Comparative Analysis of China-U.S. Scientific Collaboration Models During International Public Health Emergencies (Postprint)

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Abstract

[Purpose/Significance] China and the United States represent core forces in global scientific literature output. Investigating the characteristics and differences of their scientific collaboration patterns in response to different epidemics provides valuable references for relevant policy formulation and practice. [Method/Process] This study examines China-U.S. scientific collaboration patterns by analyzing research papers related to SARS and COVID-19, subdividing different collaboration types, improving collaboration intensity indicators, and investigating from the perspectives of research contribution, collaboration intensity, collaboration networks, and collaboration fields. [Results/Conclusion] Mainland China and the United States are both major research contributors to the two epidemics, but Mainland China's research focus on epidemics is more susceptible to changes in epidemic situations. Although China and the United States are each other's closest collaborative partners in both epidemics, the collaboration intensity between the two countries in COVID-19 research is significantly lower than that in SARS research. From the perspective of collaboration networks, the United States occupies a central position in the global collaboration networks of both epidemics, while Mainland China's centrality is lower than that of the United States. From the perspective of collaboration fields, China and the United States each demonstrate distinct emphases in the disciplinary distribution of research on the two diseases.

Full Text

Preamble

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A Comparative Analysis of China-U.S. Scientific Collaboration Patterns Under International Public Health Emergencies

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Abstract:
[Purpose/Significance] China and the United States are core forces in global scientific literature output. Exploring the characteristics and differences of their scientific collaboration patterns in responding to different epidemics provides valuable references for relevant policy-making and practice. [Method/Process] Taking SARS and COVID-19 related research papers as objects of study, and based on subdividing different collaboration types and improving collaboration intensity indicators, this research examines China-U.S. scientific collaboration patterns from perspectives of research contribution, collaboration intensity, collaboration networks, and collaboration fields. [Result/Conclusion] China and the U.S. are both major contributors to research on the two epidemics, but China's attention to epidemic research is more susceptible to changes in epidemic situations. Although China and the U.S. remain each other's closest partners in both epidemics, their collaboration intensity in COVID-19 research is significantly lower than in SARS research. From a network perspective, the U.S. occupies a central position in global collaboration networks for both epidemics, while China's centrality is lower than that of the U.S. In terms of collaboration fields, China and the U.S. each emphasize different disciplines in research on the two diseases.

Keywords: Severe Acute Respiratory Syndrome (SARS); Coronavirus Disease 2019 (COVID-19); scientific collaboration; social network analysis; public health
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Introduction

The COVID-19 pandemic has swept across the globe, becoming a focal concern for governments, enterprises, and academia worldwide. In his article "Providing Strong Scientific and Technological Support for Winning the Battle Against the Epidemic," General Secretary Xi Jinping clearly stated that "science and technology are the most powerful weapons for humanity in the struggle against diseases, and overcoming major disasters and epidemics is inseparable from scientific development and technological innovation" [1]. In recent years, science and technology have played crucial roles in combating multiple major infectious diseases, including Severe Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome (MERS), H1N1 influenza, and Ebola virus. As Zhang Lin [2] and colleagues discovered in their study of scientific response patterns

to multiple International Public Health Emergencies of International Concern (PHEIC), the volume of scientific literature on various infectious diseases rapidly increases during outbreak periods, peaking within one to two years afterward, demonstrating the scientific community's swift response to epidemics.

Scientific collaboration involves numerous complex social and scientific issues, and its exploration spans multiple disciplines and fields, including scientometrics [4-5], economics [6], computer science [7], and information science [8], each offering different perspectives on the topic. Scientific literature serves as the primary form of academic research output, making related studies more traceable. Co-authored papers contain rich information such as author affiliations, disciplinary backgrounds, and geographical distributions [9]. Based on co-authorship data, scientometrics provides quantitative approaches and methods to analyze collaboration patterns and regularities from the perspectives of individual researchers, research institutions, and countries/regions. In today's increasingly globalized technological development, scientific collaboration has become the mainstream mode of scientific research, referred to as the "fourth age of research" [3].

