The Evolution of Postprints in Open Sharing of International Scientific Research during Public Health Emergencies

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Abstract

[Purpose/Significance] In response to the current situation of insufficient understanding within China's scientific community regarding the overall landscape and relevant institutional frameworks for open sharing of scientific research achievements during public health emergencies, this study systematically reviews the main developmental trajectory of international open sharing of scientific research achievements under such circumstances, aiming to present a comprehensive overview of its developmental history and related institutional frameworks, and to provide references for Chinese research institutions, government departments, and the academic community. [Method/Process] By examining the developmental history of open sharing of scientific research achievements during public health emergencies over the past two decades, and according to the differing primary concerns throughout this evolution, the process is divided into three stages, with a systematic summary and analysis of the main events, key literature, conceptual issues, policy frameworks, and practical characteristics of each stage. [Results/Conclusion] Following development across three stages, relevant norms and mechanisms have been gradually established and refined. Since 2020, the methods and approaches for open sharing of scientific research achievements during public health emergencies have undergone further rapid development, garnering significant attention from the global scientific community, prompting reflections on how the COVID-19 pandemic has transformed traditional academic communication and research paradigms, while also highlighting several issues that warrant further in-depth research and resolution.

Full Text

The Main Development Process of International Open Sharing of Scientific Research Results in the Context of Public Health Emergencies

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Abstract: [Purpose/Significance] In view of the insufficient understanding among domestic scientific communities regarding the overall situation and relevant institutional norms of open sharing of scientific research results during public health emergencies, this paper reviews the main development trajectory of international open sharing of scientific research results in such contexts, aiming to reflect its overall development process and institutional framework to provide reference for Chinese research institutions, government departments, and academic circles. [Method/Process] By reviewing the development history of open sharing of scientific research results during public health emergencies over the past two decades, and according to the different main concerns in the development process, it is divided into three stages, with main events, important documents, conceptual issues, policy norms, and practical characteristics of each stage summarized. [Result/Conclusion] After three stages of development, relevant norms and mechanisms have been gradually formed and improved. Since 2020, the methods of open sharing of scientific research results during public health emergencies have developed rapidly, attracting high attention from the global scientific community, triggering reflections that the COVID-19 pandemic has changed traditional academic communication and research paradigms, while also highlighting issues that warrant further research and resolution.

Keywords: public health emergency; scientific research results; open sharing; new model of scholarly communication; policy norms

A public health emergency (PHE) refers to "a major infectious disease epidemic, group unexplained disease, major food or occupational poisoning, or other events that suddenly occur and cause or may cause serious damage to public health" [1]. The World Health Organization (WHO) defines a Public Health Emergency of International Concern (PHEIC) as "an extraordinary event which is determined to constitute a public health risk to other States through the international spread of disease and to potentially require a coordinated international response" [2]. Such emergencies not only threaten human life and health but also severely impact social stability, economic development, and regional security.

Science and technology are the most powerful weapons for humanity to combat major disasters and epidemics, and overcoming such challenges relies on scientific development and technological innovation [3]. During public health emergencies, scientific and technological progress in protection, detection, diagnosis, treatment, pharmaceuticals, and vaccines is crucial for defeating the epidemic, saving lives, and restoring order. Whether the scientific community can promptly and openly share relevant research results (including research data, interim findings, and final results) directly affects the pace of the global scientific response.

Since the 21st century, public health emergencies have occurred frequently, and the international community has fully recognized the important role of open sharing of scientific research results in responding to such crises. This has actively promoted the formation of mechanisms for open sharing during public health emergencies, facilitating multiple instances of international scientific cooperation against epidemics. The outbreak of COVID-19 has forced changes in the model of scientific and technological innovation, and China's scientific community has recognized the important value of open sharing during public health emergencies, taking measures to promote it [4-7]. However, due to limited understanding of international mechanisms and insufficient research on relevant policies and norms, Chinese researchers' mastery and application of international rules for open sharing during public health emergencies remain inadequate, with considerable room for improvement in related initiatives.

Based on this situation, we examine the main history of international open sharing of scientific research results during public health emergencies over the past 20 years, 梳理 ing the main threads of this mechanism's formation. This work aims to reflect the overall development process and institutional norms of open sharing during public health emergencies, providing reference for Chinese research and health institutions and government departments.

