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News and Views

# Bibliometric analysis of virology advancements in the 21st century

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Virology, an old scientific discipline that deals with viruses, has confronted huge challenges in the 21st century, marked by constant outbreaks of emerging and remerging viral infections globally. Substantial advancement has also been made in this rapidly evolving field worldwide (Howley et al., 2023). To gain a deeper insight of its remarkable progress, the status and characteristics of virology research of the 21st century are analyzed from a literature perspective.

This comprehensive literature search utilized Web of Science (WoS) database in conjugation with the Essential Science Indicators (ESI, 2024) and Nature Index (NI, 2024). The search was first conducted in the Web of Science Core Collection SCI-EXPANDED Editions (SCIE, 2024). The query term is (ts=((*virus*) or (*viral*) or (*virol*)) not ts=("computer virus*")), ensuring that the asterisk wildcard appears as a superscript in the query. The search span was from 2000-01-01 to 2023-12-31 (The time for WoS data collection was 2024-05-17). The search resulted in a total of 1,183,644 publications. To better represent the original research output, we exclusively utilized "Article" type for subsequent analysis. A total of 903,284 articles were retrieved, and

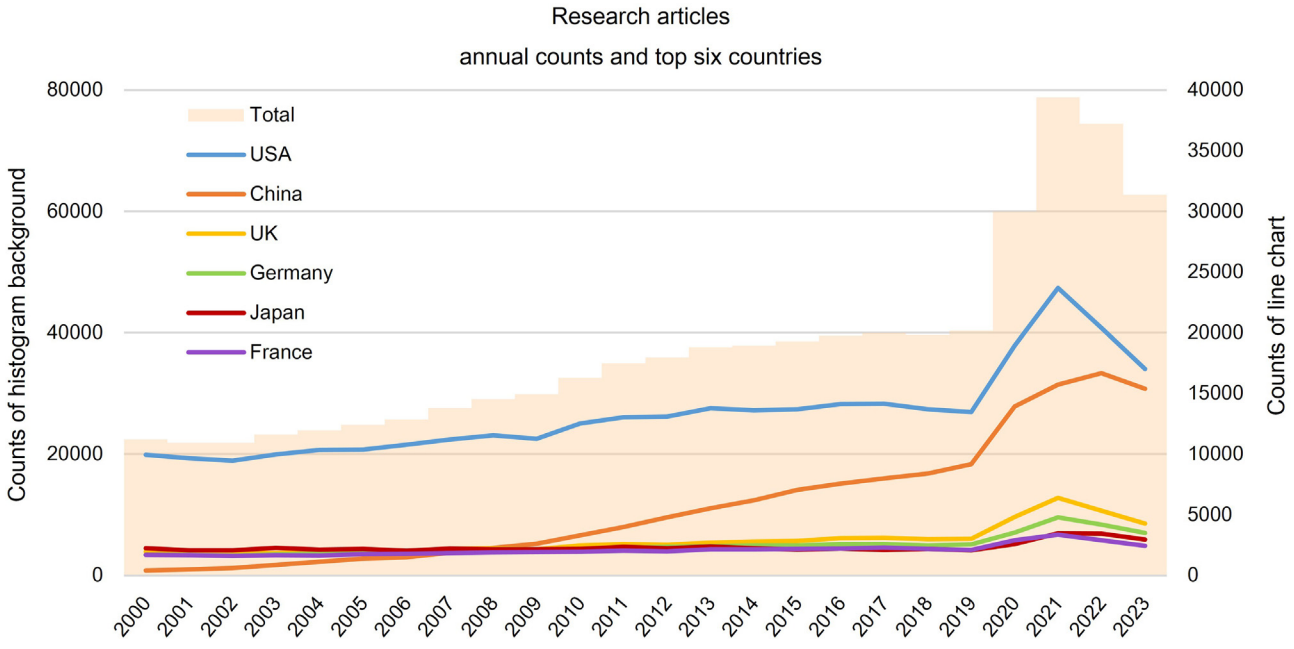


**Fig. 1.** Annual article counts from 2000 to 2023. Histogram background shows the global article counts, with scale on the left Y-axis. Colored line charts show article counts of the top six counties, with scale on the right Y-axis.