Since the outbreak of COVID-19, numerous scholars both domestically and internationally have conducted multidimensional analyses from a scientometric perspective based on literature related to the novel coronavirus [10-16] and coronaviruses in general [17-20]. Most studies indicate that China and the U.S. are not only the world's major producers of scientific literature but also core forces in COVID-19 research [2,10,21-22]. While many studies have addressed the dimension of scientific collaboration, only a few have examined it as a primary focus with detailed analysis to explore the characteristics and changes of scientific collaboration patterns in the context of global public health emergencies [21-22]. For instance, M. Pathak [23] analyzed India's international scientific collaboration patterns in COVID-19 research based on international literature co-authored by Indian researchers, finding that China, the U.S., and Thailand were India's closest collaborators. C.V. Fry [21] and colleagues used literature data from before and after the COVID-19 outbreak to conduct comparative studies on "coronavirus," finding that China-U.S. collaboration strengthened during the COVID-19 period. Zhang Lin [2] and colleagues conducted research based on literature on multiple PHEIC-causing infectious diseases, revealing that the U.S. occupied a central position in scientific collaboration for H1N1 influenza, Ebola, and Zika virus research, while China also emphasized collaboration with the U.S. in related studies.

The outbreak of a global pandemic has driven transformation in the era of "big science," expanding the breadth and depth of scientific collaboration worldwide [24]. China (excluding Hong Kong, Macau, and Taiwan, hereinafter the same) and the U.S., as core forces in global scientific literature output, have long been close scientific partners [25]. Investigating the characteristics and differences of their scientific collaboration patterns under different epidemics can provide valuable references for relevant science and technology management policy-making and scientific practice. However, few studies in existing research on scientific col-

laboration patterns during public health emergencies have focused specifically on the China-U.S. relationship. Regarding collaboration features for different epidemics, what is the intensity of collaboration between China and the U.S.? How have their collaboration patterns changed during COVID-19, a period of volatile global situations and intensifying tensions? What characteristics and differences do their collaboration patterns exhibit across different epidemics? These questions require in-depth exploration.

Based on this, this study further selects Severe Acute Respiratory Syndrome (SARS), which caused the first global public health emergency of the 21st century and is also a coronavirus infectious disease, as a comparative case in addition to COVID-19. Based on bibliographic data, this paper examines China-U.S. scientific collaboration patterns from perspectives of research contribution, collaboration intensity, collaboration networks, and collaboration fields, aiming to present a more comprehensive and specific view of China-U.S. collaboration trends under different public health emergencies.

2 Research Data and Basic Statistics

2.1 Data Acquisition

To efficiently and scientifically respond to the COVID-19 pandemic, publishers and databases worldwide have launched various integrated platforms for accessing epidemic-related literature resources. Domestic platforms include the "Wanfang Medical Network COVID-19 Special Channel" [26] and the "CNKI Anti-Epidemic Knowledge Service Platform" [27], while international platforms include "Springer Nature Novel Coronavirus Research" [28], "The Lancet Coronavirus Resource Centre" [29], and "Elsevier Novel Coronavirus Information Centre" [30]. Considering that the core content of this study is China-U.S. collaboration patterns, this research focuses on English papers published in international journals as the primary data source.

Regarding data source selection for international literature, most current international platforms provide data from specific journals or publishers rather than multi-source journal data, which lacks representativeness to some extent. Integrated platforms also suffer from issues such as duplicate records, heterogeneous structures, and inconsistent information completeness (for example, PubMed's literature data does not include affiliation/country information for non-first authors before 2014 [31], making international collaboration analysis difficult). More importantly, this study examines research outputs related to both SARS and COVID-19, and unlike COVID-19, SARS does not have multiple dedicated literature resource platforms. Considering the benchmarking and comparability of literature data for the two diseases, adopting a unified data source is more appropriate.

Web of Science (WoS), as the most widely used and authoritative comprehensive database of scientific publications and citations across disciplines [32], contains structured bibliographic information and is one of the most commonly used

data sources for scientometric analysis. Multiple studies have used WoS as the data source for international literature to conduct COVID-19-related analyses [2,11,13,33-34]. Considering the authority, representativeness, and applicability of the data, as well as the benchmarking and comparability of SARS and COVID-19 research results, this study uses the Science Citation Index Expanded (SCI-E) and Social Sciences Citation Index (SSCI) from the WoS Core Collection as data sources, with document types limited to Articles and Reviews.