According to different main concerns in the development process, we divide the evolution into three stages: the germination stage of basic concepts in the first decade of the 21st century, the formation and improvement stage of mechanisms from 2011 to 2019, and the new stage of scholarly communication and research paradigms since the COVID-19 pandemic in 2020. Using these three stages as the main framework, we summarize the main events, important documents, conceptual issues, policy norms, and practical characteristics of each stage.

The Germination of Basic Concepts for Open Sharing During Public Health Emergencies

In the first decade of the 21st century, frequent public health emergencies such as the 2003 SARS outbreak, the 2006 H5N1 influenza epidemic, and the 2009 H1N1 influenza pandemic led to the initial germination of concepts for open sharing of scientific research results during such crises.

During this period, WHO revised and formulated important documents to pro-

vide legal basis for open sharing; the public health community, influenced by genomics, reflected on and promoted open sharing; and through several public health emergencies, the international scientific community gradually formed basic concepts of open sharing and took measures to advance it.

WHO Documents Providing Legal Basis for Open Sharing

In the first decade of the 21st century, WHO revised the International Health Regulations (2005) (IHR 2005) and formulated the Pandemic Influenza Preparedness Framework (PIP Framework). These documents clarified from a legal perspective that information sharing is a core capacity requirement for responding to public health emergencies.

The International Health Regulations Establishing Information Sharing as a Basic Principle The International Health Regulations, developed by WHO and its member states, aim to prevent and control the international spread of disease and provide measures to address public health events [8]. The 2003 SARS outbreak significantly influenced the revision of IHR 2005, which was adopted at the World Health Assembly in May 2005 and entered into force in June 2007, becoming an important legal document binding on WHO and its member states [9].

IHR 2005 establishes the basic principles of information sharing during public health emergencies. Compared with the previous version, IHR 2005 imposes higher requirements on information notification and sharing, recognizing timely notification and sharing as core capacities for global response. On one hand, WHO requires member states to strengthen their abilities to monitor, detect, assess, notify, and report health events, and to provide relevant information including clinical records, laboratory results, sources and types of risks, numbers of cases and deaths, and health measures taken. On the other hand, WHO actively monitors potential public health risks through its systems and has the authority to request investigations and timely responses from concerned countries.

Article 7 of IHR 2005 specifically addresses "information sharing during unexpected or unusual public health events," requiring member states with evidence of such events within their territories that may constitute a PHEIC to provide WHO with all relevant public health information, regardless of origin or source.

The PIP Framework Clarifying Sharing Mechanisms for Influenza Virus Materials and Related Results The 2006 H5N1 influenza outbreak prompted WHO and its member states to develop the PIP Framework, which was adopted at the World Health Assembly in 2011 [10]. Officially titled the "Pandemic Influenza Preparedness Framework for the Sharing of Influenza Viruses and Access to Vaccines and Other Benefits" [11], its main objectives are to enhance sharing of pandemic influenza virus materials and related results, im-

prove global preparedness and response measures, and defend against pandemic influenza.

The PIP Framework emphasizes establishing an information sharing mechanism between national influenza centers and WHO collaborating centers to effectively share two types of PIP-related resources: (1) biological materials and related research results, such as clinical specimens (swabs, aspirates, blood, serum, plasma, excreta, and tissues), wild viruses, virus isolates, modified viruses, candidate vaccine viruses, influenza vaccines, genetic sequence data, diagnostic reagents, and related information; and (2) other clinical and epidemiological information needed for influenza virus tracking and risk assessment.

The PIP Framework also specifically addresses open sharing of influenza virus genetic sequence data, requiring member states to share such data and analytical results derived from them rapidly, timely, and systematically.

Public Health Community Reflection on Open Sharing Issues

In the early 21st century, the genomics field had established the "Bermuda Principles" and "pre-publication data release" model, becoming a leader in open sharing of biomedical research results. Under its influence, the public health community reflected on sharing issues in its own field, gradually forming concepts of open sharing and working to build policy and governance frameworks.

Genomics Sharing Models Influencing Public Health Research The Bermuda Principles were proposed at the first International Strategy Meeting on Human Genome Sequencing in Bermuda in February 1996 and further refined at meetings in 1997 and 1998 [12-13]. Most importantly, the principles established two fundamental rules for releasing human genome sequence data: (1) important genomic sequence data are public property, and large-scale sequencing funded by grants should be made freely available to the public to encourage research and development for maximum societal benefit; and (2) important genomic sequence data should be released rapidly, with sequence assembly data automatically released daily if it exceeds 1Kb, and annotated sequences submitted immediately to public databases [14].

