Article

Topic Evolution of Chinese COVID-19 Policies Based on Co-Occurrence Clustering Network Analysis

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Abstract: This study aims to explore the changes of Chinese coronavirus disease-2019 (COVID-19) policy topics in the eclipse, outbreak, and convalescent stage of COVID-19 based on 4982 textual policies. By using the co-occurrence clustering network method, we find that the strict prevention and control of the epidemic is the only topic of policies in the eclipse stage. In the outbreak stage, strict epidemic prevention and control is still the most important policy topic. The policies of resuming work of “essential” enterprises and stabilizing market prices are important support and guarantee for fighting against COVID-19. In the convalescent stage, as the prevention and control of COVID-19 has become regular, promoting and ensuring the resumption of work in all sectors of society is the most important topic of the policies. Moreover, the success of Wuhan City’s fight against COVID-19 reflects China’s governance characteristics of “concentrating power to do a major event”. Finally, the possible improvements for Chinese COVID-19 policies are discussed, which can provide practical suggestions for government departments on how to effectively respond to public health emergencies.

Keywords: topic evolution; COVID-19; policies; co-occurrence clustering network

1. Introduction

The coronavirus disease-2019 (COVID-19) pandemic, a sudden global public health incident, has posed the world into a serious crisis and has caused unpredictable damage to our physical health, economic situation, and social safety [1,2]. As of 31 July 2021, the outbreak has already been spread to 220 countries worldwide and a total of 197.87 million cases have been confirmed, and about 4.22 million cases died [3].

The urgency and high uncertainty of the COVID-19 pandemic have brought an unprecedented challenge to the modern governance system and governance capabilities. For the government, which is the leader of emergency events in a country or region, its ability to formulate timely and effective policies is the key to responding to emergencies [4,5]. Thus far, many countries’ governments have introduced various policies to control and prevent the spread of COVID-19. Due to the differences in governance systems, social structure and other factors, governments in various countries have adopted different policies to defeat COVID-19 and the policy effects are also different [6–9]. The COVID-19 policies issued by some countries have been questioned or even criticized, while some countries’ COVID-19 policies have been praised.

Specifically, several European countries, such as Sweden and the United Kingdom, have adopted herd immunity against COVID-19 [10–12]. In the face of a lack of antiviral treatment and lack of vaccines, the correctness of this measure has been questioned [13], and some scholars have even pointed out that it was a failure [14]. In the United States, the federal government did not frame an effective national policy system to better combat the COVID-19 pandemic clearly [15]. The structural and policy disparities between states...
have had a great impact on the health of Americans [16]. For example, African Americans, the homeless and other low-income groups often have very high mortality rates [17].

Fortunately, the policies issued by some countries or regions have been effective in fighting against the epidemic situation. Specifically, salient collaborative efforts that have been tried by countries in Latin America have played an important role in fighting the epidemic [18]. In Vietnam, the main reason for the low infection rate is that the provincial government has adopted effective measures, such as providing patients with free testing and treatment, closing schools and universities, and enforcing wearing facemasks in public spaces [19]. For Australia, prior quarantine policies, institutional evolution, mid-pandemic alterations of key national pandemic response plans, and investment in primary care are considered important reasons for the country’s successful response to COVID-19 [20,21]. In Norway, the COVID-19 pandemic was quickly controlled due to the collaborative and pragmatic decision-making style, successful communication with the public, a lot of resources, and a high level of citizen trust in government [22]. South Korea has formulated rapid and effective policies [23], including checking the health status of entrants from overseas, releasing detailed pandemic information [24] in the early stage of the epidemic, and coordinating limited medical resources in the outbreak stage [25].

In this COVID-19 pandemic, China was the focus of world attention since the first diagnosed patient was reported in Wuhan, Hubei, China at the end of December 2019 [26,27]. The effectiveness of Chinese anti-epidemic policies had an important impact on the global spread of COVID-19. Fortunately, reports have shown that China has taken effective measures to control the spread of COVID-19 quickly and successfully [28]. According to the total number of confirmed cases among some severely affected countries disclosed by the World Health Organization (WHO) (Figure 1), compared to other countries, the curve of Chinese cumulative confirmed patients has been stable for 10 months since March 2020, except when it rose in January and February 2020. Without the efforts of the entire society led by the Chinese government, the situation in China and the world would be worse [29]. WHO Director-General Dr. Tedros said that “there is a window of opportunity because of the strong measures China is taking at the epicenter, at the source, so let’s use this opportunity to prevent further spread and to control it” [30].

**Figure 1.** Trend of the coronavirus disease-2019 (COVID-19) cases-cumulative total among some severely affected countries. Source: Drawn by authors based on the data disclosed by WHO.
Thus, due to the remarkable success of the Chinese government during the COVID-19 pandemic, a considerable amount of literature has discussed China’s governance and policies in response to the pandemic. Specifically, the existing studies mainly focused on whether the strict emergency control measures have effectively contained the spread of the pandemic in China [31], including the lockdown of Wuhan [32], initiating a first-level response to major public health emergencies [33], cross-provincial assistance [34], the removal of leaders [35], and other mandatory government measures. The role of high-tech products and big-data, such as intelligent diagnoses, 5G telemedicine, clinical information systems, and personal-oriented digital prevention and control technology (e.g., health status code), have been discussed by [36–38]. Some studies assessed the educational policies, such as postponing the opening time of the new semester, online education, opening educational platforms, and sharing high-quality education resources without charge [39–41].

