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*Brief Communication*

# Bell's palsy research hotspots and frontiers from 2002 to 2021: a bibliometric and visual analysis

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**Abstract:** Bell's palsy is an idiopathic, acute, unilateral peripheral facial nerve paralysis, where incomplete or failed recovery causes substantial social and psychological stress to the patient, seriously influencing their quality of life and social activities. We conducted a bibliometric investigation of the knowledge structure and frontier hotspots in Bell's palsy research. Bell's palsy publications between 2002 and 2021 were retrieved from Web of Science. CiteSpace, VOSviewer, and an online bibliometric platform were used for visual, burst, citation, and co-occurrence analyses, respectively. A total of 1,378 publications were included. The annual Bell's palsy publication output followed an upward trend from 2002 to 2021. The USA and Harvard University published the most Bell's palsy research articles. Yeo SG and *Otology & Neurotology* were the most prolific author and journal, respectively, on Bell's palsy. The results suggested that Bell's palsy research hotspots focused on rehabilitating facial nerve function and improving prognosis, and combining specific therapies (acupuncture) would be of future interest. The cited references timeline revealed that Bell's palsy following COVID-19 vaccination was an emerging research hotspot. The bibliometric analysis demonstrated that the USA dominates Bell's palsy research and that rehabilitating facial nerve function and prognosis were research hotspots. Emerging mechanistic studies mainly focused on Bell's palsy following COVID-19 vaccination. Our findings could be a reliable source for global scholars to rapidly identify research hotspots and potential research directions and frontiers.

**Keywords:** Bell's palsy, bibliometrics, visualization analysis, CiteSpace, VOSviewer

## Introduction

Bell's palsy is an acute-onset peripheral facial neuropathy of unknown etiology and the most common cause of lower motor neuron facial palsy [1]. The clinical characteristics of Bell's palsy are typically unilateral, rapid-onset lower motor neuron-type facial muscle weakness with dysphonia, retro-auricular pain, hyperacusis, and subjective changes in facial sensation [2]. While typically self-limited, facial paresis/paralysis due to Bell's palsy may cause significant temporary oral weakness and inability to close the eyes, which can lead to potential eye damage [3]. Additional long-term adverse consequences can occur, which can be devastating to the patient. The treatment goals for Bell's palsy are to restore symmetry and coordination of muscle movements in all parts of the face to promote expression and to protect the eyes [4]. The effectiveness of these treatments is controversial and therefore there are discrepancies in care [5]. Patients with Bell's palsy are evaluated with various diagnostic tests (electro-diagnostic tests, diagnostic imaging tests, and laboratory tests), many of which are of controversial benefit [6]. In some patients, the loss of facial nerve function extends beyond the related functional deficits, with significant psychosocial effects. Anxiety, depression, and feelings of social isolation are common among patients with Bell's palsy [7].

Bibliometrics is an interdisciplinary scientific method of applying mathematics and statistics to quantitatively analyze scientific publications and provide a clear overview of the current trends, distribution of contributions, and frontier topics in a specific area [8]. In addition to depicting the current status of a certain

research area and predicting future trends, bibliometric analysis can also assess the contributions of different journals, countries, institutions, and authors [9]. Bibliometrics is widely used in medical research in areas such as respiratory, digestive, circulatory, endocrine, motor, and reproductive diseases [10]. Although Bell's palsy has drawn universal interest as a multidisciplinary research hotspot in previous years, Bell's palsy bibliometric studies are not available.

Bell's palsy research is extensive and features a vast number of publications and different research directions, which renders it difficult to understand the research focus and current trends in this area. Conducting a bibliometric study rather than a traditional review of this highly debated topic is important as it can provide a visual summary of previous publications and predict potential frontiers. Therefore, we aimed to summarize the overall status of global Bell's palsy research according to Web of Science data from the past 20 years. Using bibliometric methods combined with citation networks, we explored the research trends, presented global revolutions, explored hotspots and frontier directions through keyword bursts, and provide comprehensive and prospective references for future studies.