The Bermuda Principles prevented funded institutions from hoarding data privately and broke attempts by private institutions to profit from patenting genetic data [15], ensuring that important genetic sequence information is shared by all humanity.

The genomics field also developed the "pre-publication data release" model, which requires timely data release before formal publication, accelerating genomics research. At the 2003 Fort Lauderdale meeting on "Sharing Data from Large-Scale Biological Research Projects," funding agencies proposed establishing a "tripartite responsibility-sharing" organizational system [16] to ensure this model's feasibility and promote it to other biomedical fields.

In 2008, the proteomics community proposed the Amsterdam Principles to advance "pre-publication data release" in their field [17]. In 2009, the Toronto Data Release Workshop proposed extending "pre-publication data release" to broader biomedical data, including chemical structures, metabolomics, RNA interference (RNAi), and annotated clinical data resources (such as study populations and case-control studies) [18], driving open sharing in public health.

Global Health Community Building Policy and Governance Frameworks Inspired by genomics, the health community recognized that open sharing of research results could accelerate public health research, improve health environments, and promote life and health, while also identifying four challenges: incentive mechanisms, data management capacity, ethical issues, and technical standards [19-20].

To address these challenges, WHO and Wellcome Trust have worked since 2008 to develop a common code of conduct for open sharing of research results in public health to transform research models in the field. These efforts led 17 health research funding agencies to sign the "Joint Statement of Health Research Funding Agencies on Sharing Research Data to Improve Public Health" in January 2011 [21], establishing open sharing policies for public health research data they fund.

The statement proposes promoting open sharing based on principles of fairness, ethics, and efficiency, with short-term goals including developing data management standards, recognizing data management and sharing as professional indicators of important research achievements, and creating an environment where data users respect data producers' rights while adding value to original data. Long-term goals include building more well-documented public health datasets for secondary analysis, significantly enhancing data management and analysis capacity in public health, effectively linking and archiving published results with related data, and forming sustainable data sharing cultures and mechanisms.

To achieve these goals, these funding agencies established the Public Health Research Data Forum [22-23] to address issues of data citation, discovery, and linkage, and to promote data sharing policies and governance frameworks in health.

International Community Strengthening Response and Promoting Practice

Since the 21st century, frequent public health emergencies have prompted WHO and international health institutions to strengthen epidemic response systems and cooperation, promoting timely open sharing of research results. The successful responses to SARS and H5N1 demonstrated the value of open sharing and created exemplary cases.

WHO Strengthening Epidemic Response Systems and Demonstrating Value During SARS Since 2000, WHO has continuously strengthened its Global Influenza Surveillance and Response System (GISRS) [24] and Global Outbreak Alert and Response Network (GOARN) [25]. Both are essentially laboratory network alliances for monitoring, preventing, and responding to epidemics. GISRS, established in 1952 specifically for influenza, was strengthened by the PIP Framework in the 21st century [26]. GOARN, established in April 2000, brings together research teams, professionals, and technical resources to help the global health community rapidly identify, confirm, and respond to public health emergencies. Both systems cooperate in research and promote sharing of pathogen materials and related results.

In 2003, these systems played important roles in identifying the SARS pathogen and developing diagnostic methods. Under their support, WHO organized 13 laboratories on March 17, 2003, to form a collaborative research network to identify the SARS pathogen. Using modern communication technology, this network shared research results on SARS clinical samples in real time, including electron microscopy images, viral gene sequences, and virus isolates. Within two weeks, the network identified the virus causing SARS and completed its genome sequencing, enabling WHO to provide timely guidance to the international health community and recommendations for SARS prevention [27-28].

The collaboration and sharing during the SARS outbreak demonstrated the value of open sharing during public health emergencies, showing that timely sharing could accelerate research and support effective prevention and control. Many scientists believed that open sharing should become routine practice during such crises.