In terms of policy scope, more recent attention has focused on assessing the effectiveness of a specific or a certain kind of policy, or local policy in controlling COVID-19. Table 1 presents several example articles related to the COVID-19 policy for the three policy scopes. Collectively, these studies provide important insights into the critical role of public policy in fighting against the pandemic from different policy scopes, while lacking an overall and systemic analysis from a national perspective. In practice, the making and issuance of policies in a country is a systematic project, that is, there are inter-relationships between policies. Only by coordinating the relations between all kinds of national policies can the overall optimal operation be achieved. Moreover, as the situation of epidemic changes, the policies’ focus and the relationship between policies would also change accordingly. Thus, exploring the key topics of policies in different epidemic stages and the coordination relationship between them to discuss why China was able to control the epidemic in a short time can provide meaningful theoretical and practical implications.

| Policy Scope   | Author/s (Year) | Policy Name                          | Research Aims                                                                 |
|---------------|-----------------|--------------------------------------|-------------------------------------------------------------------------------|
| A specific policy | Molefi et al. (2021) | Lockdown Policy                     | Examine the impact of lockdown policy on reducing the COVID-19 incidence in China [42]. |
|                | Bikbov and Bikbov (2021) | 14-day quarantine policy             | Rethink the reasonableness of the 14-day quarantine policy and propose that the maximum incubation period of COVID-19 should be further refined [43]. |
|                | Liu et al. (2021) | Free vaccination policy              | Analyze the willingness rate of COVID-19 vaccination and its determinant factors under China’s free vaccination policy [44]. |
|                | Matsui et al. (2021) | Older-people-first policy for COVID-19 vaccination | Rethink the reasonableness of this policy issued in Japan, and propose an equal plan that includes younger people from an economic perspective [45]. |
|                | Wang et al. (2020) | Social restriction policy            | Examine whether the social restriction policy implemented in the early stage of the epidemic was effective in controlling the spread of COVID-19 in Australia [46]. |
| A kind of policy  | O’leary et al. (2021) | Healthcare policies                 | Review the healthcare policies during the first wave of COVID-19 transmission in Ireland and investigate the policies’ key focus and impact [47]. |
|                | Chen et al. (2021) | Fiscal policy                        | Explore fiscal policy’s similarities and heterogeneity in the fiscal spending size and the types and targets of fiscal policy responses to COVID-19 across 170 countries [48]. |
|                | Xue et al. (2021) | Education policy                    | Analyze the process of China’s education policy changes and the effects of this kind of policy implementation during COVID-19 [39]. |
Eum and Kim (2022) Investigate the role of this kind of policy in curbing the COVID-19 spread speed across different countries [49].

Xin et al. (2021) Summarize the policies issued in Wuhan and explore the effects to present the factors involved in fighting against COVID-19 in China [50].

Zahidie et al. (2020) Analyze the reason for the worsening COVID-19 pandemic in New York from the perspective of public policy [51].

Liang et al. (2020) Explore the effects of policies and prevention measures issued by the government in Chongqing on the prevention and control of COVID-19 [33].

Source: Concluded by authors based on example articles.

This article systematically and comprehensively studies the topic changes of Chinese COVID-19 policies during different epidemic stages. The co-occurrence clustering network analysis method is applied to unstructured policy texts to explore and visualize the evolution and connection between different COVID-19 policy topics. In the empirical analysis, we collect 4982 COVID-19-related policies from 1 January to 31 March 2020 issued by the State Council of China, from 31 provincial governments and the government of Wuhan city, which well reflects the central, provincial, and hard-affected cities’ government responses to COVID-19. From the text analysis, we have drawn many meaningful conclusions and put forward policy suggestions to better respond to emergent public health events in the future.

The rest of this paper is organized as follows. Section 2 describes the methodology and Section 3 presents the data collection, preprocessing, and description. Section 4 analyzes the evolution results of Chinese policy topics during COVID-19, and Section 5 discusses the findings of the research. The concluding remarks are in Section 6.

2. Methodology

To explore the evolution characteristics of COVID-19 policy topics at different epidemic stages, the whole framework of this research is divided into three steps: data collection, data preprocessing, and policy topic evolution. As shown in Figure 2, the first step is to obtain a policy text database by web crawler technology, the second is to extract keywords from policy documents, and the third is to map the policy keywords information to transform it into communities in the co-occurrence clustering network. The detailed process of data collection and preprocessing will be described in the data section, and in this section, we focus on the main method of this paper, namely, the co-occurrence clustering network method.

The co-occurrence clustering network method believes that the keywords in the text reflect their semantic connotations, the frequency of simultaneous appearance of the two keywords reflects the relevance between their semantic connotations, and keywords with similar semantics and high relevance are usually clustered into one topic [52]. In most recent studies, the use of the co-occurrence clustering network method is a well-established approach in the bibliometric analysis of policy documents [53]. Nan et al. (2020) employed this methodology to visualize the evolution of Chinese aging policies from 1978 to 2019 [54], and Wu et al. (2021) performed a similar series of experiments to investigate the dynamic characteristics of China’s green building policy from 1986 to 2019 [55]. Due to the simplicity and visualization flexibility, this paper also adopts this method to study the evolution of China’s COVID-19 policy topics to explore the specific content involved in the policies in depth. The specific algorithms are presented as follows.
There are two steps to conducting the co-occurrence clustering network analysis. First, we employ Python software to calculate the co-occurrence strength coefficient and construct the co-occurrence frequency matrix. Specifically, the co-occurrence clustering network is constructed with keywords as nodes and co-occurrence strength coefficients as edges [56]. As shown in Equation (1), based on the frequency of occurrence of pairwise keywords in the text, the co-occurrence strength coefficient ($\beta_{ij}$) can be calculated [57]:

