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Environmental risk assessment and comprehensive index model of disaster loss for COVID-19 transmission

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ABSTRACT

This paper focuses on the study of environmental risk assessment and comprehensive index model of disaster loss for COVID-19 transmission. Considering the five environmental vectors of carrier vulnerability, environmental instability of pregnancy and disaster, intensity of disaster-causing factors, disaster prevention and mitigation capacity and emergency prevention and control capacity and its 38 indicators, the correlation coefficient matrix and principal component expression of each vector are established by principal component analysis, respectively, and the index model of each vector is established on the basis. Then, considering the index models of these five vectors, we established the disaster loss composite index model, which was used to conduct environmental risk assessment and disaster loss composite index analysis of the transmission of COVID-19 in Hubei Province during the period of January 21, 2020 to March 18, 2020. The empirical study showed that: (1) the risk index peaked from January 21 to January 23; (2) the risk index was at a low but volatile level from January 24 to March 14; (3) the risk index rose again slightly from March 15 and rose to another peak on March 16. These fluctuating, smooth and fluctuating processes of the comprehensive index of disaster losses of COVID-19 in Hubei Province are basically stable and consistent with the actual situation of the virus outbreak in the early stage, isolation and prevention and control in the middle stage, and resumption of work and production in the late stage. The study in this paper provides a scientific decision-making reference for the prevention and control of COVID-19 as well as emergency prevention and control measures.

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1. Introduction

A novel coronavirus (2019-nCoV) outbreak in 2019 has been reported in the Chinese city of Wuhan since December 31, 2019. The cases have been exported to other Chinese cities and internationally, potentially triggering a global outbreak (Wu et al., 2020a,b). The new coronavirus 2019-nCoV rapidly spread across the global borders of 27 countries. Between 29 December 2019 and 7 February 2020, it infected 34,799 people, causing 724 (2.08%) casualties. The lethality of coronavirus MERS-CoV (3.47%) was higher than SARS-CoV (10.87%) and 2019-nCoV (2.08%); however, compared with SARS-CoV and
MERS-CoV, 2019-nCoV spread rapidly (Meo et al., 2020). The epidemic in China should peak in late February and gradually decline by the end of April. If implementation is delayed for five days, the scale of the outbreak in mainland China will triple. Machine learning prediction confirmed this result, and the cancellation of Hubei quarantine would trigger a second epidemic peak in Hubei Province in mid-March and extend the epidemic period to late April (Yang et al., 2020). To fitted a transmission model in the case information reported before 21 January to estimate key epidemiological measures and to predict possible epidemiological processes (Read et al., 2020). Estimated that the overall symptomatic mortality risk of COVID-19 in Wuhan city is much lower than that of rough or simple diagnosis. Estimating the clinical severity of COVID-19 based on the available data will help inform the public health response during the current SARS-CoV-2 pandemic (Wu et al., 2020a,b). It is important to assess how expensive resource-intensive measures implemented by Chinese authorities contribute to the prevention and control of the 2019-nCoV infection and how long they should be maintained. Under the most stringent measures, the epidemic is expected to peak in two weeks (from 23 January 2020) with a very low peak (Tang et al., 2020). The affected patients geographically related to the local market as a potential source, spread data from person to person or between hospitals, and study data on family cases (Chan et al., 2020). Using real-time liquidity data from Wuhan and detailed case data, including travel history, to clarify the role of case entry in urban transmission in China and determine the impact of control measures (Kraemer et al., 2020). Studied the clinical characteristics of patients with COVID-19. The main comprehensive focus was on admission to intensive care unit (ICU) or death. In the first two months of the outbreak, COVID-19 spread rapidly in China and caused various degrees of disease (Guan et al., 2020).