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**Table 1**
List of the top fifteen countries with their respective article counts and proportions.

| | Country | # of Articles | % of Total |
|---|---|---|---|
| 1 | USA | 319533 | 24.9% |
| 2 | China | 138653 | 10.8% |
| 3 | UK | 68768 | 5.4% |
| 4 | Germany | 58465 | 4.6% |
| 5 | Japan | 56004 | 4.4% |
| 6 | France | 50234 | 3.9% |
| 7 | Italy | 42821 | 3.3% |
| 8 | Canada | 37595 | 2.9% |
| 9 | Spain | 32799 | 2.6% |
| 10 | Australia | 30285 | 2.4% |
| 11 | India | 28625 | 2.2% |
| 12 | Brazil | 26663 | 2.1% |
| 13 | South Korea | 25918 | 2.0% |
| 14 | Netherlands | 24422 | 1.9% |
| 15 | Switzerland | 19594 | 1.5% |
| Subtotal of top 15 countries | | 960379 | 74.8% |

their annual article counts are visually depicted in the histogram background of Fig. 1.

As seen in Fig. 1, the amount of articles published each year witnessed a consistent growth through the span of 24 years generally, with an initial start point of 20,000 articles and gradually increasing to 40,000 in the first nineteen years. The amount of articles surged to 60,000 in 2020, and reached a peak of nearly 80,000 articles in 2021. After maintaining a large volume in 2022, the amount progressively decreased to 60,000 articles in 2023. The research publications of 2020–2023 aptly mirror the onset, intensification and subsequent decline of the COVID-19 pandemic.

All articles were published by 222 countries/regions, and the top fifteen countries are listed in Table 1, with their respective article counts and proportions. Collaborations led to the multiple counting of internationally co-authored articles, thereby inflating the total article count. To normalize the proportions, the counts for each country were divided by the inflated total article count. Notably, these top fifteen countries accounted for nearly 75% of the total publication output over the 24-year period. United States-based investigators published the most papers (319,533, 24.9%), followed by investigators from China (138,653, 10.8%), United Kingdom (68,768, 5.4%), Germany (58,465, 4.6%), Japan (56,004, 4.4%), and France (50,234, 3.9%). The yearly publications of the top six countries are further illustrated in the line chart presented in Fig. 1. Notably, China exhibits the most pronounced surge amongst the top six countries with the highest publication output.

We then used the ESI database and Derwent Data Analyzer (DDA) to further investigate how different scientific disciplines approach virology research, which returned a total of 883,551 articles. As shown in Fig. 2, across the 22 ESI categories, clinical medicine, immunology, and microbiology are the major disciplines publishing virology research and contributing 464,930 articles (52.6%). The COVID-19 pandemic significantly accelerated article production across all the 22 disciplines, highlighting its profound influence on the academic landscape. Notably, the COVID-19 pandemic prompted all scientific disciplines, including not only life science and medicine but also social disciplines, to embark on addressing and studying virology-related topics in 2020.

When comparing the pandemic four years (2020–2023) with the preceding four years (2016–2019), clinical medicine, immunology, and microbiology had an increase in article production ranging from 45% to 95%. Social science, chemistry, environment disciplines doubled or tripled their output of virology-related articles. Therefore, the COVID-19 pandemic has significantly increased awareness of virology and profoundly influenced the entire academic world.

The Nature Index, established in 2014, is designed to evaluate high-quality science and top-notch research. To further analyze the virology researches published in high impact scientific journals, we applied the NI journal list to the search results mentioned earlier. We found that 134 out