$$\beta_{ij} = \frac{a_{ij}}{a_i a_j}$$

where $a_i$ and $a_j$ are the frequency of occurrence of keywords $i$ and $j$, respectively, and $a_{ij}$ is the frequency of co-occurrence of keywords $i$ and $j$. The higher the co-occurrence strength coefficients, the closer the relationship between these two keywords. By calculating the co-occurrence strength coefficients of all pairwise words in the text, the co-occurrence frequency matrix can be constructed.

Second, we adopt Gephi, an open-source interactive complex network analysis software [58], to draw the co-occurrence network, carry out community detection, visualize the topic co-occurrence clustering network, and accurately calculate the network evaluation indicators. Based on the co-occurrence frequency matrix, we can draw a co-occurrence network where the size of the node indicates the total frequency of co-occurrence of a certain keyword and other keywords, and the thick line between the nodes reflects the co-occurrence strength coefficient. The larger the node, the more keywords it co-occurs with; the higher the co-occurrence strength coefficient, the thicker the edge.

Having constructed the co-occurrence network, the topic in the network should then be identified by clustering the nodes with similar semantics in the co-occurrence network. The community detection method, a widely used technology for clustering social networks [59,60], is employed to identify different text topics. Generally, the subgroups composed of highly inter-connected nodes are called “communities”. Community detection can search and discover communities in the network automatically, and finally, each community is taken as a text topic.

Among many community detection algorithms, here, we adopt the Louvain method, which can detect the community division of complex networks in a short time, and form a complete hierarchical community structure [61]. It is widely used for detecting communities in various networks due to its simplicity, efficiency, and ease of implementation [62,63]. The algorithm optimization is performed in two phases (Figure 3).
Figure 3. Graph of the Louvain algorithm. Source: drawn by authors based on Blondel et al. (2008) [61].

Specifically, each node (assuming \( N \) nodes) is initially assigned in a separate different community. Then for each node \( i \), the algorithm considers whether to join the community of node \( j \) according to the modularity gain calculated by Equation (3) of the community of \( j \) after joining \( i \), and finally, node \( i \) is placed in the community with the greatest modularity gain. The clustering process is repeated for all nodes until the maximum modularity is achieved and the first phase is complete. As for modularity, it is a quantitative indicator used to evaluate the pros and cons of network community detection results [64]. For the weighted network, the modularity is defined in Equation (2):

\[
Q = \frac{1}{2m} \sum_{i,j} \left( \beta_{ij} - \frac{k_i k_j}{m} \right) \delta(c_i, c_j)
\]

(2)

where \( \beta_{ij} \) is the edge’s weight between node \( i \) and \( j \), \( m = \frac{1}{2} \sum \beta_{ij} \) is the sum of the weights of all edges, \( k_i = \sum_j \beta_{ij} \) represents the sum of the weights of the edges connected to node \( i \), and \( c_j \) is the community to which node \( i \) is assigned. Generally, the greater the modularity of a complex network, the more optimal the topic clustering effect [65].

Based on Equation (3), we can calculate the modularity gain of community \( C \) after node \( i \) is placed to community \( C \):

\[
\Delta Q = \left[ \frac{\sum_{i \in C} k_{i, in}}{2m} - \left( \frac{\sum_{i \in C} k_i}{2m} \right)^2 \right] - \left[ \frac{\sum_{i \in C} k_{i, tot}}{2m} - \left( \frac{\sum_{i \in C} k_i}{2m} \right)^2 \right]
\]

(3)

where \( \sum_{i \in C} \) is the sum of the edges’ weights in community \( C \), \( k_{i, in} \) is the sum of the edges’ weights from \( i \) to nodes in community \( C \), \( \sum_{i \in C} \) is the sum of the edges’ weights incident to nodes in community \( C \), and \( k_i \) is the sum of the edges’ weights incident to node \( i \), \( m \) is the sum of the weights of all edges.

Then, a new network whose nodes belong to the communities formed in the first phase is constructed. Blondel et al. (2008) called the combination of the first and second phases as “pass” [61]. Then, the passes are repeated, and we finally obtain the optimal clustering effect of the network, complete the community detection, and divide keywords into different topics.
After community detection, a co-occurrence clustering network is constructed. To evaluate the connective and clustering characteristics of the co-occurrence clustering network, there are six indicators adopted by scholars [66,67]. Specifically, the number of nodes and edges, average degree, and network diameter are the four indicators used to reflect the basic connective characteristics of the network. Modularity and average clustering coefficient are two indicators to evaluate the clustering effect of network community detection results [64].

To be specific, the number of co-occurrence nodes in the network nodes represents how many keywords appear together in the text. The number of edges in the network represents the total frequency of connections between keywords. The average degree is the average number of connected edges for each node, which is defined as Equation (4):

\[
\text{Average degree} = 2 \times \frac{\text{Edges}}{\text{Nodes}}
\]  

(4)

The diameter is the maximum value of the shortest distance between any two nodes \(d_{ij}\) \((\text{Diameter} = \text{Max} \ d_{ij})\). Thus, the higher the number of nodes and edges, the higher value of the average degree, and the lower the diameter, the closer the relationship between nodes in the network.