GISAID and EpiFlu as Exemplars of Open Sharing in Public Health Between 2003 and 2006, H5N1 influenza spread globally, yet scientists faced great difficulty accessing the latest viral gene sequence information [29-30]. This motivated influenza researchers and health experts worldwide to launch the Global Initiative on Sharing All Influenza Data (GISAID) in August 2006, promoting sharing of viral gene sequencing information and collaborative research and publication [31].

GISAID, modeled on large-scale biological research data sharing mechanisms, issued the GISAID Database Access Agreement as a guideline for data sharing and utilization [32]. This agreement emphasizes that all users must abide by basic scientific norms, including acknowledging contributions of source laboratories providing samples and sequencing laboratories generating sequence data, ensuring fair utilization of results derived from data, and agreeing not to impose restrictions on data submitted to GISAID, thus enabling cooperation based on open sharing while respecting all parties' rights [33].

In 2008, the World Health Assembly officially launched the GISAID platform (EpiFlu database). The emergence of GISAID and EpiFlu provided influenza

researchers, scientists, and health officials with a trusted sharing mechanism for all influenza data, becoming a model for open sharing in health. Today, GISAID continues to play an irreplaceable role in sharing influenza data.

Formation and Improvement of Open Sharing Mechanisms

The second decade of the 21st century witnessed even more frequent global public health emergencies. WHO declared four PHEICs during this period: the 2014 polio outbreak, the 2014 Ebola outbreak, the 2015-2016 Zika outbreak, and the Ebola outbreak since 2018. Additionally, Middle East Respiratory Syndrome (MERS) outbreaks occurred in 2012 and 2015. Each major outbreak heightened international attention on rapid sharing of research results to accelerate response.

Under WHO's leadership, major international organizations, funding agencies, and research groups carefully studied open sharing issues, proposed policy principles, formed normative frameworks, promoted publishing model reforms, and gradually established and improved open sharing mechanisms.

WHO Actively Promoting Policy Development for Open Sharing

Rapid open sharing of research results during public health emergencies can accelerate pathogen identification, disease transmission prediction, diagnostic standard determination, and disease control [34]. Public health managers, clinicians, and government agencies all benefit from open sharing to control epidemics [35]. However, during the 2012 MERS and 2014 Ebola outbreaks, individuals and organizations were reluctant to share results and data promptly, affecting response efforts [36].

To address this, WHO led member states to solve policy issues, proposing global norms for sharing data and results during public health emergencies and formulating WHO's data sharing policies and draft codes of conduct for rapid open sharing of pathogen genetic sequence data during outbreaks.

Proposing Global Norms for Sharing Data and Results In September 2015, WHO convened the "2015 WHO International Stakeholder R&D Blueprint Meeting" to discuss sharing of research results and data during public health emergencies. Following the meeting, WHO issued the statement "Developing Global Norms for Sharing Data and Results During Public Health Emergencies," clarifying that timely and transparent "pre-publication release of data and results" must become a global norm [37].

The core content states that researchers with epidemic-related data or results should share them promptly once preliminary findings reach publishable quality. Researchers and funders should share results through "pre-publication release" or through "post-publication peer review" mechanisms for immediate

publication. Participating biomedical journals agreed to promptly disclose information related to public health emergencies and not discriminate against "pre-publication released" results in subsequent formal publication. The International Committee of Medical Journal Editors (ICMJE) expressed support for this statement [38].

The statement also provides clear recommendations on quality control, incentives, ethics, intellectual property, concealment risks, and privacy issues during public health emergencies, suggesting these be considered in future revisions of the International Health Regulations. This milestone document established a policy basis for global open sharing of scientific research results during public health emergencies.

Clarifying WHO's Main Data Sharing Policies To further elaborate its data sharing stance, WHO issued the "Policy Statement on Data Sharing by the World Health Organization in the Context of Public Health Emergencies" in April 2016 [39], outlining its basic policies for open sharing of three types of data:

(1) For surveillance, epidemiological, emergency response, and health facility data: WHO should disclose these when conditions specified in IHR are met, including when a PHEIC has occurred, when there is evidence of international spread, when control measures are unlikely to succeed, when states lack capacity to prevent further transmission, or when related information has been publicly disclosed elsewhere. WHO requires anonymization before release to protect privacy and confidentiality.

(2) For genetic sequence data: WHO believes sharing genetic sequence data helps track epidemics and develop diagnostic tests, treatments, and vaccines. Therefore, WHO advocates rapid open sharing of such data through genetic databases, with fair benefit-sharing with source countries.