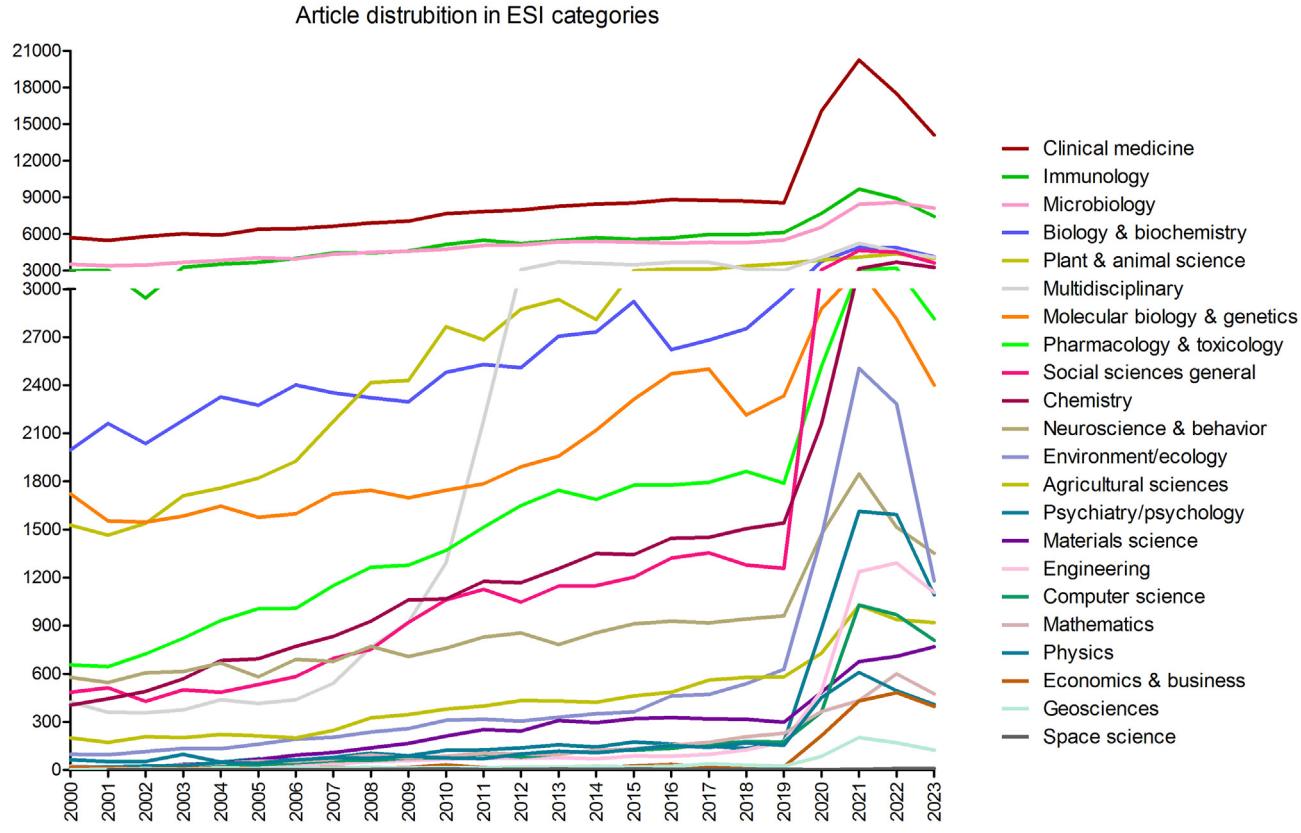


**Fig. 2.** Annual article counts and distributions across 22 Essential Science Indicators (ESI) categories.

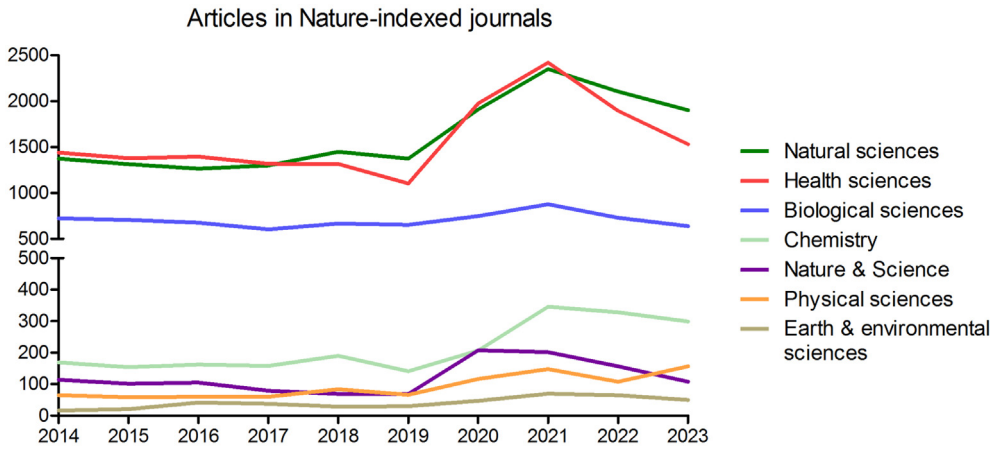


**Fig. 3.** Annual article counts in seven subjects of Nature-indexed (NI) journals.

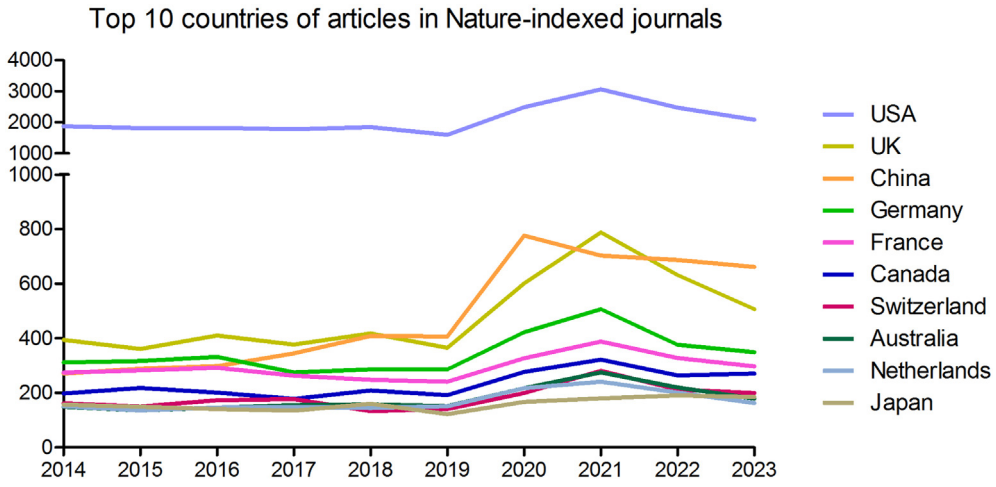


**Fig. 4.** Top ten countries with their annual article counts of Nature-indexed (NI) journals.

of 145 NI journals published virology papers, totaling 33,348 articles. The year/subject distribution is illustrated in Fig. 3. Natural sciences, health sciences, and biological sciences, are the three NI subjects that generally encompass virus research.

We further examined the contributions by countries, and the top ten countries are shown in Fig. 4. The United States produces between 2000 and 3000 articles annually, significantly surpassing other countries. Subsequently, the United Kingdom, China, Germany, France, Canada, Switzerland, Australia, Netherlands, and Japan follow in rank. We then calculated the annual ratio of NI articles to SCIE articles for these top ten countries. Interestingly, Switzerland leads the pack with a ratio of 16.7%, while the typical ratios range around 10%–13%. China and Japan, however, have ratios below 10% (Fig. 5).

