital to establish accessible, affordable, and evidence-based strategies that encompass stroke surveillance, prevention, acute care, and rehabilitation. Preventive efforts should prioritize controlling high blood pressure, promoting healthy lifestyle changes, and addressing broader environmental and social determinants of health. The GBD stresses that immediate and sustained action across all nations is critical to reversing the upward trajectory of stroke incidence and its devastating consequences.

Aside from the impact on mortality and morbidity, stroke also imposes a substantial economic burden on individuals, healthcare systems, and societies at large. Currently, the estimated global cost of stroke, which includes direct expenses related to medical treatment, hospitalisation, rehabilitation, and indirect costs such as lost income and productivity, exceeds a US\$891 billion annually. If current trends continue, this figure is projected to rise to an overwhelming US\$2.31 trillion by 2050<sup>iv</sup>. This sharp increase would not only strain global healthcare resources but would also impede economic growth, especially in low- and middle-income countries that are often the least equipped to handle such financial pressures. Importantly, a significant portion of these costs could be prevented, as stroke is both highly preventable and treatable with timely and appropriate interventions<sup>v</sup>. Investing in prevention strategies, early diagnosis, efficient acute care, and comprehensive rehabilitation programs offers a clear pathway to reducing the devastating personal, societal, and financial impacts of stroke.

# Stroke prevalence China

The Global Burden of Disease (GBD) 2021 study highlights the significant stroke burden in China, reflecting both global trends and unique national challenges. In 2021, China reported approximately 26 million stroke cases, representing a 104.26% increase since 1990<sup>vi</sup>. Correspondingly, stroke-related mortality in China increased by 69.31% over the same period<sup>vii</sup>. Like many other countries, China faces a substantial economic burden from stroke, with increased healthcare expenditure and productivity losses due to stroke-related disabilities. The rising incidence and prevalence of stroke also place immense pressure on the healthcare infrastructure, requiring expanded acute care and rehabilitation services. The GBD 2021 findings underline the urgent need for comprehensive strategies in China, emphasising prevention (through effective risk factor management, in particular controlling hypertension, reducing smoking and addressing pollution<sup>viii</sup>), along with timely treatment, and rehabilitation. Additionally, the burden of stroke is exacerbated by a pronounced urban-rural divide, whereby access to high-quality stroke care, remains uneven, with rural areas facing significant challenges in early detection, emergency response, and rehabilitation services<sup>ix</sup>.

# Strength of stroke research in China

As outlined above, China is facing a rising prevalence of stroke. Whilst this is a serious and urgent public health challenge, it has also become a catalyst for research innovation and leadership on the global stage, presenting a valuable opportunity for clinical research. With one of the world's largest stroke patient populations, China offers an unparalleled setting for conducting high-quality, large-scale studies. This has enabled researchers to gather rich, diverse datasets, such as those from the China National Stroke Registry, which have contributed to more robust and generalisable findings.

This growing disease burden has also generated urgency among policymakers, healthcare leaders, and funders to invest in stroke prevention, treatment, and recovery strategies. As a result, China has rapidly expanded its stroke research output, with landmark studies like the CHANCE trial, led by Professor Yongjun Wang<sup>x</sup>, gaining international recognition and influencing global clinical guidelines for stroke management<sup>xi</sup>. Furthermore, the country's increasing visibility in global research networks has led to strengthened international collaborations and a growing role in shaping stroke care practices worldwide. To further strengthen research capacity, partnerships with global institutions, such as the Duke Global Health Institute, in collaboration with the Duke Clinical Research Institute, Beijing Tiantan Hospital, Capital Medical University, and China National Clinical Research Center for Neurological Diseases (NCRG-ND), play a vital role. These collaborations, which support Chinese physicians in stroke-focused clinical research, help promote knowledge exchange and accelerate advances in stroke treatment.

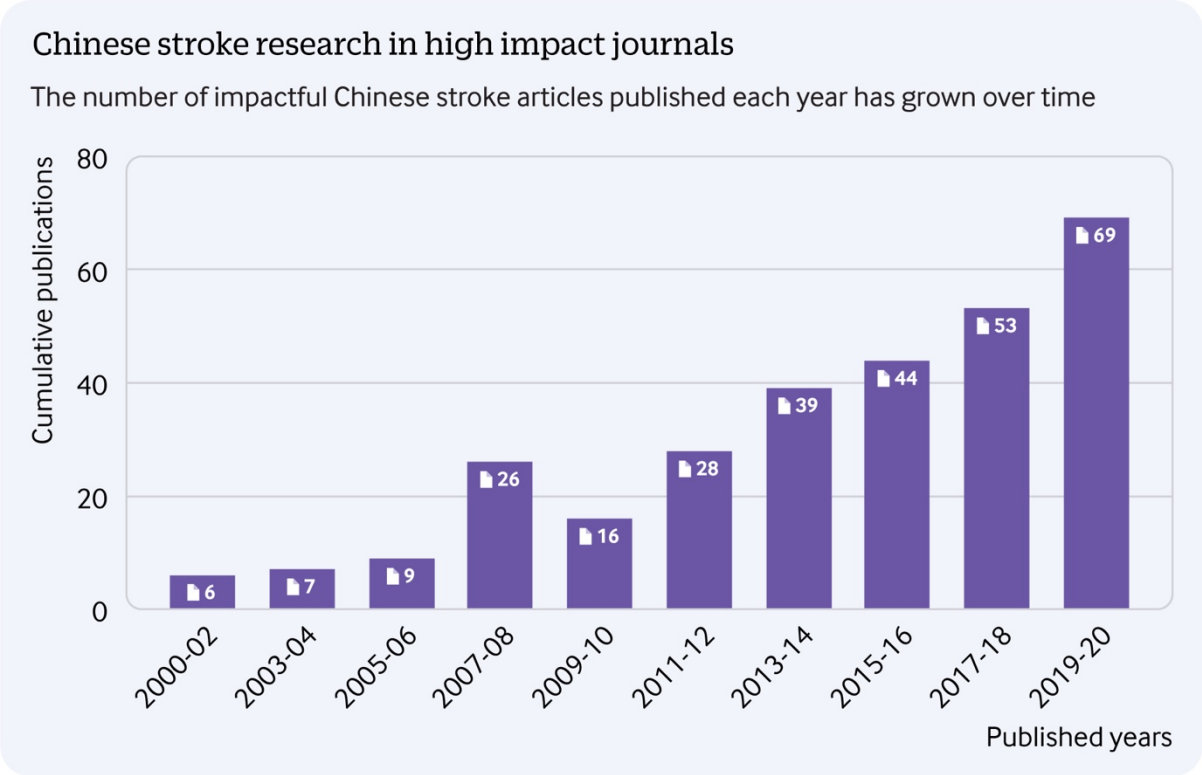
It is increasingly recognised not only within China but also globally that substantial investment is needed to ensure equitable access to stroke prevention and treatment. However, the importance of investing in stroke research itself cannot be overstated. Research plays a critical role in reducing mortality rates, improving quality of life for stroke survivors, and ultimately alleviating the heavy economic burden associated with long-term care and lost productivity. In China, in particular, homegrown research has been instrumental in shaping prevention and intervention strategies that are tailored to the country's unique risk profile. Studies originating from Chinese populations have provided valuable insights into prevalent risk factors such as hypertension, smoking, air pollution, unhealthy diets<sup>xii</sup>, and the impact of rapid urbanisation<sup>xiii</sup>. Such findings have enabled the development of targeted prevention programs, including early screening initiatives, public health campaigns promoting lifestyle modifications, and region-specific intervention strategies. By strengthening its commitment to research, China can not only address its domestic stroke burden more effectively but also contribute significantly to global knowledge and innovation in stroke care and prevention.

The growth in China's research output is clearly visible in the rising number of studies published in leading medical journals, including the *British Medical Journal (BMJ)*, the *New England Journal of Medicine (NEJM)*, *The Lancet*, and the *Journal of the American Medical Association (JAMA)*. This surge



not only highlights China's expanding influence in global health research but also reflects the country's deepening commitment to advancing medical science. Diagram 1 below captures this trend, showing a steady and continuous increase in published studies over the past 20 years, a testament to China's growth on the international research stage.