(3) For observational and clinical trial data: WHO emphasizes improving transparency, requiring all interventional clinical trials during public health emergencies to be registered in major trial registries in advance, with specific commitments to accelerated timelines for sharing results. Once the committed timeline arrives, relevant institutions and personnel must provide interim or final results without delay.

Correspondingly, participating biomedical journals agreed to promptly disclose information related to public health emergencies and not discriminate against "pre-publication released" results in subsequent formal publication.

Proposing a Code of Conduct for Open Sharing of Pathogen Genetic Sequence Data In September 2017, WHO specifically convened the "WHO R&D Blueprint Meeting on Pathogen Genetic Sequence Data Sharing in the Context of Public Health Emergencies" to discuss pathogen genetic sequence data sharing [40], forming the draft "WHO Code of Conduct for Open and

Timely Sharing of Pathogen Genetic Sequence Data During Infectious Disease Outbreaks" [41]. This draft code has been widely consulted but not yet officially released [42].

The draft requires all relevant institutions to commit to timely open sharing of complete pathogen genome data during public health emergencies, enabling the international health community to access relevant information promptly. Sequencing institutions should complete data generation and public release within 21 days of receiving samples.

The draft reaffirms the "pre-publication release" mechanism for pathogen genetic sequence data. To address concerns that other scientists might use released sequences to publish papers unrelated to the original data providers, the draft proposes a "publication embargo disclaimer" system, allowing original data providers to release data with a statement prohibiting others from publishing papers using the data without consultation.

Global Research Institutions Calling for Publishing Reform

The 2014 Ebola outbreak and 2015-2016 Zika outbreak demonstrated that traditional scientific publishing systems cannot effectively support open sharing during public health emergencies. Following WHO's 2015 statement, global health research institutions actively responded, working to reform publishing models.

Major Health Research Institutions Signing Statements to Break Traditional Publishing Models In February 2016, as the Zika outbreak was declared a PHEIC [43], Wellcome Trust and over 30 global health research institutions (later growing to more than 50) signed the "Statement on Data Sharing in Public Health Emergencies" [44]. Signatories committed to making all research data collected during the Zika outbreak and future public health emergencies openly available in a timely manner to ensure the global health community can develop response measures based on the latest and most effective scientific evidence.

The statement focused on how journal publishers and research funders should achieve sharing during PHEICs. Specifically, signatory publishers committed to ensuring all Zika-related literature they publish is open access, prioritizing papers and data publicly released on preprint servers or elsewhere for rapid dissemination rather than rejecting them. Signatory funders committed to requiring researchers working on public health emergencies to establish mechanisms for rapid, broad sharing of quality-assured interim and final results.

Ebola Outbreak Again Driving Publishing Model Reform In 2018, an Ebola outbreak occurred in the Democratic Republic of Congo. Although not yet declared a PHEIC, Wellcome Trust and other institutions recognized the serious threat and issued the "Statement on Sharing Research Findings and

Data Relevant to the Ebola Outbreak in the Democratic Republic of Congo" in May 2018 [45].

Consistent with the 2016 statement, it reaffirmed commitments from publishers and funders but made three notable advances: (1) it clarified that principles apply to similar future public health emergencies, not just PHEICs; (2) it called on other funders, journals, and research organizations to adopt these principles as routine practice; and (3) it strongly encouraged funded researchers to use new models like open research publishing platforms (e.g., Wellcome Open Research) or preprint servers for rapid publication.

Glopid-R Promoting Systematic Framework Construction

Despite consensus on open sharing, practical implementation faces many challenges, including implementation pathways, incentives, infrastructure, and ethical and legal requirements. In March 2016, the Global Research Collaboration for Infectious Disease Preparedness (Glopid-R), a research funding alliance in infectious disease prevention and control, established a data sharing working group [46] to build a systematic framework for effective data sharing during public health emergencies.