## Materials and methods

### *Data source and search strategy*

The data source in this study was the Web of Science Core Collection (Science Citation Index Expanded and Social Sciences Citation Index) as it covers the most important data sources in bibliometric analysis. To avoid bias of database renewal, all data searches and downloads were performed on September 1, 2022. We conducted a comprehensive database search limited to the years 2002-2021 and including only original articles and reviews. The search strategy was as follows: Topics = (Bell's palsy OR Bell palsy) AND Languages = English. Two researchers independently verified the data download and input. Differences between the two researchers' verification results were discussed and consensus was achieved based on expert direction. Finally, 1,378 publications were retrieved, exported in plain text format with complete records and reference, and imported into bibliometric software for analysis. **Figure 1A** depicts the detailed publication retrieval and data analysis process.

### *Bibliometric and visual analyses*

The data were analyzed with bibliometric software and the most frequently used bibliometric indicators: number of publications, occurrence frequency, number of citations, and number of citation bursts. The H-index is used not only to assess researchers' scholarly contributions and predict future academic achievements, but is also used to describe the publication output of a country/region, institution, or journal [11]. Visual analysis was performed with the following software: the collaborative relationship between countries was analyzed with an online bibliometric analysis tool (https://bibliometric.com/).

VOSviewer software can mine text for important items extracted from publications and construct visual co-occurrence network maps, which are represented with nodes and links [10]. The node size represents the number of articles while the connections between nodes reflect the association between items. In this study, VOSviewer was used to visually construct a network graph of the research team, evaluate keyword co-occurrence, and build a density map.

CiteSpace is a highly reliable and useful bibliometric software mainly designed to visualize and analyze the knowledge structure of a field and assess scientific literature evolution trends [9]. The nodes in the visualization map indicate the analyzed items, where a larger node indicates a higher frequency. Additionally, CiteSpace was used to analyze the node centrality scores. Node importance is assessed with centrality, which can measure how closely a node interacts with other nodes. Nodes with high centrality scores are considered vital bridges among different groups and represent turning or critical points in the field [12]. To detect Bell's palsy research hotspots, we conducted a series of analyses of relevant institutions and clustering of cited references.

## Results

### *Publication output and temporal trend*

Using the search strategy, a total of 1,378 publications (1,193 original articles and 185 reviews) were included in this study. Annual output increased from 47 publications in 2002 to 139 in 2021. Generally, Bell's palsy-related