Besides the modularity, the other clustering effect indicator, the average clustering coefficient is defined as follows:

\[
C_i = \frac{2e_i}{n_i(n_i - 1)}; \quad \text{Average clustering coefficient} = \frac{1}{N} \sum \frac{C_i}{N}
\]  

(5)

where \(C_i\) is the clustering coefficient of node \(i\), assuming that node \(i\) is connected to \(n_i\) nodes. The maximum number of edges that may exist between these \(n_i\) nodes is \(\frac{n_i(n_i - 1)}{2}\), and there are actually \(e_i\) edges.

3. Data

3.1. Data Collection

The time period of data collection in this article is from 1 January 2020 to 31 March 2020 (91 days), which is the main period of China’s fight against COVID-19. Specifically, the first official media statement disclosed by the Wuhan Municipal Health Commission from their website on cases of “viral pneumonia” was made on 30 December 2019 in Wuhan, People’s Republic of China. On 31 December 2019, WHO first responded to the “viral pneumonia” by picking up the media statement by the Wuhan Municipal Health Commission and provided a translation of it [68]. The Chinese government began to issue policies to control and prevent COVID-19 on 1 January 2020.

Figure 4 shows the daily growth rate of diagnosed COVID-19 patients in China based on the data disclosed by the National Health Commission of the People’s Republic of China. From Figure 4, we can see that after a surge in diagnosed cases in January and February 2020, at the beginning of March, there were a few new COVID-19 diagnosed cases. Since the longest incubation period of COVID-19 diagnosed patients was 24 days, a 24-day observation period is needed to judge whether the epidemic situation is under control [69]. Until the end of March, there were only a few new cases per day. Therefore, the epidemic in China was under control by the end of March. Thus, the sample period of 1 January to 31 March 2020 fully covers the period of evolution of COVID-19 in China from outbreak to control. By analyzing the Chinese COVID-19-related policies from 1 January to 31 March 2020, we can analyze the changes in the Chinese policy topics during COVID-19.
Having determined the data collection period, then we begin to collect the COVID-19-related policies. In this article, we first collect COVID-19-related policies issued by central and provincial governments to analyze the policy topic evolution of the whole country during COVID-19. Moreover, local community transmission and clusters of cases first appeared in Wuhan, a city of over 10 million people and the epicenter of China’s COVID-19 outbreak [70]. It is necessary to understand the Wuhan government’s response to the epidemic. Thus, we collect COVID-19 policies issued by various departments of the State Council of the People’s Republic of China, departments of 31 provincial people’s governments in mainland China and departments of the Wuhan city government.

The Institute of Science and Development of the Chinese Academy of Sciences (ISDCAS) (http://english.casisd.cn/, accessed on 31 May 2020) summarized the COVID-19-related policies. Thus, we crawled the 13,418 pieces of policy data through the website of ISDCAS from 1 January to 31 March 2020. After data cleaning, city-level policies (except Wuhan city) and news related to policies were removed and 2619 provincial policies were obtained.

Since the COVID-19-related policies summarized by the institution of ISDCAS is not comprehensive, we manually supplement policy data from the official websites of more than 20 departments of the State Council of the People’s Republic, of 31 provincial government departments in mainland China, and of Wuhan city government departments. Through a manual search, an additional 511 pieces of national policies, 1724 pieces of provincial policies, and 128 pieces of Wuhan city policies were collected. Finally, a total of 4982 pieces of COVID-19 policies from 1 January 2020 to 31 March 2020, with the information of the policy release department, release date, heading, and detailed explanation text of the policy, were collected to support the empirical analysis. As far as we know, this is the most comprehensive dataset of the Chinese COVID-19-related policies.
3.2. Data Preprocessing

To clearly present the topic evolution of Chinese COVID-19 policies, we divide the COVID-19 development process in China into three stages based on the growth rate of diagnosed patients in Figure 4: eclipse stage, outbreak stage, and convalescent stage. The eclipse stage is from 1 to 19 January 2020, in which the diagnosed patients occurred and the number of diagnosed patients rose rapidly. Then, on 20 January 2020, the National Health Commission of the People’s Republic of China announced that the COVID-19 can be transmitted from person to person for the first time, which meant that China had made a breakthrough in understanding COVID-19. From then on, the growth rate of diagnosed patients decreased significantly. Thus, the eclipse stage lasted from 1 to 19 January 2020 (19 days).

The outbreak stage is from 20 January to 18 February 2020, in which the growth rate of diagnosed patients decreased significantly and continued to decline (30 days). On 18 February 2020, the National Health and Construction Commission of the People’s Republic of China disclosed that the number of newly cured patients in China exceeded the number of newly diagnosed patients. Thus, the remaining time period (19 February to 31 March) is the third stage: the convalescent stage, in which the epidemic situation was controlled and the growth rate of diagnosed patients remained stable at a very low level (42 days).

Based on the above three epidemic stages (i.e., eclipse stage, outbreak stage, and convalescent stage), this article divides the COVID-19-related policy corpus into three sub-corpora. Then, we perform the operations of word segmentation and stop word removal for policy titles. We use the Jieba module in Python, a popular Chinese word augmentation tool to conduct Chinese word segmentation. Then, one of three widely used Chinese stop-word lists, the Harbin Institute of Technology stop-word list, is adopted to remove the meaningless text from the original policies. By doing so, we can obtain the keywords of COVID-19 policies for further co-occurrence clustering network analysis.