Diagram 1



In addition, research has led to significant improvements in acute stroke treatment, enhancing both survival rates and recovery outcomes. For example, a study led by the Department of Neurology at Beijing Tiantan Hospital examined specific genetic variants and clinical outcomes in patients treated with clopidogrel following a minor stroke or transient ischemic attack<sup>xiv</sup>. Another major initiative, the multicentre GOLDEN BRIDGE II trial, conducted across 80 hospitals in China, explored the use of artificial intelligence-based clinical decision support systems (AI-CDSSs) in the management of acute ischaemic stroke<sup>xv</sup>. Similarly, the PRINCE trial adopted a multicentre approach to evaluate the efficacy of combining ticagrelor and aspirin, assessing whether this strategy was superior to the combination of clopidogrel and aspirin<sup>xvi</sup>. Beyond these studies, China has played a key role in groundbreaking trials such as CHANCE, CHANCE-2, and CHANCE 3, which have shaped global stroke prevention and treatment guidelines. Through these contributions, China is increasingly positioning itself as a vital leader in the global effort to advance the prevention, diagnosis, and treatment of stroke.

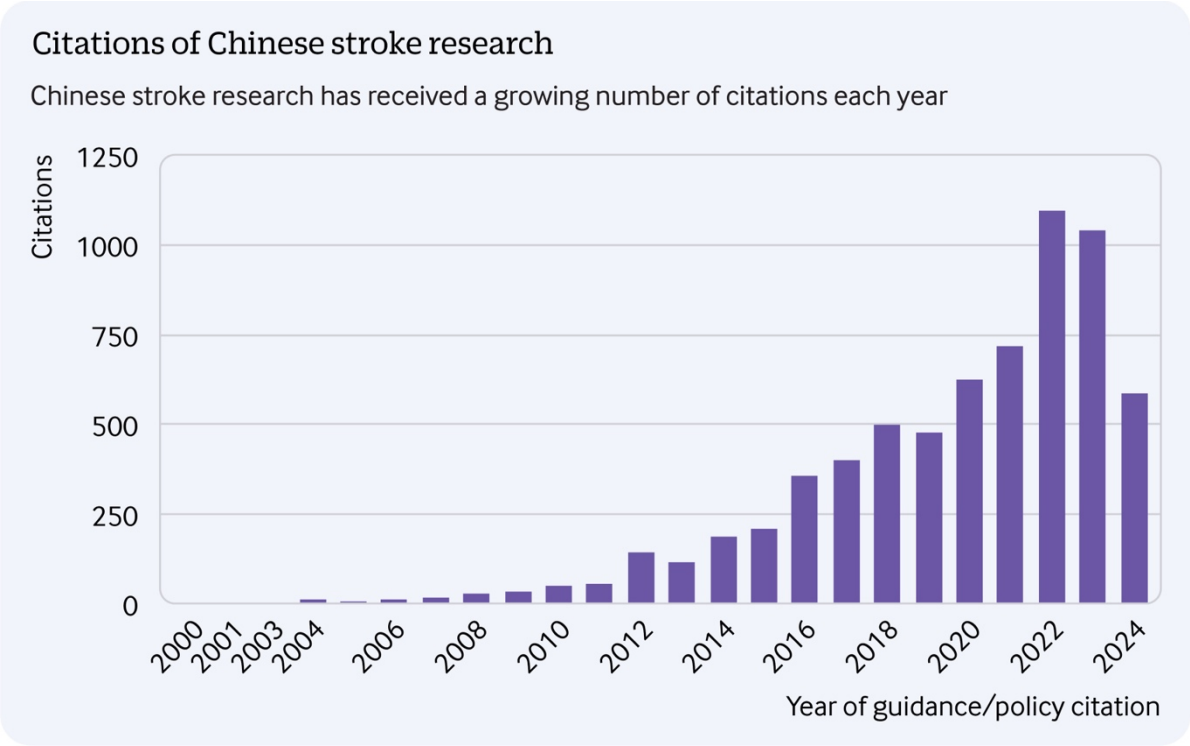
The increase in research output from China, and the way it is being used internationally, is evident in several ways. Firstly, since 1995, there have been at least 2,172 Chinese stroke papers published and



cited in international policy or guidance documents. The total number of citations of these papers in such documents from 2000 - 2024 is 6,644, as shown in Diagram 2. Importantly, the trajectory of this impact has continued to rise over time. It is also important to note that there is typically an average four-year lag between the publication of a study and its citation in policy documents, suggesting that citation numbers are likely to continue growing.

High-impact Chinese studies, such as the CHANCE trial<sup>xvii xviii xix</sup> are increasingly published in widely read journals like *The New England Journal of Medicine (NEJM)*, *JAMA*, and *The BMJ*, further boosting their visibility and influence. Moreover, the applicability of Chinese data to shared global healthcare challenges, including ageing populations, the rise of non-communicable diseases, and urban health risks, strengthens its impact on clinical guidelines and international policy documents. For example, the UK's National Institute for Health and Care Research (NIHR) recently included articles by Pan et al (2022)<sup>xx</sup> and Wang Yongjun et al (2021<sup>xxi</sup>) in a systematic review and economic model<sup>xxii</sup> evaluating the use of clopidogrel.

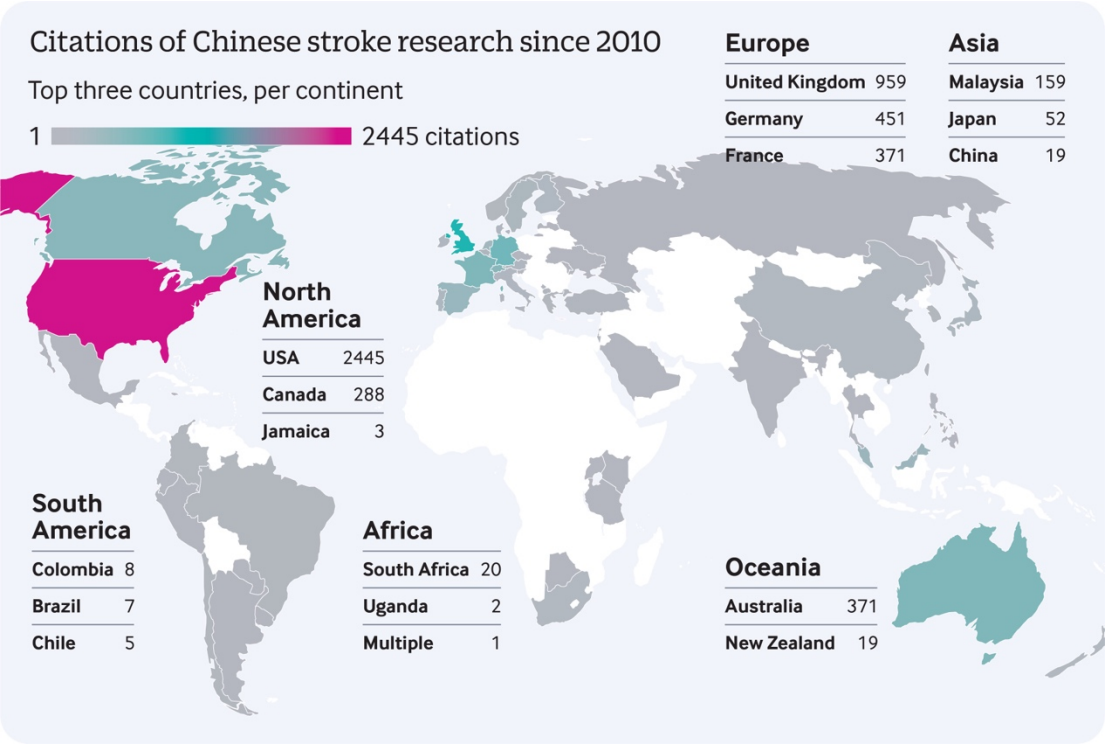
Diagram 2



A steady increase in the number of citations, in turn, increases global impact, particularly considering that papers from China on stroke have been cited across 62 countries. Since 2010, the highest frequency of citations of Chinese health research has been recorded in the United States (2,445), the United Kingdom (959), Germany (451), France (371), and Australia (371). This reflects these nations' strong engagement in global scientific discourse and their prioritisation of data-driven health policy.

These countries are leaders in medical research and frequently draw on large-scale Chinese datasets, in areas like stroke, chronic disease, and environmental health due to their global relevance. Diagram 3, illustrates this, providing a visual representation of the global distribution of citations by country.