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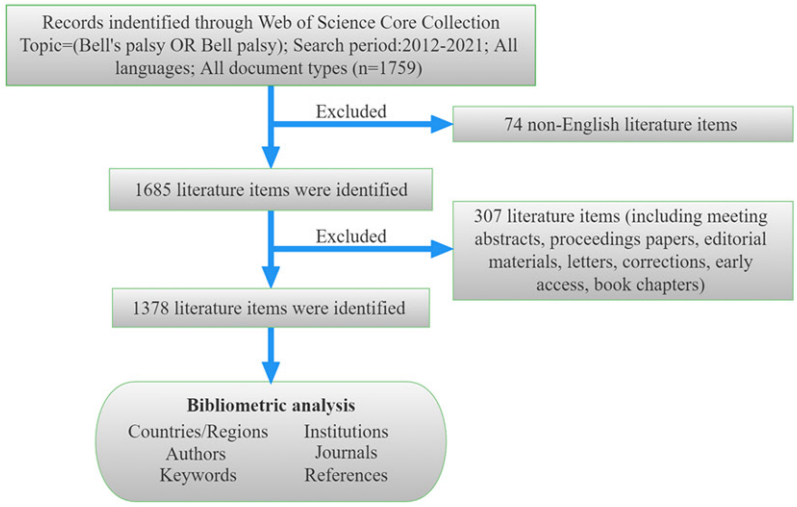
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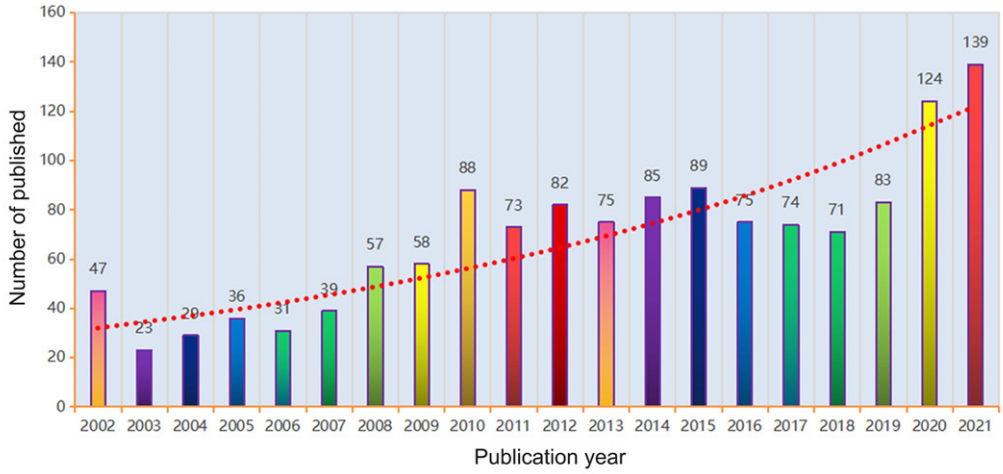
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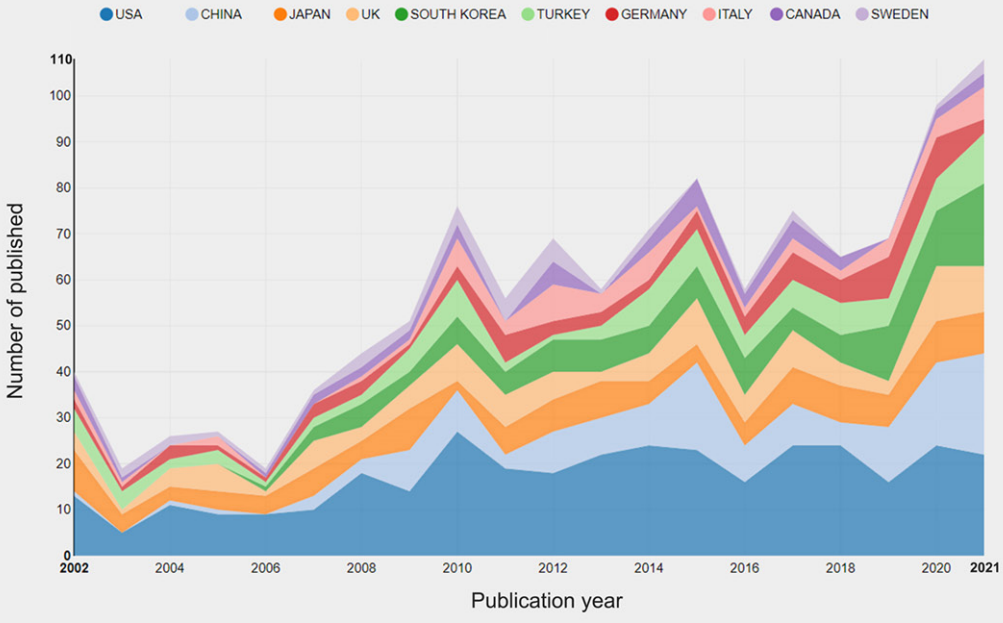
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**Figure 1.** A. Frame flow diagram of the study strategy. B. Distribution of Bell's palsy publications according to the year. C. Consistency of change in annual publication output of the 10 most productive countries (2002-2021).

**Table 1.** The 10 most productive countries and institutions contributing to Bell's palsy research

| Rank | Country | Publication count | Centrality | Institution | Publication count | Centrality |
|---|---|---|---|---|---|---|
| 1 | USA | 356 | 0.15 | Harvard University | 63 | 0.05 |
| 2 | China | 123 | 0.05 | Kyung Hee University | 43 | 0.00 |
| 3 | Japan | 121 | 0.00 | Massachusetts Eye and Ear | 25 | 0.01 |
| 4 | South Korea | 112 | 0.00 | Johns Hopkins University | 22 | 0.08 |
| 5 | UK | 98 | 0.16 | University of California | 22 | 0.03 |
| 6 | Turkey | 97 | 0.00 | University of Toronto | 21 | 0.05 |
| 7 | Germany | 78 | 0.59 | Harvard Medical School | 21 | 0.02 |
| 8 | Italy | 59 | 0.05 | Friedrich Schiller University of Jena | 20 | 0.04 |
| 9 | Canada | 46 | 0.09 | Karolinska Institute | 20 | 0.03 |
| 10 | Sweden | 37 | 0.31 | University of London | 20 | 0.00 |

publications increased steadily each year during the last 20 years (**Figure 1B**). The total citations for the publications numbered 25,559 and the mean number of citations per publication was 18.55. The H-index for all publications was 67.