3.3. Data Description

We describe the collected 4982 COVID-19-related policies from perspectives of province, time, and department. Specifically, the two maps in Figure 5 show the number of policies and the cumulative number of confirmed cases in 31 provinces in mainland China from 1 January 2020 to 31 March 2020. We can see that there is a strong correlation between the number of COVID-19 policies and the severity of the epidemic. Generally, the more serious the epidemic is in a province, the more policies its government issued. The cumulative number of confirmed cases in Hubei and its surrounding provinces is significantly higher than that in other provinces. In order to effectively prevent and control the epidemic, the government has accordingly introduced more policies. Northwest China (consisting of Xinjiang, Tibet, Qinghai, and other provinces) is presented with lighter colors on the map, indicating that there were fewer confirmed cases and that they issued fewer government policies.
Figure 5. The number of COVID-19 policies (a) and the cumulative diagnosed cases (b) in 31 provinces in mainland China (1 January 2020–31 March 2020). Source: drawn by authors based on the data disclosed by Chinese government.

Figure 6 shows the trend of changes in the number of policies issued daily by the State Council and each province. Starting from 19 January 2020, the number of policies has increased sharply and reached the peak in late January and early February 2020. The number of policies on 30 January 2020 and 7 February 2020 both exceeded 150, reaching 156 and 164, respectively. After 7 February 2020, the number of policies showed a downward trend on the whole. Since 6 March 2020, the number of policies has not exceeded 100. Furthermore, in terms of different stages, it can be found that the number of policies in the 19 days of the eclipse stage is only 8. The outbreak stage is the peak period of policies’ release. The total number of issued documents is 2734, and the average number of policies per day is 91. As the COVID-19 situation was controlled, the overall number of policies published declined, with the number being 2240 in the convalescent stage. The average number of policies per day declined to 53.

Figure 6. Number of policies issued daily by the State Council and each province. Source: authors.
Figure 7 shows the COVID-19 policies issued by departments of the State Council and provincial governments. In particular, the number of policies issued by the Health Commission is 1111, which is significantly higher than that in other departments. The People of Government issued 661 policies, second only to the Health Commission. The number of policies promulgated by other departments is less than 500.

![Figure 7: The COVID-19 policies of the State Council and provincial departments. Source: authors.](image)

4. Evolution Results of Policy Topics during COVID-19

In the empirical analysis, this article explores the changes in the focus and relationship of the topics of COVID-19 policies in different epidemic stages from the national perspective and Wuhan City perspective by mapping the policy keywords information obtained to different clusters. Based on the central and provincial policies, the analysis from the national perspective can reveal the characteristics of the evolution of COVID-19-related policies’ topics in the whole country. The analysis from the perspective of Wuhan, which is the city with the first diagnosed patient and the most serious epidemic situation, can explore whether the policy focus and relationship of Wuhan City different from that of the whole country.

4.1. Evolution Results of Policy Topics of the Whole Country

The co-occurrence clustering networks of COVID-19 policies in the eclipse, outbreak, and convalescent stages are shown in Figures 8–10, respectively. As discussed in the methodology section, the co-occurrence clustering network regards co-occurrence keywords as nodes and co-occurrence strength coefficients of two keywords as edges of nodes. The more keywords of policies appear together, the more nodes in the co-occurrence network. The higher the co-occurrence strength coefficient, the thicker the line between the two nodes in the network, and thus, the closer the connection between the two nodes. The colors of different nodes in the co-occurrence clustering network represent different policy topics.

The characteristics of the co-occurrence clustering network at each stage are summarized in Table 2. From Table 2, it can be seen that the values of nodes, edges, and the average degree in the outbreak stage are the largest, while the diameter is the smallest,
indicating that the connection between the policy topics is the closest in the outbreak stage. Thus, in the outbreak stage of a full-scale COVID-19 outbreak, various anti-epidemic policies are most closely coordinated to fight against the COVID-19. The second most closely related COVID-19 policies are issued in the convalescent stage, with the value of nodes, edges, average degree, and diameter ranking second. The COVID-19 policies of the first stage (eclipse stage) are the least closely related.

The modularity and average clustering coefficient, which are used to evaluate the clustering effect show that the policy topic identification results in three epidemic stages have a satisfactory effect (Table 2). Specifically, the values of modularity in the eclipse, outbreak, and convalescent stages are 0.522, 0.599, and 0.675, respectively, which all exceed 0.5. The values of the average clustering coefficient in the eclipse (0.799), outbreak (0.607), and convalescent (0.635) stages all exceed 0.6.

Table 2. Characteristics of co-occurrence clustering networks in three epidemic stages.

| Stage          | Nodes | Edges | Average Degree | Diameter | Modularity | Average Clustering Coefficient |
|----------------|-------|-------|----------------|----------|------------|--------------------------------|
| Eclipse stage  | 28    | 154   | 11.000         | 4.000    | 0.522      | 0.799                          |
| Outbreak stage | 161   | 3750  | 46.584         | 3.000    | 0.599      | 0.607                          |
| Convalescent   | 127   | 2697  | 42.472         | 4.000    | 0.675      | 0.635                          |

Source: authors.