Global attention to emerging novel coronaviruses (2019-nCoV) is increasing. Using all genomic information currently available, a phylogenetic tree was constructed that included representatives of other coronaviruses, such as bat coronavirus (BCoV) and severe acute respiratory syndrome (Cerarolo and Giorgi, 2020). Ecological risk assessment is very important in every stage of mining. A method of ecological risk assessment is proposed by using probability bound method. The model based on fugacity is used to characterize the exposure (Betrie et al., 2015). Samples of bronchoalveolar lavage fluid and cultured isolates from nine hospitalized patients were subjected to next-generation sequencing, of which eight had visited the South China seafood market in Wuhan. Obtained complete and partial 2019-nCoV genome sequences were from these individuals (Lu et al., 2020). If symptomatic infectious disease cases occurring before 26 January 2020 resulted from free reproduction without intervention, the basic reproductive number of 2019-nCoV was estimated based on reported confirmed and suspected cases (Zhou et al., 2020). The prediction assumes that the number of susceptible population N=20,0000 will not increase. If the epidemic situation is not properly controlled, the peak of infection will be further increased and the peak time will be slightly delayed (Wan et al., 2020). Estimate the impact of secondary epidemics that may occur in communities outside of China. Better case scenarios with different parameters will not lead to secondary cases. With these multiple scenarios with different parameters, medical professionals may be better prepared for this virus infection (Iwata and Miyakoshi, 2020). Conduct a risk assessment of the 2019 Coronavirus (COVID-19) of the Korea Centers for Disease Control and Prevention (KCDC), and apply and activate the national emergency response mechanism based on 8 risk assessments (Kim et al., 2020). The concentrations of arsenic (as) in muscle tissues of four kinds of animals were evaluated. The risk assessment method of health objectives was used to estimate the risk associated with human consumption of fish (THQ), which was lower than the EPA guidance value of 1 for all tested fish (Usese et al., 2017). Through real-time RT-PCR and next-generation sequencing, and directly communicate with patients or their families to determine epidemiological and symptom data, the results compared those who were admitted to the intensive care unit (ICU) with those who did not. Interpretation of COVID-19 infection, a severe respiratory disease such as severe acute respiratory syndrome, coronavirus syndrome is related to ICU admission and high mortality (Huang et al., 2020). The demographic characteristics, exposure history, and time of onset of the confirmed cases in the NCIPlaboratory reported on January 22, 2020. In the early days of exponential growth, the doubling time of infectious diseases and the basic reproduction number were estimated (Li et al., 2020).

This paper considers five major indicators: vulnerability of disaster bearing body, instability of pregnant environment, intensity of disaster causing factors, ability of disaster prevention and mitigation, and emergency prevention and control ability. Using principal component analysis to study the loss index of COVID-19 in Hubei Province. This paper collects the data of COVID-19 and its loss in Hubei Province, obtains the loss index of COVID-19, and combines it with the loss assessment. Then establishes the disaster loss index model of COVID-19 in Hubei Province. The structure of the paper is: Section 2 analyzes the data sources of new confirmed number and new death toll in Hubei Province; Section 3 selects and collects data for COVID-19 vector index; Section 4 constructs correlation coefficient matrix of COVID-19 vector; Section 5 describes principal component expression and constructs disaster loss index model of COVID-19; Section 6 constructs comprehensive index model of disaster loss calculation and the conclusion was given in Section 7.

2. Analysis on the data sources of newly diagnosed and newly increased deaths in Hubei Province

2.1. Raw data analysis

The time span of this study is from January 21 to March 18, 2020. The original data of daily newly diagnosed number and new death toll in Hubei Province from January 21 to March 18, 2020 are drawn, as shown in Figs. 1 and 2.

It can be seen from Fig. 1 that at the beginning of the outbreak, the epidemic situation gradually became serious from January 21, 2020, and the highest point was on February 12, 2020. On that day, the number of newly diagnosed people was 14,840, and then began to decline, and the epidemic situation was gradually controlled.
It can be seen from Fig. 2 that in the early stage of the epidemic, due to people’s ignorance of the new infectious virus and the population flow during the Spring Festival transportation, the epidemic situation developed rapidly, and the daily new death toll increased rapidly. By February 12, 2020, the daily new death toll reached the maximum value of 242, and then began to decline, and rose again on February 23, 2020, and then began to decrease the number of new daily deaths continued to drop, and the epidemic situation was gradually under control.

From New Year’s Eve on January 24th, 2020, the day after the closure of Wuhan. Medical personnel from all over the country rushed to aid Hubei Province. From New Year’s Eve to January 28th, 2020, the first batch of medical teams from all regions except Tibet arrived in Hubei Province. On February 2nd, the Fire God Mountain hospital delivered the medical personnel to Hubei Province, and the number of medical personnel who rushed to Hubei Province on that day reached 2156. On February 9th, 2020, a total of 6011 medical team members from 31 medical teams supported by the counterpart rushed to Hubei Province, which became the peak number of people rushing to aid in a single day. The daily number of medical staff in Hubei Province is shown in Fig. 3.
2.2. Data sources used in this paper

From Figs. 1 and 2, (1) The number of new confirmed cases on February 12, 2020 is 14,840, which is since both the National Health Commission of China and the health commission of Hubei Province have issued the newly confirmed cases with clinical diagnosis of 14,840 and the newly added death cases of 242. Therefore, both the newly confirmed cases and the new deaths will cause the data of the day to increase suddenly, which will lead to the inconsistency between the assessment results of risk composite index and the actual situation; (2) On April 16, 2020, the National Health Commission of China and the health commission of Hubei Province released revised data at the same time. Among them, the revised cumulative number of new confirmed cases was 68,128 and the cumulative number of deaths was 4512, which caused a second sudden increase in data. Therefore, the original data released by the National Health Commission of China and the health commission of Hubei Province cannot be used for index evaluation and prediction analysis of epidemic risk. In order to solve this problem, we adopt the data processing method of reference (Pang, 2020):

(1) Firstly, 14,840 newly confirmed cases with clinical diagnosis and 242 new deaths announced on February 12, 2020 were redistributed to each day from January 21 to February 12, 2020;

(2) Then, COVID-19 released by the Hubei health authority in April 16, 2020 will be restored to the date of the outbreak of the new crown pneumonia virus. However, since the earliest data of covid-19 can be found is the epidemic data released by China Health Commission on January 21, 2020, the revised data released by Hubei Health Commission on April 16, 2020 are all restored to every day from January 21 to April 16, 2020.