Diagram 3

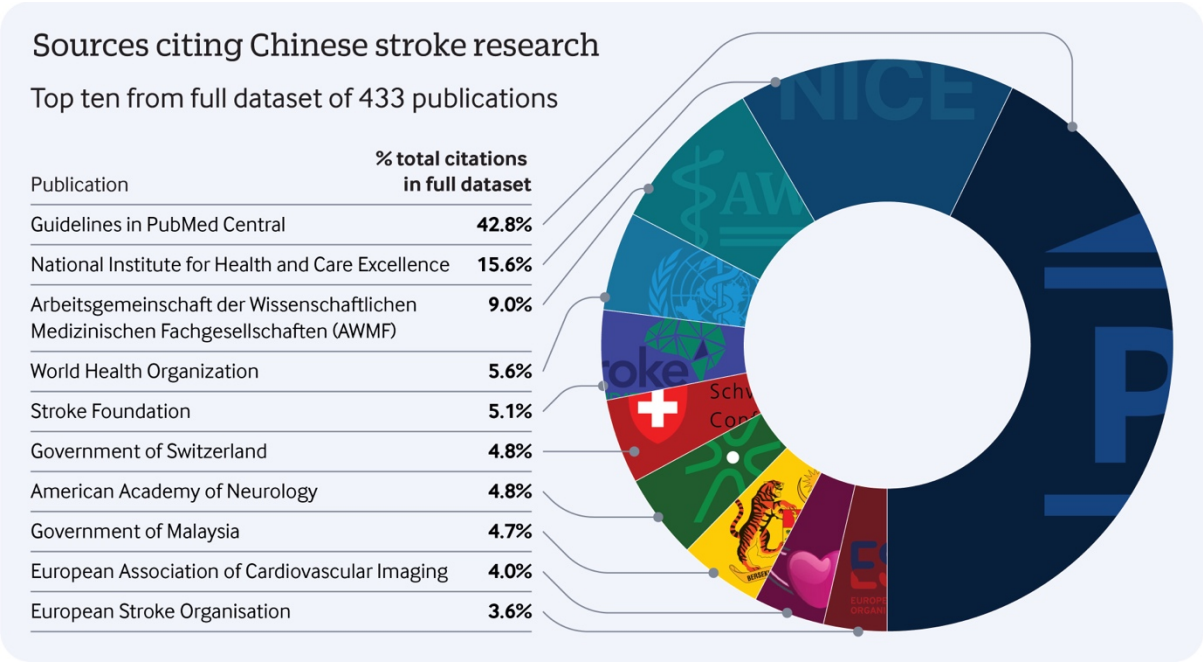


In parallel, the sources citing these research publications are notably diverse. One particularly important category is citations within healthcare guidelines, as illustrated in Diagram 4. A citation in a widely accessible clinical guideline significantly enhances the visibility and impact of research, transforming it from an academic insight into an actionable component of medical practice. When research is embedded in guidelines used by healthcare professionals worldwide, it directly informs clinical decision-making, supports the standardisation of care, and ultimately improves patient outcomes. Moreover, the inclusion of research in open-access guidelines ensures that low-resource settings can also benefit from evidence-based recommendations, helping to reduce global disparities in healthcare quality. Being cited in a guideline also increases a study’s visibility, sustainability, and influence, reinforcing its value in shaping policy, clinical training, and future research priorities.

As Diagram 4 shows, 15.6% of citations have been in guidelines produced by the UK organisation National Institute for Health and Care Excellence (NICE), a public body that develops comprehensive, evidence-based clinical guidelines informing the diagnosis, management, and treatment of a wide

range of conditions. For instance, a paper using data from the China National Stroke Registry<sup>xxiii</sup> is cited in a UK national clinical guideline on managing atrial fibrillation in adults<sup>xxiv</sup>.

Diagram 4



# Contributions/publications by leading authors

As research activity and the number of large-scale clinical trials in stroke have increased in China, it is unsurprising that there has been a corresponding rise in research outputs, both in terms of the volume of peer-reviewed publications and, as previously established, the frequency with which these are cited in national and international policy documents. This growth in publications reflects China's increasing leadership in the global stroke research landscape, particularly through contributions that influence evidence-based practice and guideline development.

While these contributions are the results of efforts by many, Table 1 highlights the top five most prolific authors in China, detailing the number of stroke-related publications and the number of times their specific work has been cited in health policy documents since 1995<sup>1</sup>. Their affiliations with leading Chinese academic and clinical institutions underscore the role of well-resourced, research-intensive universities in driving high-impact work. This data provides an important insight into the individuals and institutions that are shaping stroke care policy both within China and globally.

Table 1: Top authors from Chinese Institutions by Output

Author	Number of publications	Number of policy citations	University affiliation
Yongjun Wang	93	296	Capital Medical University
Yilong Wang	76	195	Capital Medical University
Liping Liu	66	202	Capital Medical University
Ka Sing Wong	55	200	Chinese University of Hong Kong
Yuesong Pan	44	138	Capital Medical University

Capital Medical University is affiliated with Beijing Tiantan Hospital, a leading centre for neuroscience making it a prominent institution for stroke research in China. Notably, it is home to four of the five most prolific authors in the field, highlighting its strong academic and clinical research capacity. Given this, it is unsurprising that as shown in Table 2, and Diagram 5, Capital Medical University ranks first among Chinese institutions for the number of stroke-related publications and the total citations

<sup>1</sup> Please note when looking at this data that publications can be attributed to multiple authors from different institutions.

those articles have received. This underscores not only the university's central role in advancing stroke research and influencing clinical practice, but also the significant role of Beijing Tiantan Hospital as its affiliated hospital.

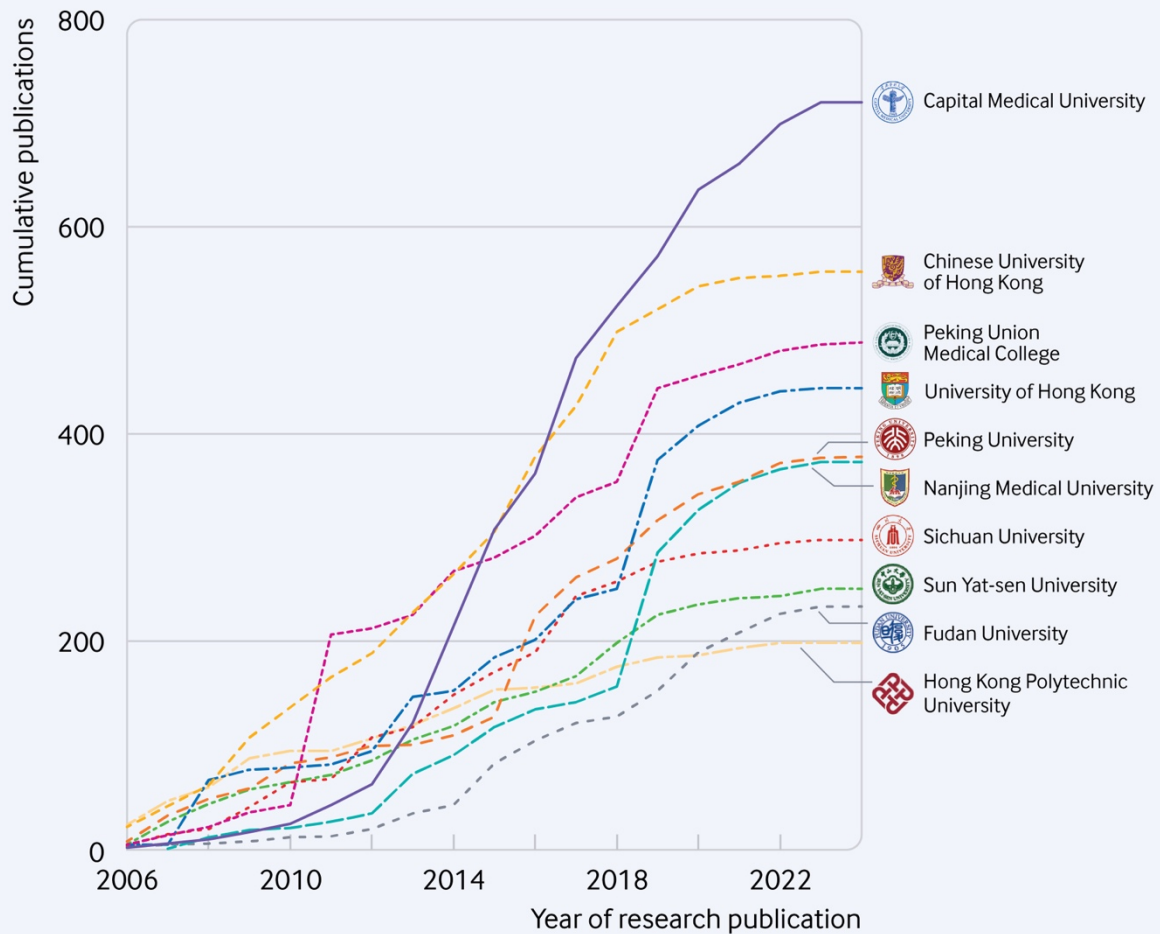
Table 2: Top 10 Chinese Institutions by stroke research publication and citation output.