Glopid-R Proposing Core Principles for Data Sharing Glopid-R's working group identified core principles as key to building a systematic framework. In June 2018, based on analysis of data sharing issues, they released "Data Sharing in Public Health Emergencies: Principles" [47-48], identifying seven principles: (1) Timeliness: provide data sharing as quickly as possible with minimal access restrictions; (2) Ethics: comply with moral and legal requirements to protect confidentiality, personal privacy, and community dignity; (3) Accessibility: minimize technical or legal restrictions; (4) Transparency: clearly describe how data are shared and accessed, including timelines and conditions; (5) Fairness: provide data free or at cost-recovery prices only, rejecting profit-making; (6) Objectivity: ensure all participants are treated fairly with contributions recognized; and (7) Quality assurance: providers must guarantee data quality, and users must ensure proper data processing and analysis.

Glopid-R Developing a Roadmap for Data Sharing To provide an implementation pathway, Glopid-R released the "Glopid-R Roadmap for Data Sharing in Public Health Emergencies" in June 2019 [49], analyzing effective measures funders can take to encourage grantees to share data. The roadmap identifies three strategic steps: (1) improve data sharing levels in Glopid-R-funded projects; (2) extend improvements to other funded projects; and (3) create a data sharing culture and build infrastructure. It addresses five issues: inappropriate funding policies, researcher capacity, trust between research groups, funder influence, and systemic paradigm transformation, proposing 13 action recommendations.

New Development Stage of Open Sharing During Public Health Emergencies

The COVID-19 outbreak in early 2020 constitutes the largest public health emergency in nearly a century. The world is responding with unprecedented cooperation. To achieve open sharing during this crisis, important international organizations have issued new recommendations from legal and organizational perspectives, while research institutions call for paradigm transformation and new models of scholarly communication. Within just over four months, preprint communication, open rapid review, post-publication peer review, and open datasets supporting data mining have rapidly developed, attracting global attention and triggering reflections that COVID-19 is changing traditional academic communication and research paradigms. However, this outbreak has also highlighted issues requiring attention.

International Organizations Clarifying Requirements for Scholarly Communication Models

Since the COVID-19 outbreak, important international organizations have further clarified specific requirements for information sharing.

WHO, GPMB and Others Specifying Information Sharing Requirements for COVID-19 On January 30, 2020, WHO declared COVID-19 a PHEIC [50] and recommended that countries regularly share information, cooperate in research, and promote global sharing of experiences and successful measures. WHO praised China's transparency in investigating and controlling the outbreak, affirmed its timely sharing of data and biological materials, and called for continued sharing of case data. WHO specifically required all countries to share all data with WHO, emphasizing this is a legal requirement under IHR 2005.

On the same day, the Global Preparedness Monitoring Board (GPMB), convened by WHO and the World Bank [51], issued a statement on the COVID-19 outbreak [52], calling for six urgent actions, three concerning information sharing. GPMB required states, institutions, communities, and partners to ensure open, rapid sharing of all outbreak-related information to support response under IHR 2005. It demanded timely, unrestricted sharing of coronavirus samples and clinical specimens to advance R&D, early diagnosis, and global response. To ensure rapid sharing of new discoveries, GPMB required immediate open access to all peer-reviewed research publications related to the outbreak and rapid sharing of research data with WHO. GPMB also emphasized that states, institutions, media, and WHO should communicate timely, accurate, and transparent information to the public.

International Research and Health Institutions Building New Scholarly Communication Models In response to GPMB and WHO calls, 85

international institutions (now 153) signed the "Statement on Sharing Research Data and Findings Relevant to the Novel Coronavirus (COVID-19) Outbreak" on January 31, 2020 [53], deepening the principles established in the 2016 statement. The main contents include: (1) immediate open access or free availability during the outbreak for all published, peer-reviewed research related to the outbreak; (2) journals sharing COVID-19-related submissions with WHO immediately upon author notification; (3) releasing all research results first through preprint servers or other "publish first, peer review later" platforms, with clear statements on data availability, followed by journal publication; (4) researchers sharing interim and final data, experimental steps, and data collection standards as quickly and widely as possible with public health and research institutions and WHO; and (5) informing authors that pre-publication data sharing or preprints will not affect subsequent journal publication.

This statement outlines a new model of scholarly communication during public health emergencies.

National Science Advisory Bodies Proposing Open COVID-19 Datasets On March 13, 2020, national science and technology advisory bodies from 12 countries proposed an initiative specifically requesting journals to open all published research papers and data on coronavirus, SARS-CoV-2, and COVID-19, granting users rights for secondary reuse to support text mining and enhance pandemic control capabilities [54]. As of July 2, 2020, 43 major international publishers have committed to supporting this initiative, agreeing to provide all COVID-19 and coronavirus-related publications and data in PubMed Central (PMC) and other appropriate public repositories (such as WHO's COVID-19 database) with reuse permitted [55].