The search strategy combined Medical Subject Headings (MeSH) terms related to the viruses from the U.S. National Library of Medicine with commonly used vocabulary. The search strategies and retrieved document volumes are shown in Table 1 .

2.2 Basic Statistics

For temporal division, since the SARS literature spans a large time range, we used the year information provided in the WoS database for time segmentation. The COVID-19 literature, concentrated in 2020, was divided by month to show fine-grained changes. Given that the "Publication Date" field containing month information in the WoS Core Collection has serious missing data, the month information for COVID-19 literature was obtained by linking PubMed IDs to the PubMed database. Ultimately, 34,078 documents could be matched to specific month information.

As shown in Figure 1 [Figure 1: see original paper], global academic attention to SARS originated from the 2003 outbreak, with publication volume peaking within two years after the outbreak and showing an overall declining trend thereafter. In contrast, COVID-19-related literature experienced explosive growth in April and May 2020, with subsequent growth remaining strong and only a slight decline in November and December. Overall, the academic community has responded actively and rapidly to emerging epidemics.

The top 10 countries/regions by total publication volume (using full counting method [35]) for SARS and COVID-19 research are shown in Figure 2 [Figure 2: see original paper]. From a global perspective, Asian countries/regions, as the main outbreak areas for SARS, participated more extensively in epidemic-related research activities. In COVID-19 research, European countries such as the UK and Italy, which were among the first to experience the outbreak, also had high publication outputs. Specifically regarding China and the U.S., in SARS research, China had the highest publication volume, with the U.S. a close second. In COVID-19 literature, the U.S. was the top publishing country, far ahead of China in second place.

3 Collaboration Pattern Analysis

3.1 Research Contribution

Scientific papers are a primary form of research output and an important indicator of research contributions from different countries/regions, institutions, and scholars. In addition to publication quantity and proportion, "research dominance" is also an important dimension reflecting different countries/regions' contributions to collaborative epidemic response. This section compares China and the U.S. research contributions across the two epidemics from the perspectives of "publication scale" and "collaboration dominance."

3.1.1 Publication Scale Perspective The basic statistical analysis above shows that China and the U.S. are both core forces in research on the two epidemics. However, as the core outbreak regions changed over time, this may have affected countries'/regions' attention to epidemic research. How did China and the U.S. change their attention to epidemic-related research across different epidemic stages, and how sustainable was this attention?

As shown in Figure 3 [Figure 3: see original paper], as one of the core outbreak areas for SARS, China produced substantial literature during the SARS outbreak period—Chinese scholars' participation in papers exceeded 45% in 2003, and remained above 30% in the following two years. After 2005, Chinese scholars' research enthusiasm diminished as the epidemic ended, with both publication volume and proportion showing a clear downward trend. The U.S. participation proportion in SARS research remained at approximately 25% for an extended period, indicating more sustained attention to SARS compared to China. For COVID-19 research, before March 2020, China's publication volume and proportion were both significantly higher than those of the U.S., coinciding with the concentrated outbreak period in China. After March, as China's epidemic situation eased, its publication proportion showed a clear declining trend. Meanwhile, Europe and the U.S. were experiencing outbreak phases, with European and American countries'/regions' publication proportions rising continuously from April to June, and the U.S. proportion surpassing China's in June.

Overall, China's publications during both epidemics demonstrated higher "epidemic sensitivity," meaning they tended to change with epidemic situations—for example, Chinese publications decreased as epidemics eased. This study argues that scientific response systems for public health emergencies need flexible adjustment according to different epidemic stages, but should also ensure systematic and sustainable research investment.

3.1.2 Collaboration Dominance Perspective To explore dominance differences between China and the U.S. across different collaboration types, this study classified literature based on the number of countries/regions involved: single-country literature (all author affiliations belong to China or the U.S.

exclusively), bilateral collaboration literature (all author affiliations belong to China and the U.S. only), and multilateral collaboration literature (author affiliations belong to China, the U.S., and other countries/regions). In both SARS and COVID-19 research, nearly half of the literature by Chinese and American scholars is "single-country literature." In collaborative research between the two countries, the volume of bilateral collaboration literature is significantly higher than that of multilateral collaboration involving other countries/regions.