*Leading countries/regions and institutions*

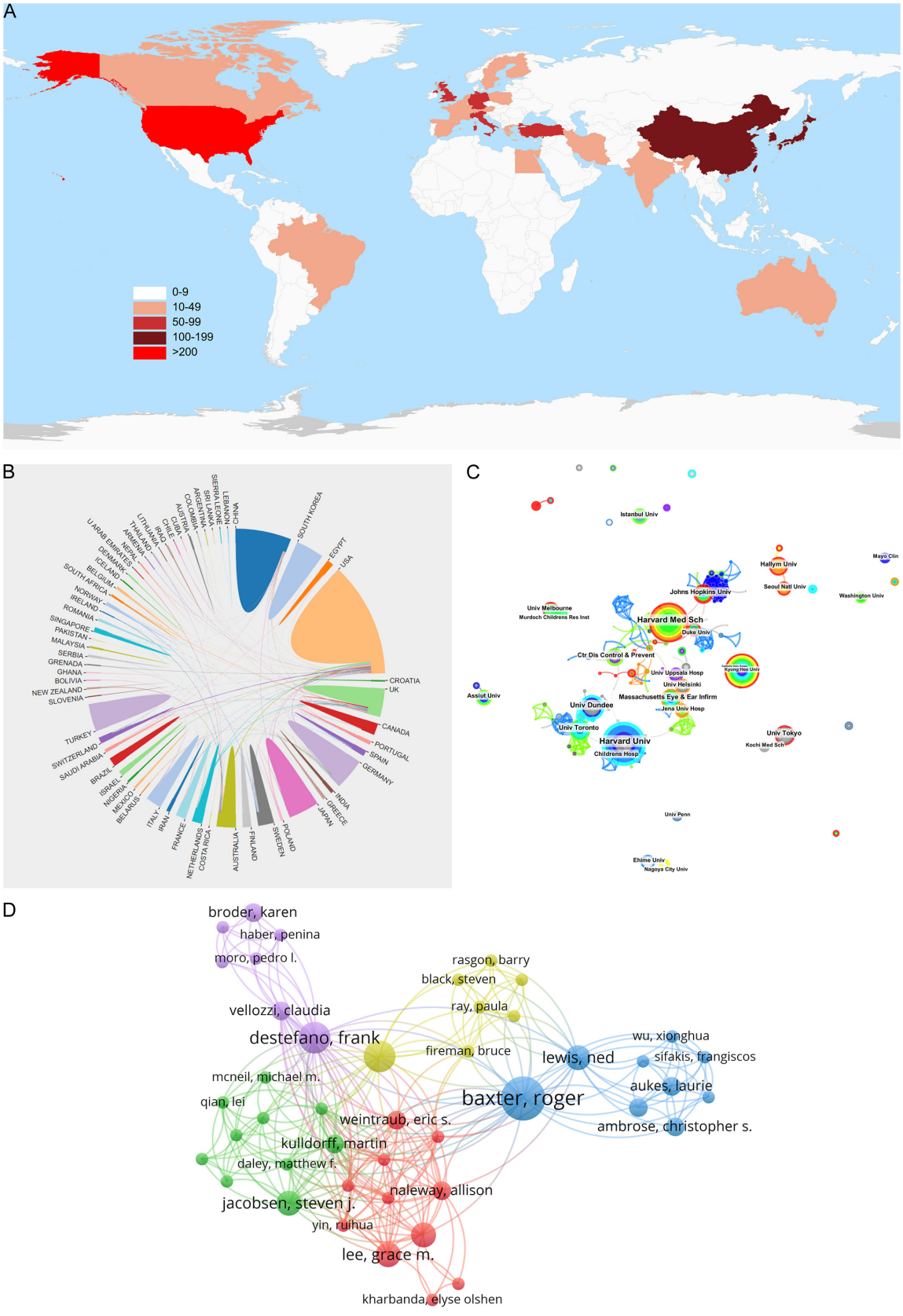
The bibliometric analysis determined that 71 countries/regions contributed to Bell's palsy research. **Figure 1C** and **Table 1** list the 10 most productive countries. The articles were mainly published by the USA (356 publications), China (123 publications), and Japan (121 publications), which accounted for 43.5% of the total publications. The most productive countries were mainly in Europe, East Asia, and North America (**Figure 2A**). The network diagram depicts the research activities and collaboration between these countries/regions (**Figure 2B**). Although Germany ranked seventh in total publications, it ranked first in centrality (0.59), followed closely by Sweden (0.31) and the UK (0.16). A total of 1,737 institutions contributed to Bell's palsy research, where **Table 1** lists the 10 most productive institutions. The three most productive institutions were Harvard University (63 publications, 4.6%), Kyung Hee University (43 publications, 3.1%), and Massachusetts Eye and Ear (25 publications, 1.8%). The collaborative relationships among the most prolific institutions were analyzed through collaborative networks (**Figure 2C**). All institutions had centrality scores < 0.1, which suggested a lack of inter-institution cooperation.