Since the time span of this study is from January 21 to March 18, 2020, the data of newly diagnosed number and new death toll in this paper is the data of each day in the period from January 21 to March 18, 2020 after the above two processing of the original data.

3. Index selection and data collection of COVID-19 vector

3.1. Index selection

By considering the four carriers of Typhoon: the vulnerability of disaster bearing body, the instability of disaster pregnant environment, the intensity of disaster causing factors and the ability of disaster prevention and mitigation, the typhoon carrier disaster loss index models were studied by principal component analysis method, and the economic loss caused by typhoon was analyzed (Pang et al., 2020).

To study the environmental risk of the spread of COVID-19 in Hubei Province and its disastrous impact on social and economic development, this paper mainly considers five carrier: the vulnerability of disaster bearing body, the instability of disaster environment, the intensity of disaster causing factors, the ability of disaster prevention and mitigation, and the ability of emergency prevention and control.

(1). Vulnerability of disaster bearing body

The vulnerability of the disaster bearing body emphasizes the vulnerability of the environment and the ability to deal with the COVID-19 in the region, which reflects the susceptibility of people to COVID-19. In this paper, five indicators of vulnerability of disaster bearing body are considered: new confirmed number (NCN), new deaths (NDN), new close contacts (NCC), new suspected cases (NSC) and under medical observation (UMO).

(2). Instability of pregnant environment

The transmission routes of COVID-19 are direct transmission, aerosol transmission and contact transmission. Therefore, the COVID-19 is greatly affected by the unstable degree of the disaster environment. Environmental conditions can directly affect the intensity of transmission of COVID-19, and increase or decrease the risk of transmission of the COVID-19. This paper considered the key factors affecting the most damaging degree as eight indicators of environmental instability in pregnant with COVID-19, that is: Daily average temperature (AT), air quality index (AQI), PM2.5, PM10, sulfur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO), ozone (O₃).

(3). Intensity of disaster causing factors

Where the pathogen comes from, the intensity of the spread of the COVID-19 and other factors determine the size of its impact, so it is necessary to select factors that can characterize the spread of the COVID-19 as the catastrophic factor of the COVID-19. Based on the understanding of reality, and based on the availability and authority of data under actual conditions, this article considers 10 indicators that are closely related to the impact of the COVID-19 as the hazard factors of the COVID-19: population density (PD), area (MA), total population (TP), 0–14 years old (NC), 15–64 years old (MAP), 65 years old and above (NEP), gender ratio (male/female) (SR), urban population proportion (PUP), household number (HH) and employment number (EP).

(4). Disaster prevention and mitigation capability

The ability of disaster prevention and mitigation focuses on the ability of emergency departments and the masses to prepare for disasters before and during disasters. Based on the relevant research results and the availability, authority and authenticity of the data, this paper uses five indicators to represent the disaster prevention and mitigation capacity of disaster affected areas. These five indicators are: the number of new cured (NPC), the number of new medical observation (NMO), the number of centralized isolation (NPCI), the number of severe cases reduced (RSC) and the number of critically ill cases (RCIC).
(5). Emergency prevention and control capability

The ability of emergency prevention and control focuses on the ability of the government and medical related sectors to cope with the spread of COVID-19. Based on the relevant research results and the availability, authority and authenticity of the data, this paper uses 10 indicators to represent the disaster prevention and mitigation capacity of disaster affected areas. These 10 indicators are: medical protective clothing (MPC), medical N95 mask (N95), medical surgical mask (SM), medical protective mask (MPM), isolation clothing (IC), disposable medical gloves (DMG), medical isolation shoe cover/boot cover (MIS), disposable medical hat (DMH), the number of medical staff in Hubei Province (NMHP), the Red Cross Society of Hubei Province (including provincial Red Cross) A novel coronavirus pneumonia epidemic prevention and control (HRC) was accepted by the cross foundation.

3.2. Data acquisition

In this paper, the data of Hubei Province from January 21 to March 18 were collected and statistically analyzed, and then the disaster loss index of new coronavirus pneumonia in Hubei Province was calculated. The data are collected from five carriers, i.e., vulnerability of disaster bearing body, instability of pregnant environment, intensity of disaster causing factors, ability of disaster prevention and mitigation and emergency prevention and control.