In co-authored literature, the first author can be considered the "leader" in scientific collaboration activities [36]. Figure 4 [Figure 4: see original paper] shows the proportion of first authors from China and the U.S. across different collaboration types. Overall, in both SARS and COVID-19 research, the proportion of first authors from China in bilateral and multilateral collaborative literature is significantly higher than that from the U.S., reflecting Chinese scholars' relative leadership in public health emergency research. Specifically, the proportion of first authors from China in COVID-19 bilateral collaboration literature is higher than in SARS research, indicating stronger Chinese leadership in bilateral collaboration with the U.S. during the COVID-19 pandemic. However, the combined proportion of first authors from China and the U.S. in COVID-19 multilateral collaboration is lower than in SARS research, suggesting that more countries/regions played leading roles in research during this globally widespread event compared to SARS.

3.2 Collaboration Intensity

Compared to absolute numbers of collaborative papers, collaboration intensity indicators are often used to reflect the closeness of collaboration between countries/regions because they standardize for different levels of scientific productivity. This section first reviews traditional indicators, proposes an improved method for calculating collaboration intensity, and then compares China-U.S. collaboration intensity and its changes across different periods of the two epidemics based on this method.

3.2.1 Collaboration Intensity Indicators Building upon indicators such as co-authored paper counts and proportions, this study primarily uses collaboration intensity indicators to characterize the closeness of collaboration between countries/regions. The Salton index is a commonly used metric for calculating collaboration intensity [2,36-38], with the formula:

$$r_{AB} = \frac{P_{AB}}{\sqrt{P_A \times P_B}}$$

In this formula, the numerator P_{AB} represents the number of papers co-authored by country A and country B. For P_A and P_B, there are different interpretations. The most common interpretation is that P_A is the total number of papers published by country A, and P_B is the total number of papers published by country

B, where "total papers" includes not only co-authored papers involving both countries but also single-country papers from each nation. However, T. Luukkonen and colleagues' 1993 article [39] treated P_A (P_B) as the number of internationally co-authored papers by country A (B), excluding single-country papers. This method calculates collaboration intensity based solely on each country's collaborative papers.

Both interpretations analyze collaboration intensity from a "paper count" perspective without considering the "scale" of collaboration—the number of countries/regions involved in co-authored articles. Generally, the collaboration intensity of a bilateral paper between countries A and B should be greater than that when A and B both participate in a multilateral paper. Therefore, this study treats P_A (P_B) in the Salton index as the number of "collaboration links" between country A (B) and all other countries/regions. A "link" refers to a collaborative relationship between country A (B) and each other country/region in a paper. For example, if a paper involves collaboration among countries A, B, and C, then A's collaboration links are "A-B" and "A-C." When calculating collaboration intensity between A and B, the denominator is the total number of "collaboration links" between country A (B) and all other countries/regions. Based on this indicator, the more countries/regions involved in a paper (the larger the collaboration scale), the larger the denominator value, and the weaker the collaboration intensity between countries A and B. This study uses this algorithm to calculate collaboration intensity between countries for subsequent analysis.

3.2.2 Changes in Collaboration Intensity Since the COVID-19 outbreak, the global academic community has continuously called for strengthened scientific collaboration and shared research. C.V. Fry and colleagues' comparative analysis of "coronavirus" literature before and after the outbreak showed that China-U.S. collaboration became closer after the COVID-19 pandemic [21]. How does China-U.S. collaboration intensity compare between the two coronavirus-caused epidemics, SARS and COVID-19, and how does it change across different time periods?

Based on the complete SARS (2003-2019) and COVID-19 (2020) datasets, China-U.S. collaboration intensity in SARS research is 0.325, while for COVID-19 it is only 0.147—significantly lower than in SARS research. Changes in different collaboration types (bilateral/multilateral) can partially explain this difference. Specifically, the proportion of China-U.S. bilateral collaboration in COVID-19 research (9.4%) decreased significantly compared to SARS research (12.14%), while the proportion of multilateral collaboration was higher in COVID-19 research (6.56% vs. 4.8% in SARS). According to the calculation principle of this collaboration intensity indicator, the more countries/regions involved in a paper, the weaker the collaboration intensity between target countries (China and the U.S.).