*Active authors*

A total of 5,886 authors contributed Bell's palsy-relevant publications. **Figure 2D** illustrates the co-authorship network diagram. Yeo SG of Kyung Hee University was the most prolific author (27 publications). The other highly productive researchers were Hadlock TA (Massachusetts Eye and Ear, USA) and Guntinas-Lichius O (Jena University Hospital, Germany). Hadlock TA had the highest total number of citations and the highest H-index. There was insufficient collaboration between the research teams, with all authors scoring < 0.10 for centrality.

*Keyword analysis*

We extracted 4,249 keywords from all publications and analyzed their co-occurrence with VOSviewer (**Figure 3A**). We used a burst detection algorithm to identify the keywords with the strongest citation bursts from the Bell's palsy publications (**Figure 3B**). The timeline is depicted as a blue line while the period of a burst is a red line. Among the keywords, "prednisone" (2002-2008), "valacyclovir" (2007-2009), "multicenter" (2010-2013), "placebo" (2013-2015), and "rehabilitation" (2016-2021) in each stage were the five most explosive keywords. Notably, the citation burst for "rehabilitation" has been sustained to date, which indicated that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Washington Univ
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Univ Melbourne
Murdoch Childrens Res Inst
Harvard Med Sch
Duke Univ
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Univ Uppsala Hosp
Univ Helsinki
Massachusetts Eye & Ear Infirm
Jena Univ Hosp
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Univ Dundee
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**Figure 2.** A. Geographical distribution of publications. B. Network map of countries/regions engaged in Bell's palsy research. C. Distribution of publications from different institutions. D. Co-occurrence network visualization map of authors.