Innovation Practices in New Scholarly Communication Models

Corresponding to these requirements, global research and health institutions have rapidly implemented various open sharing methods since 2020, quickly promoting innovation in scholarly communication models during public health emergencies.

Academic Communities Promoting New Publishing and Review Models Preprint-based publishing has gained scientific community recognition. During the COVID-19 outbreak, large volumes of research results and data have been released first through preprint platforms, leading Science to exclaim that preprints have brought a "fire hose" of outbreak data [56]. As of July 2, 2020, medRxiv had 4,757 COVID-19-related preprints, bioRxiv had 1,236 [57], and arXiv had 1,524 [58].

Many open research platforms have launched dedicated COVID-19 collections, such as F1000Research, Wellcome Open Research, AAS Open Research, and HRB Open Research. These platforms promote rapid open sharing through fast publication, open data policies, and transparent peer review. For example,

F1000Research requires only 7 days from submission to publication and 16 days from publication to completed peer review for COVID-19-related papers [59], greatly accelerating sharing.

The surge in preprints has also promoted review model innovation. Many researchers discuss and review preprints on platforms like Slack and Twitter. On March 3, 2020, Nature launched the Outbreak Science Rapid PREreview platform [60] with Wellcome Trust support, an open platform for rapid review of outbreak-related preprints where scientists with ORCID identifiers can submit comments (currently limited to preprints from medRxiv, bioRxiv, and arXiv). These comments are aggregated to assess importance and quality [61].

To support rapid publication of COVID-19 research, on April 27, 2020, F1000Research joined with eLife, FAIRsharing, Hindawi, PeerJ, PLOS, Royal Society, and Outbreak Science Rapid PREreview to launch the COVID-19 Rapid Review Initiative [62], calling for more volunteers with COVID-19 expertise to join reviewer groups to maximize peer review efficiency and ensure rapid publication of key work.

Some peer-reviewed journals have adopted "priority rapid publication" or "publish first, peer review later" mechanisms. For example, Taylor & Francis prioritizes COVID-19 papers for accelerated publication [63], while WHO's *Bulletin of the World Health Organization* has established the "COVID-19 Open" data sharing and notification protocol [64], publishing COVID-19-related submissions online within 24 hours while undergoing peer review. If accepted after review, the open access review status is noted in the final publication; if not accepted, authors can publish elsewhere freely.

Research Institutions Launching COVID-19 Open Datasets Since the outbreak, major publishers have built coronavirus resource hubs for free access and open sharing, including BMJ's Coronavirus Hub [65], NEJM Coronavirus Collection [66], Cell Coronavirus Resource Hub [67], Nature COVID-19 Collection [68], Lancet COVID-19 Resource Center [69], and Science Coronavirus Research, Commentary, and News [70]. WHO also established a freely accessible COVID-19 publications database [71].

The EU launched the European COVID-19 Data Platform on April 20, 2020 [72], sharing SARS-CoV-2 DNA sequences, protein structures, clinical trial data, and epidemiological data [73].

Notably, open datasets for text mining and secondary reuse have emerged. The most influential is the COVID-19 Open Research Dataset (CORD-19) [74-75], built by the Allen Institute for AI in partnership with the Chan Zuckerberg Initiative, Georgetown University's Center for Security and Emerging Technology, Microsoft Research, and the U.S. National Library of Medicine. As of July 2, 2020, it contains over 130,000 articles in JSON format on COVID-19 and coronavirus research for text mining and data analysis to efficiently find countermeasures.

Other important datasets include LitCOVID (NIH) [76], COVID-19 Resource Page (Microsoft Academic) [77], COVID-19 Research Export File (Dimensions) [78], Day-Level COVID-19 Dataset (Kaggle) [79], COVID-19 Global Cases (Johns Hopkins University) [80], and PMC Research Articles and Preprints on Coronavirus [81].