4.1.1. Eclipse Stage (1 January 2020–19 January 2020)

In this section, we describe the co-occurrence clustering network for each stage in detail. Specifically, as shown in Figure 8, the anti-epidemic policy keywords information in the eclipse stage (1 January 2020–19 January 2020) are mapped and transformed into four topics. Blue nodes represent the policy topic of notifying information about the unknown pneumonia virus. Yellow nodes represent the policy topic of formulating treatment, prevention, and control plans for pneumonia caused by COVID-19. The policy topic represented by green nodes in the network is establishing epidemic response teams and expert groups. Pink nodes represent the policy topic of disclosing information about confirmed cases. These four topics of epidemic policies reflect the initial response of the Chinese government for fighting against the unknown pneumonia. At this stage, policies are basically epidemic prevention and control policies. The foci are to understand the unknown virus, to attempt to control the spread of the virus, and to find effective treatment plans.

Figure 8. Co-occurrence clustering network of the eclipse stage. Source: authors.
4.1.2. Outbreak Stage (20 January 2020–18 February 2020)

In the outbreak stage (20 January 2020–18 February 2020), when the number of confirmed cases is rapidly increasing, the government’s epidemic prevention and control measures have been comprehensively upgraded. Figure 9 shows the co-occurrence clustering network of COVID-19 policies in this stage. Obviously, compared with the eclipse stage, the topics of policies became more diversified. Among various topics of policies, epidemic prevention and control policies represented as green nodes account for the highest proportion, indicating that the prevention and control of COVID-19 at this stage is the top priority. It can be seen that “COVID-19”, “epidemic”, “coronavirus”, “infection”, “pneumonia”, “prevention and control”, and other epidemic nodes are significantly larger than other nodes. As of 29 January, all 31 provinces in China have initiated Level I responses to major public health incidents, which means that the most comprehensive and strict national war against the epidemic has begun.

To cooperate with the epidemic prevention work and keep the normal operation of society, many other topics of policies were issued. Specifically, several yellow and orange nodes in the left parts of the co-occurrence clustering network are classified into policy topic of emergency material supply, including “emergency”, “materials”, “purchase”, and “masks”. The nodes of emergency materials are closely related to the epidemic prevention and control nodes, reflecting one of the important tasks at this stage is to guarantee the supply of emergency materials for epidemic prevention and control. In practice, due to the rapid increase in the number of confirmed diagnoses in a short time period, the materials for the epidemic in China at this stage were not fully guaranteed. Materials such as masks were in short supply and there was even the phenomenon of driving up the prices of epidemic supplies on the market.

Thus, another important policy topic is market policy, which mainly focuses on stabilizing market prices and closing the wild animal markets. The blue nodes clustered on the market topic include “market”, “price”, “vegetable basket”, “supply”, “product”, “order”, “production”, “agriculture”, and “wild animal”. With the spread of COVID-19, epidemic protective materials and people’s daily necessities were in short supply, so the prices rose sharply. Guarantee supply and stable prices of various products are the primary tasks of the market departments of all provinces. In addition, due to the suspicion that the host of pneumonia virus was wild animals, the market departments have decided to close the wild animal trading markets to block the possible source of infection and the route of virus transmission in time.

The pink nodes clustered in the right side of the network represent another important policy topic: resumption of work and production, which mainly aim to guarantee the work resumption of “essential” enterprises under the severe epidemic situation. Specifically, the node of “enterprise” relates to “resumption of work”, “resumption of production”, “support”, “funds”, and “fiscal”. To keep the society running, the “essential” enterprises that are involved in public utilities (water supply, gas supply, power supply, communications, etc.), epidemic prevention and control (production and sales of medical equipment, medicines, epidemic protective materials, etc.), people’s daily needs (supermarkets, food production and supply, etc.), and other important industries needed for people to resume work.

Other topics are also represented, such as “science and technology”, “school”, and “medical personnel”, indicating the various topics of policies issued in the outbreak stage in order to cooperate and support the prevention of COVID-19 and keep the normal operation of society.
Figure 9. Co-occurrence clustering network of the outbreak stage. Source: authors.

4.1.3. Convalescent Stage (19 February 2020–31 March 2020)

In the convalescent stage, as shown in Figure 10, compared with the outbreak stage, the policy topic of epidemic prevention and control is no longer the only topic that stands out. In other words, no longer are all other topics of policies issued to support and cooperate the epidemic prevention and control. As the number of confirmed cases decreases, in order to avoid unemployment and reduce economic losses, promoting resuming work and ensuring the normal operation of enterprises under the strict and scientific prevention and control measures of the epidemic has become the backbone of policies in the third stage. Moreover, in order to make the society return to normal operation, various policies with different topics that have been issued in the outbreak stage were further refined and deepened in this stage.