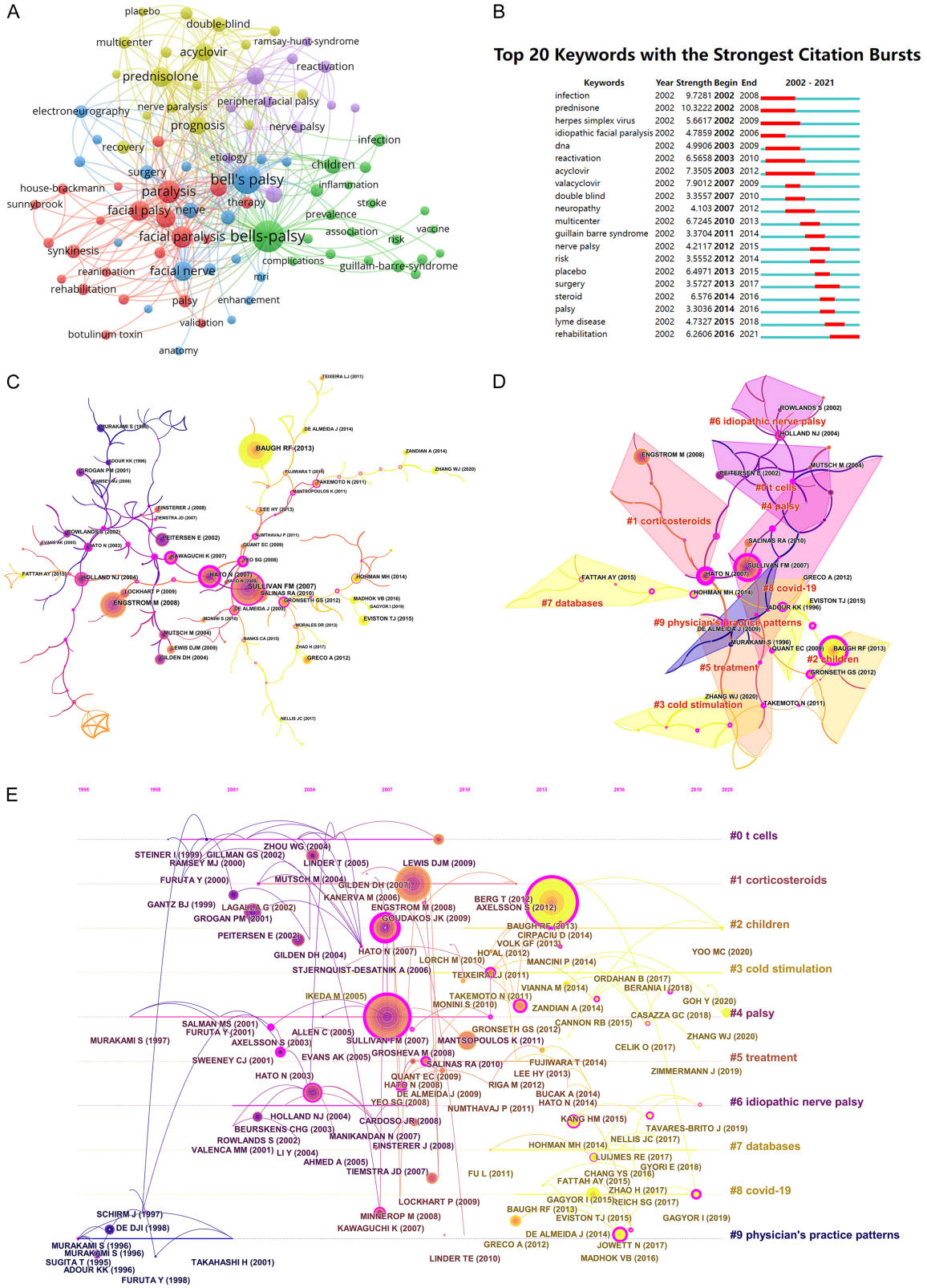

**Figure 3.** A. Visualization map of Bell's palsy high-frequency keyword clustering analysis. B. The 10 keywords with the strongest citation bursts (2002-2021). C. Map of cited references of Bell's palsy publications. D. Visual network of cited references with cluster labels. E. Timelines of the cited references with cluster tags.

researchers have been focusing on Bell's palsy prognosis.

*Analysis of cited references*

The network of cited references consisted of 226 nodes and 250 links representing the co-citation relationships between the references in a publication (**Figure 3C**). **Figure 3D** depicts the 10 largest clusters in the reference co-citation map, which represented the 10 most important themes in this area: "T cell" (#0), "corticosteroids" (#1), "children" (#2), "cold stimulation" (#3), "palsy" (#4), "treatment" (#5), "idiopathic nerve palsy" (#6), "databases" (#7), "COVID-19" (#8), and "physician's practice patterns" (#9). **Figure 3E** depicts the scientific correlation of the cited references with time, which was created by illustrating the evolution of the 10 largest clusters on the timeline. Based on temporal order, the most recent clusters were "COVID-19" (#8), "databases" (#7), and "treatment" (#5).