Institution	Number of Publications	Number of Citations
Capital Medical University	246	719
Chinese University of Hong Kong	216	620
Peking Union Medical College	127	526
University of Hong Kong	113	324
Peking University	113	378
Nanjing Medical University	112	234
Sichuan University	92	268
Sun yat-sen University	91	383
Fudan University	85	448
Hong Kong Polytechnic University	80	222

Diagram 5

### Cumulative institutional output cited in guidance / policy by year

Publications may be attributed to multiple institutions





# Profile: Professor Yongjun Wang

Having understood the growth and impact of stroke research emerging from Chinese institutions, it is fitting to examine in greater depth, a leading figure behind such works of progress; Professor Yongjun Wang. Professor Yongjun Wang is an eminent neuroscientist and healthcare leader, currently serving as President of Beijing Tiantan Hospital, Capital Medical University. He holds multiple prestigious appointments, including Chief Scientist and Professor of Neurology at the hospital's Stroke Center. Nationally, he serves as Vice Director of the China National Clinical Research Center for Neurological Diseases and Director of the China National Center for Healthcare Quality Management in Neurological Diseases. His professional leadership extends further as Chairman of the Neurology Branch at the Chinese Medical Association and President of the Chinese Stroke Association. Professor Wang also contributes to academic communication as Editor-in-Chief of the peer-reviewed journal *Stroke and Vascular Neurology*.

Professor Wang is a pioneering neuroscientist in cerebrovascular disease and a highly accomplished researcher, having published over 400 papers in leading medical journals such as *The New England Journal of Medicine (NEJM)*, *JAMA*, and *Circulation*. The CHANCE series (*NEJM* 2013/2021, *The BMJ* 2024) has redefined global guidelines by establishing time-targeted dual antiplatelet therapy (DAPT) and genotype-guided precision protocols, resolving longstanding controversies in secondary stroke prevention. The TRACE trials (*The Lancet* 2022, *NEJM* 2024) extended thrombolysis time windows through perfusion imaging breakthroughs and demonstrated reteplase's superiority over alteplase, transforming acute stroke therapeutics. As architect of China's National Stroke Care Quality Monitoring System (*JAMA* 2018), he integrated big data/AI technologies across 3,000 hospitals, achieving unprecedented care standardisation.

Professor Wang has also received numerous national awards, including the National May Day Labor Medal, Wu Jieping Medical Innovation Award, and First National Innovation Awards Medal. His ongoing significant contributions to the investigation and management of stroke clinical research was most recently recognised in his winning of the William M. Feinberg Award for Excellence in Clinical Stroke at the 2025 International Stroke conference.

His work is widely recognised for its contributions to stroke classification, prevention, and control strategies, shaping both clinical practice and public health policies. His research spans key areas, including risk factor

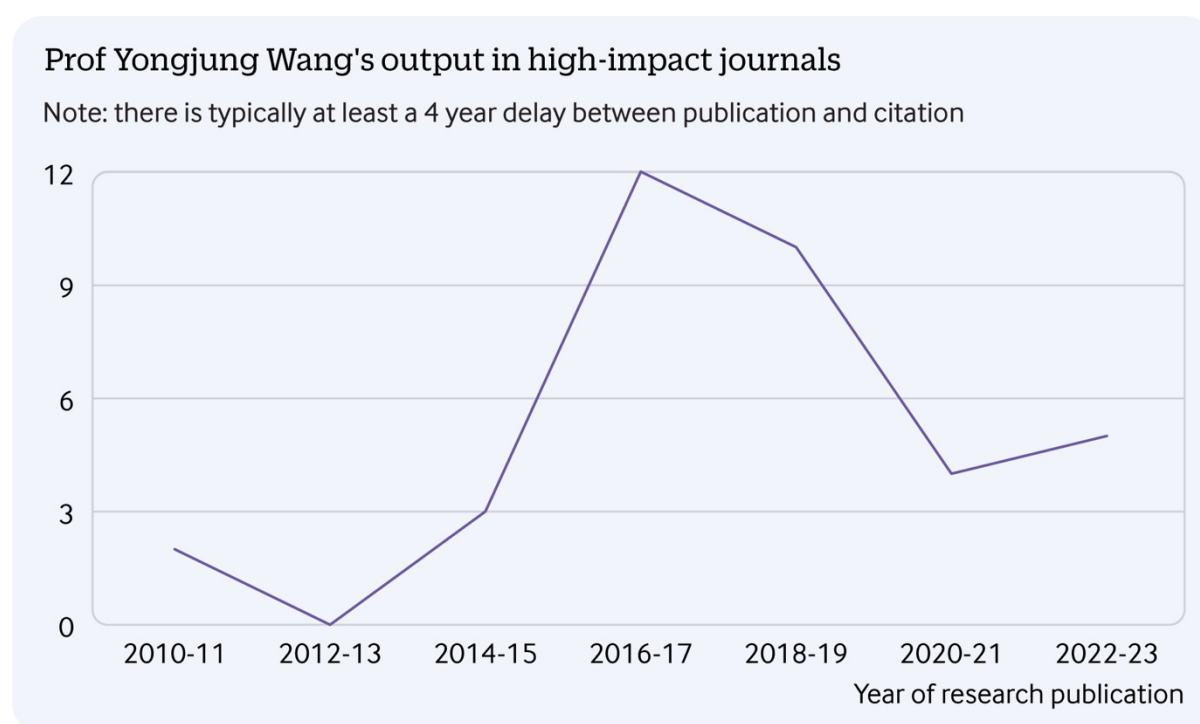




management, acute stroke interventions, rehabilitation strategies, and the integration of AI in stroke care. Through large-scale clinical trials, epidemiological studies, and translational research, he has played a pivotal role in advancing stroke treatment and prevention worldwide.

Diagram 6 provides a visual portrayal of Professor Wang's article output in high-impact journals over a 12-year period, highlighting a consistent record of high standard contributions to stroke research. It also tracks the transition from publication to implementation by showing the number of articles published by Professor Wang that have subsequently been cited in the development of guidelines and health policy documents. Between 2010 and 2023, there were a total 296 citations in these types of documents. This is an impactful number considering they are influencing policy and practice.

Diagram 6



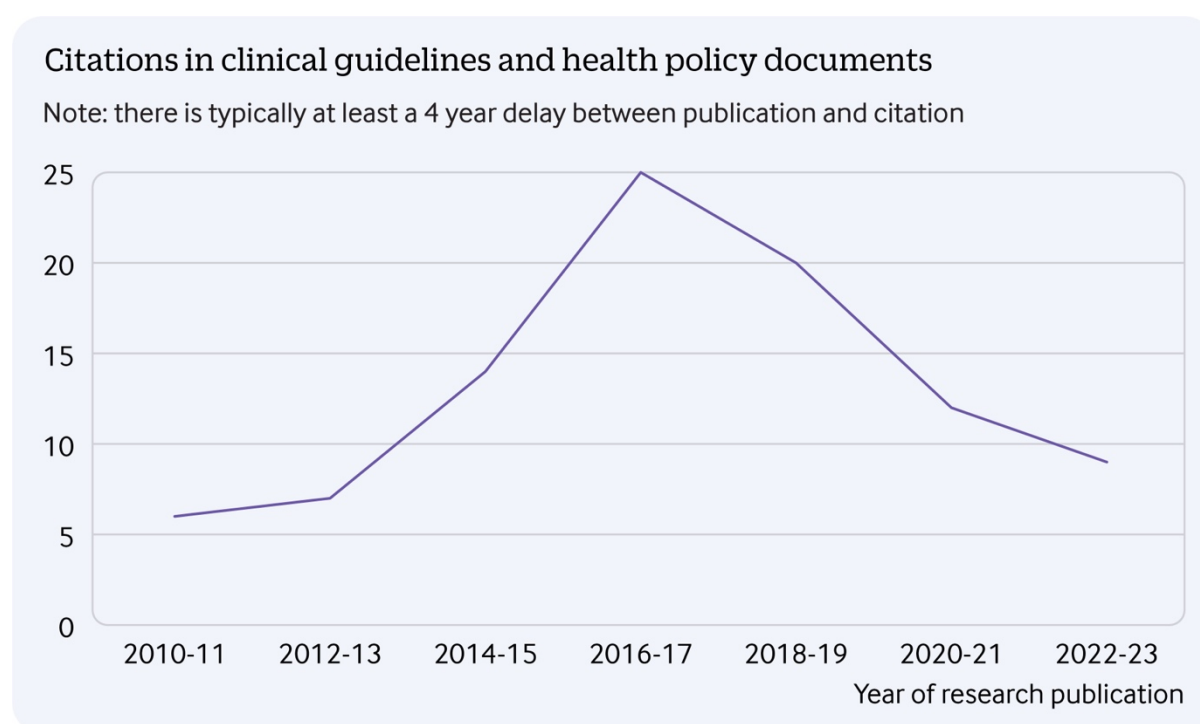
The diagram clearly illustrates Professor Wang's key involvement in the CHANCE studies (1,2 and 3) and other major stroke research studies such as TRACE-2. The first CHANCE study took place between 2009 and 2012, reflected in publications such as a 2013 article by Wang et al<sup>xxv</sup> in the New England Journal of Medicine, on combination therapy of clopidogrel with Aspirin after an acute minor stroke or transient ischemic attack. CHANCE 2 and 3 were conducted between 2021 and 2023 respectively, and with the undertaking of further stroke research the output trajectory of articles in high impact journals has begun to grow.