Specifically, besides “essential” enterprises, “non-essential” enterprises gradually returned to work and production with fiscal and financial support. The blue-green nodes in the bottom parts of Figure 10 such as “resumption of work”, “resumption of production”, “enterprise”, “support”, and “promote” are obviously larger, which means that they are mentioned more often by the policies. During the COVID-19 pandemic, the slowdown in consumer spending due to people staying at home has put tremendous pressure on local businesses and the local economy [71] and some companies or businesses are even facing closure. Thus, adequate fiscal and financial support to enterprises in various industries is important for the resumption of work, with nodes such as “fiscal”, “funds”, “loan”, “special”, “reduce”, “social insurance premium”, and “small- and medium-sized enterprises (SMEs)” in the network. We can conclude that the government provides enterprises with support from three aspects: direct financial subsidies, reduction of social insurance premiums, and discounts on loans to small- and medium-sized enterprises.
The yellow and orange nodes in Figure 10 are clustered into the topic of epidemic prevention and control policies. Compared with the epidemic prevention and control policies issued in the outbreak stage, the biggest change is the adjustment of emergency plans for public health incidents, that is, many provinces adjusted the Level I emergency response of COVID-19 to Level II or Level III emergency response with “adjustment”, “emergency”, and “response” as nodes in Figure 10. The other important change is that strictly preventing imported cases from abroad is a new content of epidemic prevention and control policies in the convalescent stage. Keywords such as “overseas” and “personnel” first appeared in the co-occurrence network. In the convalescent stage, although the epidemic in China was effectively controlled, the epidemic situations in many other countries were still severe. Thus, the Chinese government decided on the prevention strategy of “preventing imported cases from abroad and preventing the outbreak from rebounding within China”, making it one of the priorities of epidemic prevention and control. Compared with the previous two stages, the national anti-epidemic process is more refined, flexible, and targeted, which provides an important guarantee for the comprehensive resumption of work and production.

Educational policies have become one of the important policy topics in the convalescent stage. Green nodes such as “school”, “attend school”, “colleges”, “graduates”, and “employment” are relatively large in the network. In order to effectively prevent and control the epidemic, education departments worked with other departments and have put in place many measures, such as delaying attending school and adopting an online school model. At the same time, in order to solve the employment problem of graduates during the epidemic, the government and universities have also adopted some assistance and guarantee policies to stabilize the overall employment situation, such as organizing online recruitment, encouraging enlistment or employment at the grassroots level, and granting entrepreneurial subsidies.

Finally, “science and technology”, “housing”, “agricultural products”, “pension”, and other nodes reflect that the topics of policies at this stage is becoming richer and involves almost all walks of life. The social order gradually returned to normalization.

Figure 10. Co-occurrence clustering network of the convalescent stage. Source: authors.
4.2. Evolution Results of Policy Topics of Wuhan City

After analyzing the topic evolution of the whole country’s anti-epidemic policies, in this section, we further analyze whether there are differences in the evolution of policy topics between Wuhan and the whole country. Since the Wuhan City government only notified the epidemic information about confirmed cases in the eclipse stage with few policies, the topic is very clear and there is no need to draw a co-occurrence clustering network. Thus, here, we mainly construct the co-occurrence clustering networks of Wuhan City policies in the outbreak and convalescent stages.

The comparison of co-occurrence clustering networks of Wuhan City policies in the outbreak and convalescent stages is shown in Figure 11. Specifically, in the outbreak stage, the prevention and control of COVID-19 in Wuhan is the most important topic of policies. The epidemic prevention and control nodes, such as “epidemic”, “prevention and control”, “pneumonia”, and “infection” in Figure 11 are obviously larger than other nodes and account for a large proportion. Thus, epidemic prevention and control is the only outstanding topic in this stage.

In the convalescent stage, different from the finding based on the whole country’s COVID-19 policies, the epidemic prevention and control is still the most prominent policy topic with significantly larger orange nodes of “epidemic” and “prevention and control”. Although the nodes of “enterprise”, “resumption of work”, and “resumption of production” became larger, none of them affected the core status of epidemic prevention and control policies. This finding is different from the conclusion derived based on the whole country’s COVID-19 policies, which is that the focus of the third stage is to vigorously resume work and production under the condition of paying attention to prevention and control of the epidemic.

The reason for this is that the epidemic situation in Wuhan is the most serious. The core position of epidemic prevention and control should not be shaken. Thus, many “essential” enterprises in Wuhan could not even resume work and production. Wuhan City could not only rely on its own strength to support the normal operation of the city. To support Wuhan City, other places in China took support measures for Wuhan, including sending medical personnel, donating epidemic materials and daily necessities, etc., which fully reflects China’s governance characteristics of “concentrating power to do a major event”. Thus, although Wuhan City did not return to work and production in the convalescent stage, with the support of other provinces in China, Wuhan City was able to maintain basic operation and guarantee citizens’ basic living needs while fully focusing on epidemic prevention and control.

![Figure 11. Wuhan city’s co-occurrence clustering networks in the outbreak stage (a) and convalescent stage (b). Source: authors.](image-url)
5. Discussion

To sum up, epidemic prevention and control policies run through the whole stage of COVID-19 in China. However, the importance and status of epidemic prevention and control policies changed in different epidemic stages. Specifically, in the eclipse stage, epidemic prevention and control is the only policy topic. The Chinese health department took several response measures, such as formulating prevention and control plans and setting up response teams and expert groups, which laid the foundation for the comprehensive and strict prevention and control of the second stage.

In the outbreak stage, although other topics of policies have been issued, the epidemic prevention and control policies are still the outstanding policy topic. Other topics of policy, such as emergency material supply, market price stability, resumption of work, and production of “essential” enterprises, were issued to support and cooperate with the implementation of epidemic prevention and control policies. This finding is consistent with that of Wang et al. (2021), who investigated initial responses to COVID-19 across 120 countries, and found that China was among the countries that focused more on containment and health policies than social policies [72]. The Chinese government has taken the most stringent prevention and control measures nationwide to protect the health of the people, and the spread of the virus was initially controlled.