From a social factors perspective, international collaboration relationships and

patterns are influenced by multiple factors such as geography, language, political environment, and economic development level [40-41]. Among these, changes in political situations between countries/regions are important factors affecting collaboration tendencies [42]. Retrospective analysis of major China-U.S. relations events, as well as relevant government and academic discourse on bilateral relations, shows that China-U.S. relations in 2003 developed steadily on a relatively stable foundation, with further deepening cooperation in multiple international areas [43-44], providing a favorable political environment foundation for scientific collaboration in response to SARS. However, the sudden COVID-19 pandemic has not only posed enormous challenges to people's lives, economic trade, and social stability worldwide but has also profoundly influenced the evolution of the global political landscape [45-46]. The complex political relationship and intensified strategic competition between China and the U.S. may be one reason for the significant changes in scientific collaboration intensity between the two countries during the COVID-19 pandemic.

To further observe collaboration intensity during the intensive publication period after the outbreak, this study uses SARS data from the concentrated publication period of 2003-2006 and COVID-19 data from different quarters of 2020 for time-segmented comparison, as shown in Figure 5 [Figure 5: see original paper]. The results show that China-U.S. collaboration intensity in all COVID-19 periods is lower than in SARS research. In the early stage of COVID-19, when China was the core outbreak region with the highest publication volume, collaboration with the U.S. was relatively close. However, over time, China-U.S. collaboration intensity showed a "cliff-like" decline. Data from both epidemics indicate that China-U.S. collaboration intensity tends to decline over time. As mentioned above, the complex and changing international landscape may be one of the social background factors for the significant decline in collaboration intensity during COVID-19. Additionally, China's significant improvement in the epidemic situation after March-April 2020 may also be a reason for the decreased collaboration intensity.

3.3 Collaboration Networks

To comprehensively display China-U.S. collaboration networks in research related to the two epidemics, this study examines the networks from both global and bilateral perspectives. It first compares China and the U.S.'s positions and centrality in global collaboration networks, then analyzes the evolution of each country's collaboration network across different time periods.

3.3.1 Global Perspective Figure 6 [Figure 6: see original paper] shows visualization maps of collaboration networks among the top 30 countries/regions by publication volume for both epidemics. From a global perspective, COVID-19 research involves more extensive international collaboration, with greater participation from Middle Eastern and African countries/regions compared to SARS research. From a China-U.S. perspective, as major contributors to both SARS

and COVID-19 research, the two countries are each other's closest partners. Additionally, Canada is also a close collaborator for both China and the U.S. in both epidemics.

To analyze international collaboration networks more precisely, this study uses social network analysis indicators—degree centrality, betweenness centrality, and closeness centrality—to examine the influence of China, the U.S., and other countries/regions on information and resource transmission in international collaboration networks. Table 2 shows the centrality indicators for the top 10 countries/regions by total publication volume in the international collaboration network. The results show that the U.S. has the highest degree, betweenness, and closeness centrality in both SARS and COVID-19 research. Although China ranks first and second in publication volume for the two epidemics, all three centrality indicators are lower than those of the U.S. This indicates that in global collaboration networks, China has fewer direct collaborative relationships than the U.S. and lower control over network resources. Based on the normalized centrality measures, the U.S. occupies a core position in international collaboration networks for both epidemics, while China's centrality is significantly lower despite its large publication volume.

3.3.2 China-U.S. Perspective Tables 3 and 4 show the top 10 countries/regions by collaboration intensity with China and the U.S. respectively across different time periods in SARS and COVID-19 research.

As shown in Table 3, China and the U.S. have long been each other's closest partners in SARS research. During the concentrated publication period (2003-2006), China, the U.S., and Canada formed a tight collaboration network. Additionally, during this period, China tended to collaborate with Australia and European countries/regions. However, in later SARS research (2007-2019), the ranking of collaboration intensity between China and European countries/regions generally declined, while Singapore's collaboration intensity ranking with China increased significantly. Unlike China, the U.S. in SARS research (with Asia as the core outbreak region) had higher collaboration intensity with Asian countries/regions such as Taiwan (China), Singapore, and Japan during 2003-2006, while later periods showed a gradual shift toward collaboration with Europe and Australia.