Notably, an article about CHANCE 2, led by Professor Wang was published in BMJ Stroke and Vascular Neurology in 2021<sup>xxvi</sup>. BMJ recently published an article on CHANCE 3<sup>xxvii</sup> in 2024.

Furthermore, 2023 saw the publication in the Lancet of an article about TRACE-2 (Wang et al 2023)<sup>xxviii</sup>, which examined tenecteplase versus alteplase in acute ischaemic cerebrovascular events.

A clear visualisation of how the work of Professor Wang has translated into significant real-world impact, particularly through the frequent citation of his articles in clinical guidelines, health policy documents, and evidence-based recommendations worldwide, is shown in Diagram 7. His influential research continues to shape contemporary stroke care protocols, inform health policies, guide clinical practice, and inspire innovative treatment strategies. This ongoing integration into practical healthcare settings solidifies his global reputation as a leading expert whose research directly enhances patient outcomes and advances stroke management internationally.

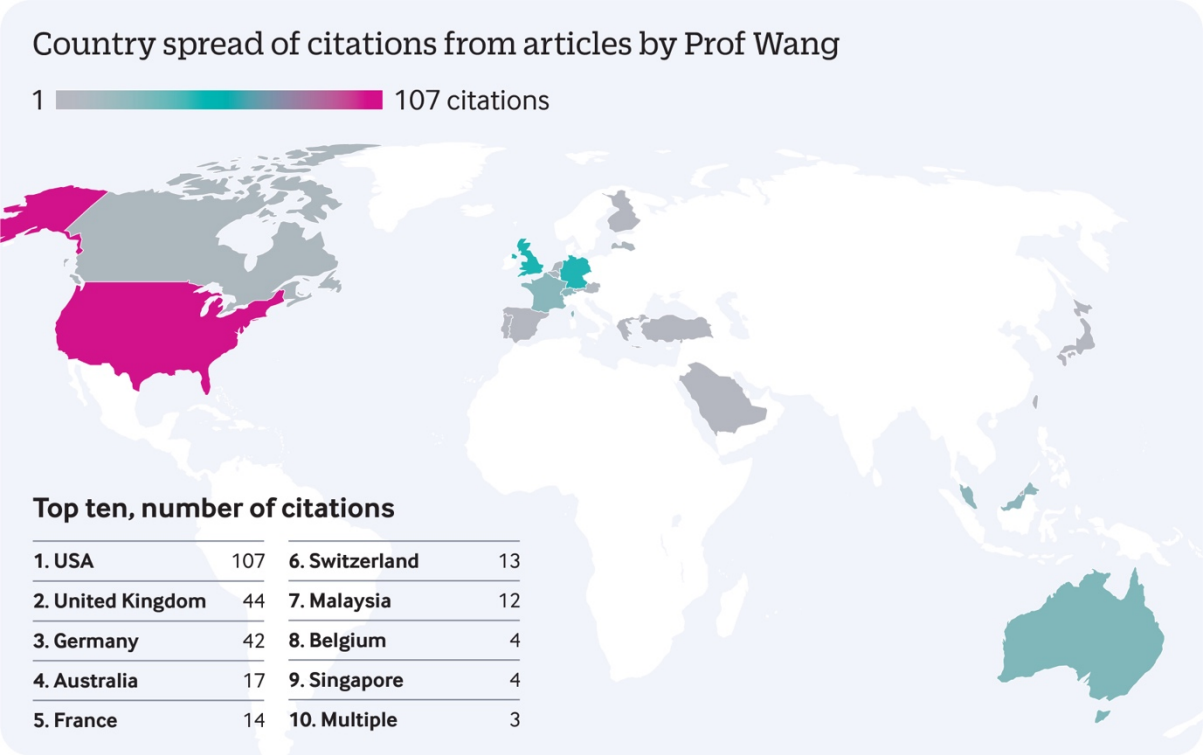
Diagram 7



Following citations recorded in PubMed General, the Association of Scientific Medical Societies (AWMF, Germany) has been highlighted as citing Professor Wang's work the most, contributing 30 out of 296 citations. Articles related to the CHANCE<sup>xxix</sup> study and the SOCRATES<sup>xxx</sup> trial are among those cited in documents published by AWMF. Similarly, two UK institutions responsible for funding national health and care research and developing national clinical guidelines, the National Institute for Health and Care Research (NIHR) and the National Institute for Health and Care Excellence (NICE), collectively account for 30 citations, frequently citing CHANCE and SOCRATES and other studies. The European reach of Professor Wang's research is extensive, considering the significant contributions of Germany and the UK influence, along with citations by the European Stroke Organisation, the Deutsche Gesellschaft Für Neurologie (German Neurological Association) and BMJ Best Practice.

Further expanding this global influence are organisations such as the WHO, the American Academy of Neurology and the Government of Malaysia. The widespread citation of his work across guidelines and policy documents worldwide ultimately contributes to improved health outcomes on a global scale. Diagram 8 illustrates this international spread.

Diagram 8



# CHANCE Seminal stroke studies China

Professor Wang's publications in high impact journals is an insight into the significance of his work, particularly in stroke prevention and treatment. Notably, Professor Wang has been the principal investigator for the CHANCE series of clinical trials, through which he has made significant contributions to refining antiplatelet strategies and advancing personalised medicine approaches in stroke prevention, not just in China but globally.

The CHANCE studies ran over a period of 14 years from 2009 - 2023. The original CHANCE Study (2013) was a randomised, double-blind, placebo controlled trial involving 5,170 patients across 114 centres in China. It evaluated the efficacy of combining clopidogrel with aspirin versus aspirin alone in reducing recurrent strokes among patients with minor ischemic strokes or high-risk transient ischemic attacks (TIAs<sup>xxxix</sup>). The study found that combination therapy significantly lowered the risk of subsequent strokes compared to aspirin alone. Over 20 publications discussing these results have been produced. These include a 2015<sup>xxxix</sup> paper in *Neurology* examining the use of dual antiplatelet therapy in stroke and intracranial atherosclerosis (ICAS); a paper reviewing the use of elevated sCD40L levels as predictors of recurrent stroke in patients with minor stroke and transient ischaemic attack<sup>xxxix</sup> and another investigating the role of high-sensitive C-reactive protein (hsCRP) as a predictor of recurrent stroke and poor functional outcomes (2016)<sup>xxxix</sup>.

CHANCE-2 (2021) aimed to assess the efficacy of ticagrelor combined with aspirin versus clopidogrel combined with aspirin in patients carrying CYP2C19 loss-of-function alleles, which can impair clopidogrel's effectiveness. The results indicated that ticagrelor combined with aspirin was more effective than clopidogrel combined with aspirin in preventing stroke recurrence in this genetic subgroup. Importantly this study provided evidence supporting genotype-guided antiplatelet therapy, particularly for populations with a high prevalence of CYP2C19 loss-of-function alleles.

Several pivotal publications associated with the CHANCE-2 trial have been published. For example, one article in *The New England Journal of Medicine* compared the efficacy of ticagrelor versus clopidogrel in patients carrying the CYP2C19 loss-of-function allele following minor stroke or TIA<sup>xxxv</sup>. Further contributions include an analysis published in 2023<sup>xxxvi</sup> in *Stroke*, exploring dual antiplatelet therapy efficacy in relation to the causes of minor stroke or TIA. Finally a post hoc analysis was published assessing the influence of renal function on treatment outcomes<sup>xxxvii</sup>.

The most recent study in the series, CHANCE-3 (2024) evaluated the efficacy and safety of low-dose colchicine versus placebo in reducing the risk of subsequent stroke in patients with acute non-cardioembolic minor-to-moderate ischemic stroke or TIA with elevated high-sensitivity C-reactive protein levels. The study found no evidence that low-dose colchicine reduced the risk of subsequent stroke within 90 days compared to placebo, suggesting that colchicine may not be effective in

preventing early recurrent strokes in this patient population. The article referred to above by Li et al (2024)<sup>xxxviii</sup> is the only article currently relating to CHANCE-3.