China Building Multiple Open Access Platforms Since the COVID-19 outbreak, China has shared the detected novel coronavirus gene sequence information with WHO on January 11, 2020 [82]. To strengthen academic exchange and support prevention and research, China has established multiple open sharing platforms, including the 2019 Novel Coronavirus Resource (2019nCoVR) [83], the Novel Coronavirus National Science and Technology Resource Service System [84], the Global Coronavirus Omics Data Sharing and Analysis System [85], the COVID-19 Prevention and Treatment Scientific Research Results Academic Exchange Platform [86], and the Chinese Academy of Sciences COVID-19 Research Literature Sharing Platform [87]. CNKI also built a COVID-19 research results online first publishing platform (OA) [88]. These platforms have played important roles in promoting research by domestic and international teams.

Issues of Concern in Open Sharing During Public Health Emergencies

The COVID-19 pandemic has also highlighted issues requiring attention.

Balancing Rapid Publication and Quality The pandemic has shown that balancing rapid publication with effective quality management is challenging. Flawed results have been published and controversial. For example, on January 31, 2020, Indian scientists posted a paper on bioRxiv suggesting "uncanny" similarities between SARS-CoV-2 and HIV, which was quickly withdrawn within 48 hours after being identified as flawed. A paper published in NEJM on January 30 suggesting asymptomatic transmission also faced criticism when it was revealed the authors had not actually communicated with the supposedly asymptomatic patient, who in fact had symptoms; the journal added this information as an appendix [56].

Mass Health Data Processing and Privacy Protection To combat the pandemic, countries are using digital technologies to monitor and collect citizens' location and health data. How to effectively protect individual and group privacy while sharing and utilizing mass health data has raised concerns. German data privacy experts caution that governments and researchers should exercise legal powers to obtain and process personal data cautiously, complying with data protection regulations such as Europe's GDPR and ePrivacy Directive and corresponding national laws [89-90].

On April 2, 2020, 110 civil society organizations worldwide issued a joint statement urging governments to use digital surveillance technologies only when

strictly meeting conditions including legality, necessity, proportionality, time limitation, purpose limitation, data protection, and effective oversight [91]. This indicates that citizens' data rights during public health emergencies require serious study.

Summary of Main Development Process

Open sharing of scientific research results during public health emergencies is crucial for prevention and response. This paper reviews three main development stages, clearly showing that WHO and other international organizations have played important roles in promoting open sharing, with a series of international rules already formed. During the COVID-19 pandemic, a new scholarly communication model is emerging, which will significantly impact future responses to public health emergencies and global academic communication.

Facing this sudden pandemic, China's scientific community has actively shared research results, making important contributions to the global scientific response. However, due to insufficient understanding and application of international rules, China's voice in international open sharing during public health emergencies remains limited, with room for improvement in using international rules to protect researchers' and national interests. International rules regulate behavior and provide guidance for researchers. For example, the "publication embargo disclaimer" system protects original data providers' rights, while encouraging open sharing does not mean blind openness—WHO's global norms emphasize considering source countries' legitimate requirements.

China's scientific community needs to strengthen research and dissemination of international rules for open sharing during public health emergencies. While promoting open sharing, China should use international rules to enhance its voice and leadership in international pandemic response while protecting relevant rights and interests.

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The Main Progress of Global Efforts on Open and Sharing of Scientific Results in the Context of Public Health Emergencies

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Abstract: [Purpose/Significance] In view of the fact that domestic scientific and technological circles do not have enough understanding of the overall situation and relevant institutional norms of open sharing of scientific research results during public health emergencies, this paper combs the main development context of international open sharing of scientific research results during public health emergencies, hoping to reflect its main development process and the overall overview of relevant institutional norms, and provide reference for China's scientific research institutions, government departments and academic circles. [Method/Process] By reviewing the development history of open sharing of scientific research results during public health emergencies for more

than 20 years, according to the different main concerns in the development process, it is divided into three stages, and the main events, important documents, problem concepts, policy norms, and practice characteristics of each stage are summarized. [Result/Conclusion] After three stages of development, relevant norms and mechanisms have been gradually formed and improved. Since 2020, the methods of open sharing of scientific research results during public health emergencies have been further developed rapidly, which has attracted high attention from the global scientific and technological community, triggered the exclamation that the COVID-19 epidemic has changed the traditional academic exchange and scientific research paradigm, and also highlighted that there are still some problems worthy of further research and resolution.

Keywords: public health emergency; scientific research results; open sharing; new academic exchange model; policy norms

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