As shown in Tables 4 and 5 , similar to SARS research findings, China and the U.S. are also each other's closest collaborators in COVID-19 research. In the early stage when China was the core outbreak region, China, the U.S., Canada, and the UK formed a tight collaboration network. As the pandemic spread globally (April-June 2020), Italy's collaboration intensity ranking with both China and the U.S. increased to varying degrees, particularly with the U.S. During the same period, an increasing number of Asian countries/regions, such as South Korea, Japan, Taiwan (China), and the Philippines, rose in China's collaboration intensity rankings. Subsequently, apart from each other, the U.S. and China formed relatively stable collaborative relationships with Canada and

the UK respectively. Meanwhile, India's collaboration intensity ranking with the U.S. showed an upward trend, while Pakistan's collaboration with China became increasingly close.

3.4 Collaboration Fields

To explore differences in China-U.S. collaboration patterns across different research fields, this study uses the widely adopted Web of Science subject categories (WCs) [47] to compare China and the U.S. publication distributions and collaboration intensity across disciplines. It first compares disciplinary distributions and core field collaboration intensity from the total publication perspective, then examines field distribution characteristics of different types of collaborative literature.

3.4.1 Total Publication Perspective Figure 7 [Figure 7: see original paper] shows the top 10 core disciplines by total publication volume for China and the U.S. From the perspective of major disciplines in total publications, virology is the most concentrated discipline for both China and the U.S. in SARS research, yet it does not appear among the top 10 disciplines in COVID-19 literature distribution. In COVID-19 research, public health, environmental and occupational health literature is most numerous, with the vast majority from the U.S. and only a small portion from China. This aligns with existing research findings that Chinese scholars have relatively weaker attention to public health research compared to European and American scholars in scientific responses to major historical health events [2]. Specifically examining China's disciplinary distribution, virology and biochemistry/molecular biology have the highest literature volumes in SARS research, indicating high Chinese scholarly attention to basic medical research at the molecular level of the SARS virus. In COVID-19 research, infectious diseases and internal medicine have the highest literature volumes, showing greater Chinese scholarly focus on the disease itself and clinical internal medicine research. In addition to medical and biological sciences, "psychiatry" related research has also received considerable attention in the prolonged global COVID-19 pandemic, mostly from U.S. scholars, indicating that the academic community is exploring the pandemic's impact from broader social perspectives.

Figure 8 [Figure 8: see original paper] shows China-U.S. collaboration intensity comparisons across eight overlapping disciplines among the top 10 disciplines for SARS and COVID-19. Only the discipline of "infectious diseases" maintains the same collaboration intensity level in both disease studies, while collaboration intensity in all other disciplines is substantially lower in COVID-19 research than in SARS research. From a temporal perspective, the above conclusions still hold. First, except for "infectious diseases," China-U.S. collaboration intensity in all other disciplines is lower in COVID-19 research than in SARS research. Additionally, in the top 10 disciplines for both SARS and COVID-19, China-U.S. collaboration intensity shows a declining trend over time.

3.4.2 Collaborative Literature Perspective The above analysis is based on disciplinary distribution of total publications involving China and the U.S. This section further examines differences in focus areas between China and the U.S. across different collaboration types, using all China-U.S. collaborative literature as the data foundation, as shown in Figure 9 [Figure 9: see original paper].

First, in terms of overall collaborative publication volume, China and the U.S. prefer bilateral collaboration over multilateral collaboration in both epidemics. In SARS research, China-U.S. co-authored literature is concentrated in three major disciplines: virology, infectious diseases, and biochemistry/molecular biology, with multilateral collaborative literature more distributed in infectious diseases and immunology. In COVID-19 research, the top three disciplines for China-U.S. co-authored literature are immunology, public health/environmental and occupational health, and infectious diseases. Compared with bilateral collaboration, multilateral collaborative research focuses more on multidisciplinary fields, immunology, public health, and internal medicine. Overall, China and the U.S. show slightly different emphases across focus areas in different collaboration types.