The research output from these studies, in terms of published papers, has been significant. However, an even greater impact has been demonstrated by the frequency with which these papers have been cited in policy and guideline documents. Diagram 9 highlights the diverse range of global sources citing CHANCE studies, led by the Association of Scientific Medical Societies (AWMF, Germany), an organisation responsible for coordinating Germany's national medical guidelines. This is closely followed by the American Academy of Neurology and the German Neurological Society. Each of these three organisations, along with others represented in the diagram, plays a pivotal role in developing policies and clinical guidelines related to stroke prevention, management, and treatment for healthcare professionals. Diagram 10 that follows provides a visual depiction of the global impact that these papers have had.

Diagram 9

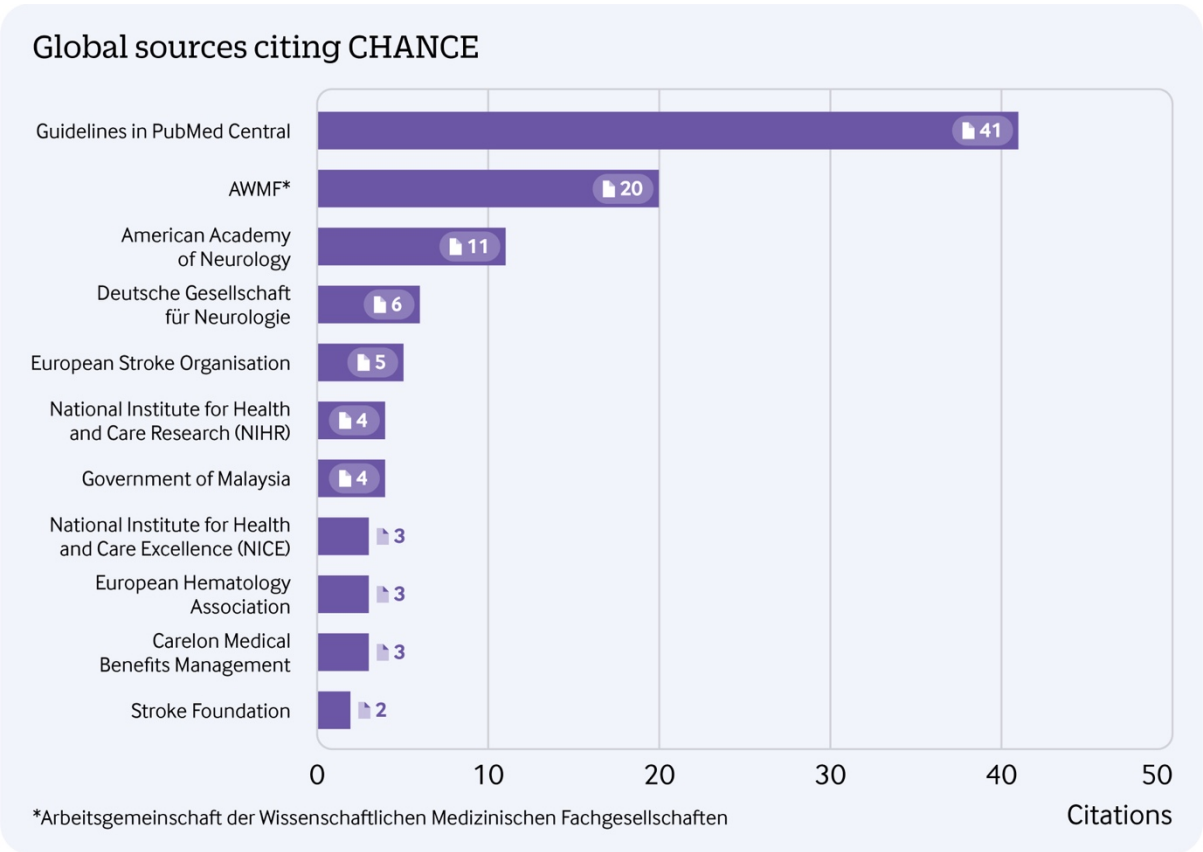
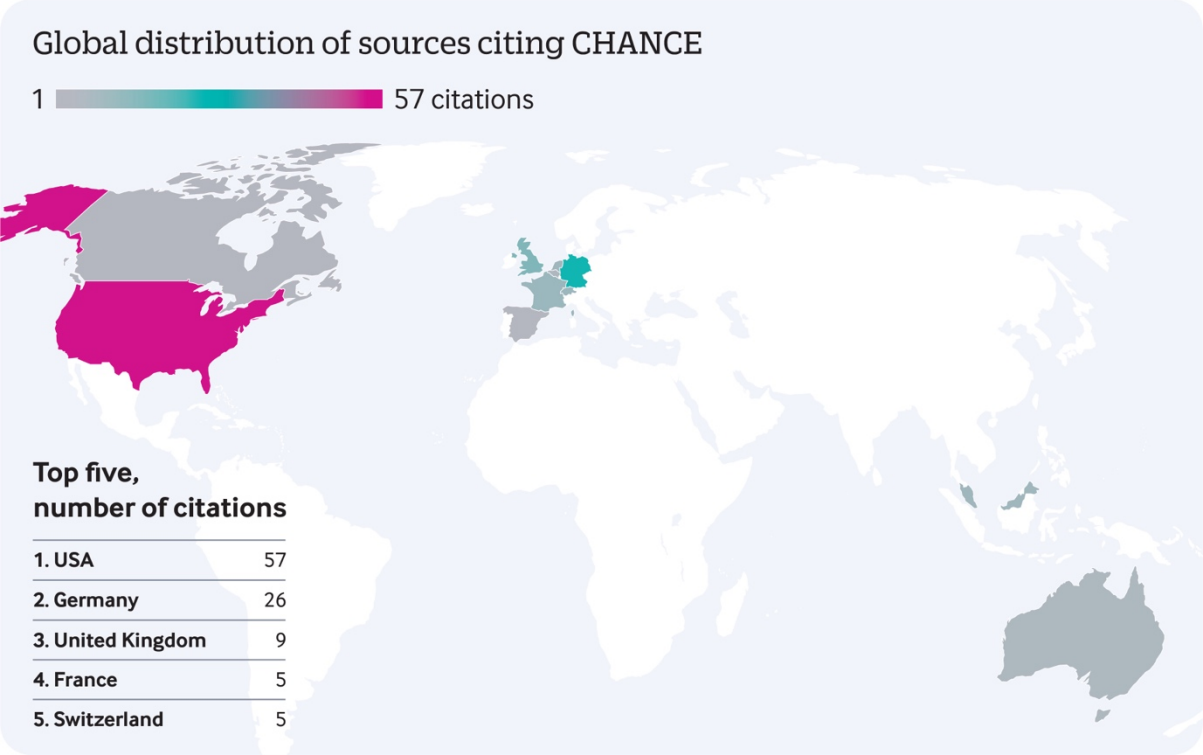


Diagram 10



# Conclusion

Stroke remains one of the most pressing global health challenges, with China bearing a significant share of the burden. However, as this report illustrates, China, through institutions like Beijing Tiantan Hospital and Capital Medical University and leaders such as Professor Yongjun Wang, has emerged as a global force in advancing stroke research, prevention, and treatment. The country's large and aging population, rising risk factors, and expanding clinical infrastructure have created both urgency and opportunity for innovation.

Over the past decade, Chinese stroke research has accelerated in both volume and impact, with increasing citations in high-impact journals, clinical guidelines, and policy documents. Landmark studies like the CHANCE series, led by Professor Wang, have shaped international treatment protocols and exemplify China's growing influence on global stroke care. Importantly, the real-world application of this research, its integration into national and international health policies, demonstrates the tangible benefits of China's contributions to clinical science.

With continued investment in talent development, international collaboration, and the integration of advanced technologies such as AI, China is well positioned to further drive improvements in stroke outcomes, both nationally and globally. The case of Beijing Tiantan Hospital exemplifies how academic excellence, research leadership, and strategic vision can collectively improve population health and contribute meaningfully to global scientific progress. The lessons learned from China's experience offer valuable insights for countries worldwide as they strive to meet the growing challenge and demands of stroke.



# Methodology

Data presented in this report was collated using Impact Analytics, an innovative tool developed by BMJ, in collaboration with Overton, which tracks the real-world impact of medical and health research. Traditional citation analysis measures where research has been cited by other research, thereby assessing its contribution to academic scholarship. Impact Analytics, identifies where research has been cited in clinical guidance and health policy documents, providing a more direct measure of its influence on healthcare practice.