## Discussion

Named after the Scottish anatomist Sir Charles Bell, Bell's palsy is the most common acute mononeuropathy and the most common cause of peripheral facial palsy [13]. Bell's palsy is defined as an acute unilateral facial nerve palsy of unknown origin that occurs within 72 hours and requires the exclusion of other causes of facial palsy [1, 2]. We performed a bibliometric analysis of Bell's palsy-related publications to provide inspiration for future research.

The analysis revealed that 5,886 authors from 1,737 institutions in 71 countries published 1,378 articles in 500 scientific journals between 2002 and 2021. The results indicated that the number of Bell's palsy publications increased significantly in the last 20 years. The visual analysis of national contributions demonstrated that the USA was the obvious leader in Bell's palsy research, where it published 25.8% of the total number of papers. Remarkably, China contributed 123 Bell's palsy papers and was the only developing country in the top 10 group. The contribution of China to Bell's palsy research increased dramatically in a short period. We predict that China will overtake the USA as the most productive country in Bell's palsy research in the near future, which may be partly attributed to increased national funding investments in related research. China has a large population with numerous Bell's palsy patients, and there is an urgent need for effective treatment thereof. Generally, the economic imbalances, population sizes, and differences in policy specifications between countries may lead to imbalances in the scientific literature output. More than 1,500 institutions worldwide have published Bell's palsy-related studies, where Harvard University was the most prolific institution in this study. It is important to enhance cooperation between countries and institutions researching similar topics to promote the development of Bell's palsy research.

Frontier topics and research hotspots in a specific field can be identified through keyword citation bursts [14]. Our findings indicated that keywords such as "rehabilitation", "Lyme disease", "steroid", and "surgery" had sustained bursts in recent years and remained hot, reflecting recent research dynamics. Bell's palsy is a potentially devastating disease that may cause a wide range of emotional, functional, and psychosocial sequelae in patients. Therefore, Bell's palsy treatment is a perpetually hot research topic. The complexity of Bell's palsy determines its treatment complexity, which promoted the development of various treatment methods. In the future, facial palsy care should be a comprehensive treatment that includes patient education, medication, physical therapy, and surgery [15].

A safe and effective vaccine against severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is critical to end the COVID-19 pandemic. Nevertheless, it should be noted that several Bell's palsy cases developed after COVID-19 vaccination, most of which were related to mRNA vaccines [16]. Vaccination-associated Bell's palsy typically responds well to oral corticosteroids, but the precise mechanism remains unclear. In a case-control study that compared the clinical parameters of Bell's palsy patients after COVID-19 mRNA vaccina-

tion with those of unvaccinated Bell's palsy patients [17], 21 of 37 vaccinated patients developed Bell's palsy within 2 weeks after the first vaccine dose, while there were no differences in any clinical parameters between the vaccinated and unvaccinated groups. A clinical vaccination trial that involved 44,000 participants recorded 4 cases of Bell's palsy, while no Bell's palsy case was reported in the placebo group [18]. The Moderna clinical trial reported Bell's palsy in three vaccine recipients and one placebo recipient among 30,400 participants [19]. An analysis of the combined phase 3 data from the Pfizer-BioNTech and Moderna trials indicated higher Bell's palsy prevalence than expected [19]. Although several potential factors, including autoimmune, viral, or innate immune activation, were suggested as causes of Bell's palsy after COVID-19 immunization, the mechanisms involved may be multifactorial and do not apply to all cases. Further studies are needed to explore the underlying mechanism of Bell's palsy after COVID-19 vaccination.

## Conclusion

To the best of our knowledge, this is the first comprehensive bibliometric analysis of the literature on Bell's palsy, where the state of research during the last two decades was elucidated. The Bell's palsy publication output followed an overall upward trend over time. Authors from different countries/regions and institutions should overcome institutional and language barriers to strengthen international collaboration and communication. Our findings suggested that the hot topics are rehabilitating facial nerve function and improving prognosis. The emerging trends and frontiers of the current research theme focused on the association between COVID-19 vaccination and Bell's palsy. Some issues remain unsolved, such as accurate diagnostic criteria, exact causes, and optimal surgical approach for Bell's palsy. These issues need to be on the research agenda, which would assist researchers in exploring new research directions.

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## Disclosure of conflict of interest

None.

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