In the convalescent stage, epidemic prevention and control have become normalized, and the focus has shifted to returning to normal production and life. As the prevention and control of COVID-19 became regular, the Chinese government adopted a sophisticated and flexible prevention and control plan, namely a region-specific and risk-based epidemic prevention plan, which ensured the normal operation of the national economy and efficient control of the epidemic in local areas. The topics of policies at this stage became more diverse and involved almost all aspects of life.

Furthermore, the experience of Wuhan City’s fighting against COVID-19 has fully demonstrated the superiority of China’s “concentrated efforts to do a major thing” governance. The Chinese government did not overly care about local and temporary losses, but took decisive measures (such as closing the city in Wuhan and building Huoshenshan Hospital) and gathered the national strength to support these measures. This finding broadly supports the previous works in the Wuhan COVID-19 policy effectiveness. Mei (2020) suggested that a policy mix comprised measures such as lockdown of Wuhan, strict community control, and cross-jurisdictional mobilization of resources, which contributed to an effective response to the epidemic in Wuhan [70]. Furthermore, Lago-Peñas et al. (2021) demonstrated that countries with a centralized leadership performed better in policy coordination than those with decentralized parties [73]. In summary, the orderly coordination and consistency of policies in the three stages allowed China to control COVID-19 well within three months.

Based on the co-occurrence clustering network analysis, there is still room for improvements in China’s policies against COVID-19. First, in the eclipse stage of the pandemic, there was a certain delay and non-publicity in the release of early information in China, resulting in insufficient awareness of COVID-19 and great pressure on the health system in the outbreak stage. In fact, this was a common problem in many countries in the process of fighting against the epidemic [74]. Geldsetzer (2020) indicated that in the early stage of the COVID-19 pandemic, in the United States and the United Kingdom, little accurate information about the disease was known by the public due to the information opacity and delay [75]. Therefore, the government’s information disclosure needs to increase transparency, and release scientific and public information in a timely manner to prevent the situation from worsening due to insufficient public awareness. Moreover, the government needs to formulate a “normal + emergency” response plan for public safety management. In a normal situation, the government needs to strengthen supervision and timely identify risks. In an emergency, the speed of emergency response and mobilizing social resources should be maximized.
Second, in the outbreak stage of the pandemic, there are serious supply shortages and sharp price increases of epidemic prevention materials. With the spreading of the pandemic around the world, similar stories were reported in many other countries, such as the United States [76], India [77], and Japan [78]. It is necessary for the government to have a complete anti-epidemic material production and supply agenda. Even if there is no public health incident, the government still needs to save some of these materials (such as masks, protective clothing, medical equipment, and emergency place). When an epidemic occurs, the agenda can balance the supply and demand of materials well.

6. Conclusions

This article comprehensively analyzes China’s COVID-19 policies to study the evolution and cooperation of different epidemic policy topics based on the co-occurrence clustering network method, which is of great importance for responding to possible future public health events. In the empirical analysis, we collect a total of 4982 COVID-19 policies from 1 January 2020 to 31 March 2020 (91 days), which is the most comprehensive dataset of Chinese COVID-19 policies as far as we know. The evolution of COVID-19 in China is divided into three stages: eclipse stage, outbreak stage, and convalescent stage, based on the number of diagnosed patients in China.

By mapping the policy keywords information into different topics, the empirical results show that the policies of the eclipse stage paid more attention to the strict prevention and control of the epidemic, and the health department played a vital role. In the outbreak stage, strict epidemic prevention and security of basic life (such as the resume work of “essential” enterprises and stabilizing market prices) were the foci of the policies. In the convalescent stage, promoting and ensuring the resumption of work in all sectors of society was the most important topic of the policies. In addition, the success of Wuhan City’s fight against COVID-19 reflects China’s governance characteristics of “concentrating power to do a major event”. Finally, the possible improvements for Chinese COVID-19 policies were discussed and some policy suggestions were provided.

Theoretically, the thesis enriches the policy research related to COVID-19 from a systematic decision-making perspective. Most previous research focused on a specific or a kind of policy, or local policy in fighting against COVID-19. The present study, which covered all kinds of central, provincial, and hard-affected cities’ policies, provides a supplement to the current literature. Based on a comprehensive policy text database, a systematic quantitative work for detecting the evolution of the COVID-19 policy topics in different stages can provide deeper insights into the critical role of public policy in fighting against the pandemic.

The results reveal how Chinese anti-epidemic policy foci change and what the coordinated relationships between policies are at different stages, which has practical significance for China and other countries to formulate an effective policy mix to prevent and control the spread of future respiratory infectious diseases in a short time. Moreover, this paper discusses some common problems (e.g., the delayed and non-public information in the eclipse stage and the supply shortage of medical materials) that need to be addressed in the countries affected by COVID-19. Some feasible strategies to deal with these issues are proposed in the study, such as a “normal + emergency” response plan and a complete anti-epidemic material production and supply agenda, which are highly significant in terms of policy formulation and practical applications around the world.

Nonetheless, this research is not without limitations. The present paper has comprehensively collected Chinese COVID-19 policies and discussed the topic evolution of textual policies; however, the effect of anti-epidemic policies is not included in the research scope. Exploring whether policies issued in different stages have really achieved the government’s expected effect is crucial to optimizing the policy mix and effectively responding to the epidemic. Thus, future research in this field could emphasize the quantitative work from a systematic public policy perspective to examine (1) the impact of the policies on preventing and controlling COVID-19, (2) the economic effect of the policies on...
consumption, investment, stock market, etc., and (3) the policies’ social effect on the public sentiment, rumor spreading, social wellbeing, etc.

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