4 Conclusions and Discussion

4.1 Research Conclusions

This study examines scientific outputs and collaboration patterns between China and the U.S. during the SARS and COVID-19 infectious disease outbreaks from perspectives of research contribution, collaboration intensity, collaboration networks, and collaboration fields.

In terms of research contribution, China and the U.S. are both major contributors to research on the two epidemics. Existing research shows that the U.S. is a major contributor in international public health emergencies caused by various viruses (such as H1N1 influenza, Ebola, and Zika), while China focuses more on diseases with severe domestic outbreaks and pays relatively less scientific attention to Ebola and Zika [2]. This study's findings align with these conclusions: the U.S. remains a major contributor to SARS and COVID-19 research, while China, as one of the early core outbreak regions for both epidemics, is also a major contributor worldwide. Additionally, from the perspective of collaboration dominance reflected by first authors, Chinese scholars occupy a relatively dominant position compared to U.S. scholars in both bilateral and multilateral collaborations.

Regarding collaboration intensity, China-U.S. collaboration is lower in COVID-19 research than in SARS research. Although China and the U.S. remain each other's closest partners in both epidemics, their collaboration intensity in COVID-19 research is significantly lower than in SARS research. From a temporal perspective, collaboration intensity between the two countries shows a declining trend over time in both epidemics. As discussed above, the com-

plex and changing international landscape may be one of the social background factors for the significant decline in collaboration intensity during COVID-19.

From a network perspective, China and the U.S. occupy important positions in global collaboration networks, but the U.S. has higher centrality indices. In terms of partner selection preferences, the U.S. tends to collaborate with countries/regions that are core outbreak areas—a tendency also observed in previous research on multiple international public health emergencies, where the U.S. collaborated more closely with African countries/regions in Ebola research [2]. This also suggests that core outbreak countries/regions tend to seek scientific collaboration with scientific powers like the U.S. As one of the early core outbreak regions for both epidemics, China similarly initially preferred collaboration with developed countries/regions in Europe, America, and Australia, with collaboration intensity with Asian countries/regions increasing later.

Regarding collaboration fields, eight of the top 10 disciplines in China-U.S. SARS and COVID-19 literature overlap, focusing primarily on medical and biological sciences. Additionally, psychiatry-related issues have gradually gained attention in COVID-19 research. Notably, in public health research, most literature comes from the U.S., with only a small portion from China, again indicating that Chinese scholars pay relatively less attention to public health research in scientific responses to major health events. Furthermore, examining China-U.S. collaborative publications, different collaboration types (multilateral/bilateral) show different disciplinary focus areas—for example, in COVID-19 research, China-U.S. multilateral collaborative research is more concentrated in multidisciplinary fields.

4.2 Policy Recommendations

As the global COVID-19 pandemic continues to spread, close scientific collaboration, joint research efforts, and sharing of research results and experiences are crucial means to concentrate forces against this common threat to global public health security. However, differences in systems, cultures, politics, economies, and societies among countries and regions lead to different measures in response to the pandemic. Based on this study's findings, three recommendations are proposed to improve China's scientific response system for public health emergencies:

(1) **Flexibly adjust research response mechanisms while ensuring sustainable attention to viruses and related diseases.** The results show that although China's total publication volume ranks first and second in SARS and COVID-19 research respectively, its research enthusiasm for SARS diminished as the epidemic ended, showing weaker sustained attention compared to the U.S. As Zhang Jingren, Vice Dean of Tsinghua University School of Medicine, noted in an interview, China did not conduct systematic research on the SARS virus and related diseases after the SARS epidemic ended, nor did it use known information about

SARS virus infection to establish reliable animal infection models. The lack of understanding of such pathogens' biological characteristics made it difficult to provide timely and effective guidance for COVID-19 vaccine development [48]. Therefore, this study argues that while the academic community should flexibly adjust research response mechanisms according to different epidemic stages, it should also ensure sustainable and systematic investment in basic research on COVID-19, coronaviruses, and infectious diseases. On one hand, the current severe global pandemic situation still requires intensive research efforts; on the other hand, long-term basic research on viruses and related diseases, accumulating rich scientific knowledge, experience, and technology, is an important pathway for rapid and effective response to future public health emergencies.