For the sections of this report analysing Chinese stroke research more broadly, the following search was performed in Impact Analytics: *MeSH terms = Stroke; Stroke Rehabilitation; Stroke Volume; Ischemic Stroke Country = China.*

This search returned 2,072 stroke-related research outputs, with an author from China, which have been cited in clinical guidance and health policy documents. Impact Analytics was used to export detailed information about these research outputs, including the number and nature of these citations. Author lists from outputs were further searched and collated to assess the comparative influence of leading authors and institutions.

For the analysis of research output in high impact journals, a web search was performed to identify the top ten journals, based on the most recent Journal Impact Factor, in the following categories: Clinical Neurology; Cardiac & Cardiovascular Systems; Peripheral Vascular Disease; and Medicine, General & Internal. A selection of additional JAMA and Lancet journals were also included based on their reputations.

For the sections analysing the CHANCE study research, a targeted Impact Analytics search was performed using the DOIs of the relevant CHANCE articles. This returned 26 CHANCE research outputs that have been cited in clinical guidance and health policy documents. Details from these outputs were exported from Impact Analytics to measure the real-world impact of this research.

This data has been used to inform both the text and the accompanying diagrams throughout the report. Diagrams were generated based on extracted citation metrics, institutional outputs, author contributions, and international guideline citations. The integration of findings ensures that the report reflects not only the volume of research output but also its practical influence on clinical guidelines and stroke management policies worldwide.

All data was carefully verified against original publications and official databases, and citations were included according to Vancouver referencing style to maintain academic rigor and transparency.

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## References

- <sup>i</sup> World Health Organization Regional Office for the Eastern Mediterranean. Stroke (Cerebrovascular accident) [Internet]. Cairo: WHO EMRO; [cited 2025 Apr 10]. Available from: <https://www.emro.who.int/health-topics/stroke-cerebrovascular-accident/index.html>
- <sup>ii</sup> GBD 2021 Stroke Risk Factor Collaborators. Global, regional, and national burden of stroke and its risk factors, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet Neurol.* 2024;23(11):973–1003. Available from: <https://pubmed.ncbi.nlm.nih.gov/39304265/>
- <sup>iii</sup> Zhou XD, Chen QF, Yang W, Zuluaga M, Targher G, Byrne CD, et al. Burden of disease attributable to high body mass index: an analysis of data from the Global Burden of Disease Study 2021. *EClinicalMedicine.* 2024 Sep 24;76:102848. doi: 10.1016/j.eclinm.2024.102848. Erratum in: *EClinicalMedicine.* 2024 Nov 21;78:102958. PMID: 39386160; PMCID: PMC11462227.
- <sup>iv</sup> Feigin VL, Owolabi MO; World Stroke Organization–Lancet Neurology Commission Stroke Collaboration Group. Pragmatic solutions to reduce the global burden of stroke: a World Stroke Organization–Lancet Neurology Commission. *Lancet Neurol.* 2023 Dec;22(12):1160–1206. doi: 10.1016/S1474-4422(23)00277-6. Epub 2023 Oct 9. Erratum in: *Lancet Neurol.* 2023 Dec;22(12):e13. doi: 10.1016/S1474-4422(23)00425-8. PMID: 37827183; PMCID: PMC10715732.
- <sup>v</sup> Feigin VL, Owolabi MO; World Stroke Organization–Lancet Neurology Commission Stroke Collaboration Group. Pragmatic solutions to reduce the global burden of stroke: a World Stroke Organization–Lancet Neurology Commission. *Lancet Neurol.* 2023 Dec;22(12):1160–1206. doi: 10.1016/S1474-4422(23)00277-6. Epub 2023 Oct 9. Erratum in: *Lancet Neurol.* 2023 Dec;22(12):e13. doi: 10.1016/S1474-4422(23)00425-8. PMID: 37827183; PMCID: PMC10715732.
- <sup>vi</sup> Ji C, Ge X, Zhang J, Tong H. The stroke burden in China and its long-term trends: insights from the Global Burden of Disease (GBD) Study 1990–2021. *Nutr Metab Cardiovasc Dis.* 2025 Jan 3:103848. doi: 10.1016/j.numecd.2025.103848. Epub ahead of print. PMID: 39948019.
- <sup>vii</sup> Li X, Jin T, Bai C, Wang X, Zhang H, Zhang T. Analysis of Stroke Burden in China from 1990 to 2021 and Projections for the Next Decade. *Neuroepidemiology.* 2024 Nov 7:1–12. doi: 10.1159/000542487. Epub ahead of print. PMID: 39510046.
- <sup>viii</sup> Tian W, Zhu G, Xiao W, Gao B, Lu W, Wang Y. Stroke burden and attributable risk factors in China, 1990–2019. *Front Neurol.* 2023 May 24;14:1193056. doi: 10.3389/fneur.2023.1193056. PMID: 37292127; PMCID: PMC10245554.
- <sup>ix</sup> Tu WJ, Wang LD; Special Writing Group of China Stroke Surveillance Report. China stroke surveillance report 2021. *Mil Med Res.* 2023 Jul 19;10(1):33. doi: 10.1186/s40779-023-00463-x. PMID: 37468952; PMCID: PMC10355019.

---

<sup>x</sup> Wang Y, Wang Y, Zhao X, Liu L, Wang D, Wang C, Wang C, et al; CHANCE Investigators. Clopidogrel with aspirin in acute minor stroke or transient ischemic attack. *N Engl J Med*. 2013 Jul 4;369(1):11–19. doi: 10.1056/NEJMoa1215340.

<sup>xi</sup> Chan BPL, Wong LYH, Tan BYQ, Yeo LLL, Venketasubramanian N. Dual Antiplatelet Therapy for the Acute Management and Long-term Secondary Prevention of Ischemic Stroke and Transient Ischemic Attack, An Updated Review. *J Cardiovasc Dev Dis*. 2024 Jan 31;11(2):48. doi: 10.3390/jcdd11020048. PMID: 38392262; PMCID: PMC10889184.

<sup>xii</sup> Peng W, Chen S, Chen X, Ma Y, Wang T, Sun X, Wang Y, Ding G, Wang Y. Trends in major non-communicable diseases and related risk factors in China 2002-2019: an analysis of nationally representative survey data. *Lancet Reg Health West Pac*. 2023 Jun 20;43:100809. doi: 10.1016/j.lanwpc.2023.100809. PMID: 38456095; PMCID: PMC10920046.

<sup>xiii</sup> Ye Y, Zhu YT, Zhang JC, Zhang HL, Fan RW, Jin YX, Hu HQ, Xin XY, Li D. Burden and attributable risk factors of ischemic stroke in China from 1990 to 2019: an analysis from the Global Burden of Disease Study 2019. *Front Neurol*. 2023 Jul 26;14:1216777. doi: 10.3389/fneur.2023.1216777. PMID: 37564738; PMCID: PMC10409994.

<sup>xiv</sup> Wang Y, Zhao X, Lin J, Li H, Johnston SC, Lin Y, Pan Y, Liu L, Wang D, Wang C, Meng X, Xu J, Wang Y; CHANCE investigators. Association Between CYP2C19 Loss-of-Function Allele Status and Efficacy of Clopidogrel for Risk Reduction Among Patients With Minor Stroke or Transient Ischemic Attack. *JAMA*. 2016 Jul 5;316(1):70-8. doi: 10.1001/jama.2016.8662. PMID: 27348249.

<sup>xv</sup> Li Z, Zhang X, Ding L, Jing J, Gu HQ, Jiang Y, et al. Rationale and design of the GOLDEN BRIDGE II: a cluster-randomised multifaceted intervention trial of an artificial intelligence-based cerebrovascular disease clinical decision support system to improve stroke outcomes and care quality in China. *Stroke Vasc Neurol*. 2024;9. doi: 10.1136/svn-2023-002743.

<sup>xvi</sup> Wang Y, Lin Y, Meng X, Chen W, Chen G, Wang Z, Wu J, Wang D, Li J, Cao Y, Xu Y, Zhang G, Li X, Pan Y, Li H, Liu L, Zhao X, Wang Y; PRINCE Protocol Steering Group. Effect of ticagrelor with clopidogrel on high on-treatment platelet reactivity in acute stroke or transient ischemic attack (PRINCE) trial: Rationale and design. *Int J Stroke*. 2017 Apr;12(3):321-325. doi: 10.1177/1747493017694390. Epub 2017 Jan 1. PMID: 28381198.