Web of Science has established 254 categories for content classification, one of which is Virology. However, the Virology category encompasses approximately 120,000 research articles from 2000 to 2023, accounting for merely 13.6% of the articles retrieved using our search term. Consequently, the search term employed in this study offers a broader scope of virology-focused and virus-related research beyond the Virology category. This unbiased search facilitates a comprehensive understanding of how scientific disciplines approach and resolve virus-related challenges.

This analysis utilizes bibliometric methods to evaluate the global status of virology research post-2000. Our findings suggest that virology research has experienced significant advancements, driven by the urgency to address critical public health issues and the integration of multidisciplinary approaches. This academic prosperity also highlights

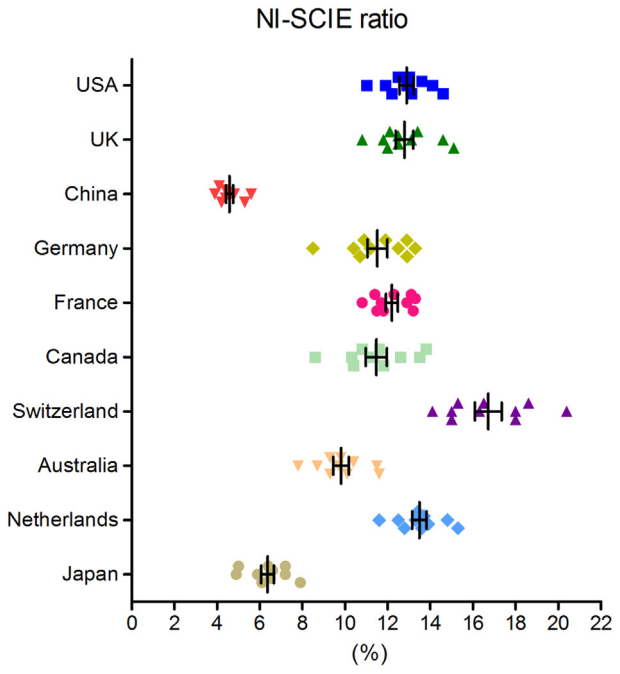


**Fig. 5.** Ratios of Nature-indexed articles to Science Citation Index Expanded (SCIE) articles of the top ten countries in years 2014–2023.

the importance of interdisciplinary collaborations among experts from various fields for advancing future virology endeavors. We hope these insights will be beneficial for policymakers, funders, and researchers interested in shaping the future direction of virus science.

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