(2) **Support research in health and medical fields while also addressing epidemic impacts from broader social perspectives.** The global pandemic is not only a biological and medical issue but also a social, political, cultural, and economic problem, with these backgrounds being integral components of the epidemic itself [49]. As UN Secretary-General António Guterres called for in May 2020, the international community should pay attention to mental health issues triggered by COVID-19, stating that "the pandemic is not only attacking our bodies but also causing increasing psychological distress" [50]. Governments, health organizations, and research institutions should actively address psychological and social problems caused by the epidemic. This study shows that Chinese scholars' publication trends in public health and psychiatry are still relatively weak compared to the U.S. China's scientific response to epidemics needs to address impacts from broader social perspectives, strengthening attention to public health, sociology, and psychology while maintaining biomedical research as the core, to explore the multidimensional impacts of the pandemic on public health and social development and better address social problems triggered by the epidemic.

(3) **Actively expand international collaboration networks and strengthen scientific collaboration with countries worldwide.** The COVID-19 pandemic is a challenge for all humanity, requiring global cooperation and joint response. Scientific research, as an indispensable part of epidemic prevention and control, also needs to gather global scientific forces to combat the epidemic collectively. The multiple impacts of emerging infectious diseases on society and the economy also profoundly affect global development patterns and trends, bringing changes to global scientific collaboration and development models. As long-term close scientific partners, China and the U.S. have significantly lower collaboration intensity in COVID-19 research compared to SARS research. As a leading and core force in epidemic research, China has large publication volumes but significantly lower centrality in international collaboration networks than the U.S. Based on these findings, this study suggests that China should continue to actively expand its global

scientific collaboration network, strengthen joint research efforts with different countries/regions, and enhance its international core position in scientific collaboration.

4.3 Research Outlook

Against the backdrop of complex international situations during the COVID-19 pandemic, this study uses scientific literature data from the SARS and COVID-19 outbreaks to explore collaboration patterns and changes between China and the U.S. from multiple perspectives, and discusses China's strategies for scientifically responding to epidemics, aiming to provide useful references for research efforts and scientific management during the pandemic. Additionally, this study's new interpretation of the Salton index offers new thinking and insights for methodological research on scientific collaboration calculation methods.

Based on the limitations of data source selection, research samples, and methods, future research could further expand data sources and examine more international public health emergencies to explore changes and developments in global scientific collaboration patterns across different epidemics. Furthermore, regarding the new interpretation of the Salton index proposed in this study, in-depth empirical comparison and validation with the original index could be conducted to discuss the applicability of different indicators from methodological and practical perspectives.

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Author Contributions

Zhao Wenjing: Designed the research framework, collected and processed data, wrote and revised the manuscript.
Zhang Lin: Proposed the research topic, designed the research scheme, guided data processing, revised and finalized the manuscript.
Shang Yuanyuan: Conducted literature review, verified data results, revised and reviewed the manuscript.
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A Comparative Analysis of Scientific Collaboration Patterns Between Mainland China and the USA Under Public Health Emergencies

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Abstract: [Purpose/significance] Understanding the pattern of scientific collaboration between Mainland China and the USA—the world's leading producers of scientific publications—could be beneficial to decision-makers in research and health policy in creating and adjusting anti-epidemic strategies. [Method/process] Taking publications related to SARS and COVID-19 as research objects, this study explored the collaboration patterns of Mainland China and the USA from the perspectives of research effort, collaboration strength, collaboration network and major fields on the basis of classification of collaboration types and improvement of Salton's index. [Result/conclusion] Both Mainland China and the USA are the main contributors to the research on SARS and COVID-19, while the attention of Chinese scholars to relevant research tends to change with the situation of the epidemics. Although Mainland China and the USA were the closest partners for each other in SARS and COVID-19 research, the collaboration strength between the two countries is obviously lower in COVID-19 research than that of SARS research. The USA is at the heart of both SARS and COVID-19 collaborative networks, while Mainland China's position is significantly lower. As for the research fields, Mainland China and the USA have different emphasis on the discipline distributions.

Keywords: SARS; COVID-19; scientific collaboration; social network analysis; public health

Note: Figure translations are in progress. See original paper for figures.