<sup>xvii</sup> <https://www.nejm.org/doi/full/10.1056/NEJMoa1215340>

<sup>xviii</sup> <https://jamanetwork.com/journals/jamaneurology/fullarticle/2748072>

<sup>xix</sup> <https://svn.bmj.com/content/1/2/29>

<sup>xx</sup> Pan Y, Meng X, Jin A, et al. Time course for benefit and risk with ticagrelor and aspirin in individuals with acute ischemic stroke or transient ischemic attack who carry CYP2C19 loss-of-function alleles: a secondary analysis of the CHANCE-2 randomized clinical trial. *JAMA Neurol*. 2022 Aug 1;79(8):739–745. doi: 10.1001/jamaneurol.2022.1457.

<sup>xxi</sup> Wang Y, Meng X, Wang A, Xie X, Pan Y, Johnston SC, Li H, Bath PM, Dong Q, Xu A, Jing J, Lin J, Niu S, Wang Y, Zhao X, Li Z, Jiang Y, Li W, Liu L, Xu J, Chang L, Wang L, Zhuang X, Zhao J, Feng Y, Man H,

---

Li G, Wang B; CHANCE-2 Investigators. Ticagrelor versus Clopidogrel in CYP2C19 Loss-of-Function Carriers with Stroke or TIA. *N Engl J Med*. 2021 Dec 30;385(27):2520-2530. doi: 10.1056/NEJMoa2111749. Epub 2021 Oct 28. PMID: 34708996.

<sup>xxii</sup> Carroll J, Lopez Manzano C, Tomlinson E, Sadek A, Cooper C, Jones HE, Rowsell L, Knight J, Mumford A, Palmer R, Hollingworth W, Welton NJ, Whiting P. Clinical and cost-effectiveness of clopidogrel resistance genotype testing after ischaemic stroke or transient ischaemic attack: a systematic review and economic model. *Health Technol Assess*. 2024 Sep;28(57):1-194. doi: 10.3310/PWCB4016. PMID: 39269241; PMCID: PMC11417645.

<sup>xxiii</sup> Li SY, Zhao XQ, Wang CX, Liu LP, Liu GF, Wang YL, Wang YJ. One-year clinical prediction in Chinese ischemic stroke patients using the CHADS2 and CHA2DS2-VASc scores: the China National Stroke Registry. *CNS Neurosci Ther*. 2012 Dec;18(12):988-93. doi: 10.1111/cns.12021. Epub 2012 Nov 2. PMID: 23121837; PMCID: PMC6493534.

<sup>xxiv</sup> National Institute for Health and Care Excellence (NICE). Atrial fibrillation: diagnosis and management [Internet]. London: NICE; 2014 [cited 2025 Apr 10]. Available from: <https://www.nice.org.uk/guidance/cg180> This guideline has since been update to clinical guideline 196 <https://www.nice.org.uk/guidance/ng196>

<sup>xxv</sup> Wang Y, Wang Y, Zhao X, Liu L, Wang D, Wang C, et al; CHANCE Investigators. Clopidogrel with aspirin in acute minor stroke or transient ischemic attack. *N Engl J Med*. 2013 Jul 4;369(1):11–19. doi: 10.1056/NEJMoa1215340.

<sup>xxvi</sup> Wang Y, Johnston C, Bath PM, Meng X, Jing J, Xie X, Wang A, Pan Y, Xu A, Dong Q, Wang Y, Zhao X, Li Z, Li H; CHANCE-2 Investigators. Clopidogrel with aspirin in High-risk patients with Acute Non-disabling Cerebrovascular Events II (CHANCE-2): rationale and design of a multicentre randomised trial. *Stroke Vasc Neurol*. 2021 Jun;6(2):280-285. doi: 10.1136/svn-2020-000791. Epub 2021 May 5. PMID: 33952670; PMCID: PMC8258075.

<sup>xxvii</sup> Li J, Meng X, Shi F, Jing J, Gu H, Jin A, et al. Colchicine in patients with acute ischaemic stroke or transient ischaemic attack (CHANCE-3): multicentre, double-blind, randomised, placebo-controlled trial. *BMJ*. 2024;385:e079061. doi: 10.1136/bmj-2023-079061.

<sup>xxviii</sup> Wang Y, Li S, Pan Y, Li H, Parsons MW, Campbell BCV, et al; TRACE-2 Investigators. Tenecteplase versus alteplase in acute ischaemic cerebrovascular events (TRACE-2): a phase 3, multicentre, open-label, randomised controlled, non-inferiority trial. *Lancet*. 2023 Feb 25;401(10377):645–654. doi: 10.1016/S0140-6736(22)02600-9. Erratum in: *Lancet*. 2023 Apr 1;401(10382):1078. doi: 10.1016/S0140-6736(23)00627-X. PMID: 36774935.

<sup>xxix</sup> Wang Y, Johnston SC; CHANCE Investigators. Rationale and design of a randomized, double-blind trial comparing the effects of a 3-month clopidogrel-aspirin regimen versus aspirin alone for the treatment of high-risk patients with acute nondisabling cerebrovascular event. *Am Heart J*. 2010 Sep;160(3):380–386.e1. doi: 10.1016/j.ahj.2010.05.017. PMID: 20826243.

<sup>xxx</sup> Amarenco P, Albers GW, Denison H, Easton JD, Evans SR, Held P, et al; SOCRATES Steering Committee and Investigators. Efficacy and safety of ticagrelor versus aspirin in acute stroke or

---

transient ischaemic attack of atherosclerotic origin: a subgroup analysis of SOCRATES, a randomised, double-blind, controlled trial. *Lancet Neurol*. 2017 Apr;16(4):301–310. doi: 10.1016/S1474-4422(17)30038-8. PMID: 28238711.

<sup>xxxi</sup> Wang Y, Wang Y, Zhao X, Liu L, Wang D, Wang C, et al; CHANCE Investigators. Clopidogrel with aspirin in acute minor stroke or transient ischemic attack. *N Engl J Med*. 2013 Jul 4;369(1):11–19. doi: 10.1056/NEJMoa1215340.

<sup>xxxii</sup> Liu L, Wong KS, Leng X, Pu Y, Wang Y, Jing J, et al; CHANCE Investigators. Dual antiplatelet therapy in stroke and ICAS: subgroup analysis of CHANCE. *Neurology*. 2015 Sep 29;85(13):1154–1162. doi: 10.1212/WNL.0000000000001972.

<sup>xxxiii</sup> Li J, Wang Y, Lin J, Wang D, Wang A, Zhao X, et al; CHANCE Investigators. Soluble CD40L is a useful marker to predict future strokes in patients with minor stroke and transient ischemic attack. *Stroke*. 2015 Jul;46(7):1990–1996. doi: 10.1161/STROKEAHA.115.00868.

<sup>xxxiv</sup> Li J, Zhao X, Meng X, Lin J, Liu L, Wang C, et al; CHANCE Investigators. High-sensitive C-reactive protein predicts recurrent stroke and poor functional outcome: subanalysis of the Clopidogrel in High-Risk Patients With Acute Nondisabling Cerebrovascular Events trial. *Stroke*. 2016 Aug;47(8):2025–2030. doi: 10.1161/STROKEAHA.116.012901.

<sup>xxxv</sup> Wang Y, Meng X, Wang A, Xie X, Pan Y, Johnston SC, et al; CHANCE-2 Investigators. Ticagrelor versus clopidogrel in CYP2C19 loss-of-function carriers with stroke or TIA. *N Engl J Med*. 2021 Dec 30;385(27):2520–2530. doi: 10.1056/NEJMoa2111749.

<sup>xxxvi</sup> Xie X, Jing J, Meng X, Johnston SC, Bath PM, Li Z, et al; CHANCE-2 Investigators. Dual antiplatelet therapies and causes in minor stroke or transient ischemic attack: a prespecified analysis in the CHANCE-2 trial. *Stroke*. 2023 Sep;54(9):2241–2250. doi: 10.1161/STROKEAHA.122.042233. PMID: 37548009.

<sup>xxxvii</sup> Wang A, Xie X, Tian X, Johnston SC, Li H, Bath PM, et al. Ticagrelor-aspirin versus clopidogrel-aspirin among CYP2C19 loss-of-function carriers with minor stroke or transient ischemic attack in relation to renal function: a post hoc analysis of the CHANCE-2 trial. *Ann Intern Med*. 2022 Nov;175(11):1534–1542. doi: 10.7326/M22-1667. PMID: 36315949.

<sup>xxxviii</sup> Li X, Jin T, Bai C, Wang X, Zhang H, Zhang T. Analysis of Stroke Burden in China from 1990 to 2021 and Projections for the Next Decade. *Neuroepidemiology*. 2024 Nov 7:1-12. doi: 10.1159/000542487. Epub ahead of print. PMID: 39510046.

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