The data of five indicators of vulnerability of disaster bearing body were collected, including the number of newly diagnosed cases, the number of new deaths, the number of new close contacts, the new suspected cases, and the patients under medical observation. The data of 8 indicators were collected for the instability of pregnant environment, including daily average temperature, air quality index, PM2.5, PM10, sulfur dioxide, nitrogen dioxide, carbon monoxide and ozone. The data of 10 indicators of disaster factor intensity were collected, including population density, area, total population, 0–14 years old, 15–64 years old, 65 years old and above, gender ratio (male/female), urban population proportion, household number and employment number. The data of 5 indicators of disaster prevention and mitigation ability were collected, including the number of new cured people, the number of new medical observation and centralized isolation the number of people, the number of severe cases reduced and the number of critical illness cases reduced. The data of 10 indicators of emergency prevention and control ability were collected, including medical protective clothing, medical N95 mask, medical surgical mask, medical protective mask, isolation clothing, disposable medical gloves, medical isolation shoe cover/boot cover, disposable medical hat, the number of medical staff in Hubei Province in China, and the red color of Hubei Province COVID-19 was used to prevent and control social donations.

Data sources are: Hubei Health Committee (http://wjw.hubei.gov.cn/), China Statistical Yearbook, Hubei Red Cross Society (http://www.hbsredcross.org.cn/), Historical weather forecast of Hubei (http://www.tianqihoubao.com/lishi/hubei.htm).

4. Correlation coefficient matrices of COVID-19 vector

This paper considered five vectors of COVID-19 are as follows: vulnerability of disaster bearing body, instability of pregnant environment, intensity of disaster causing factors, ability of disaster prevention and mitigation and emergency prevention and control. According to Section 2.2, we selected 5 indicators of vulnerability, 8 indicators of pregnant environment instability, 10 indicators of disaster causing factors, 5 indicators of disaster prevention and mitigation capacity, and 10 indicators of emergency prevention and control capacity. This paper selected a total of COVID-19 disaster indicators as $5 + 8 + 10 + 5 + 10 = 38$.

4.1. Standardization of raw data

Firstly, the correlation coefficient matrix is established. However, due to the different dimensions of each index, the significance of the data of the five indicators is different, and there is a great difference in the number, which affects the research. Therefore, we need to standardize the original data first. The standardization method used in this paper is as follows:

Assume $x'_i$ ($i = 1, 2, \ldots, p$, the same below) is the original sample data. $x_{\text{min}}$ is the minimum value of the original data matrix, $x_{\text{max}}$ is the maximum value of the original data matrix. The original data is standardized and the calculation formula is as follows:

$$x_i = \frac{x'_i - x_{\text{min}}}{x_{\text{max}} - x_{\text{min}}}$$  \hspace{1cm} (1)

Then calculated the correlation coefficient matrix $R$ of standardized data $x_i$, and solved the eigenvalues of the correlation matrix $R$ by algebraic method. Calculate the variance contribution rate and cumulative variance contribution rate and the corresponding feature vector.

4.2. Correlation coefficient matrix

We obtained the correlation coefficient matrix of vulnerability of disaster bearing body, instability of disaster pregnant environment, disaster causing factors and disaster prevention and mitigation ability through calculation, as shown in Table 1, Table 2, Table 3, Table 4, and Table 5 respectively.
Table 1
Correlation coefficient matrix of vulnerability of disaster bearing body.

|       | NCN | NDN | NCC | NSC | UMO |
|-------|-----|-----|-----|-----|-----|
| NCN  | 1.000 | 0.656 | 0.843 | 0.858 | 0.739 |
| NDN  | 0.656 | 1.000 | 0.820 | 0.609 | 0.916 |
| NCC  | 0.843 | 0.820 | 1.000 | 0.848 | 0.852 |
| NSC  | 0.858 | 0.609 | 0.848 | 1.000 | 0.618 |
| UMO  | 0.739 | 0.916 | 0.852 | 0.618 | 1.000 |

Table 2
Correlation coefficient matrix of environmental instability.

|       | AT   | AQI  | PM2.5 | PM10 | SO₂  | NO₂  | CO   | O₃   |
|-------|------|------|-------|------|------|------|------|------|
| AT    | 1.000| 0.067| 0.005 | 0.269| 0.589| 0.211| 0.582| 0.435|
|AQI   | 0.067| 1.000| 0.985 | 0.877| 0.369| 0.670| 0.451| 0.286|
|PM2.5 | 0.005| 0.985| 1.000 | 0.877| 1.000| 0.527| 1.000| 0.378|
|PM10  | 0.269| 0.877| 1.000 | 1.000| 0.527| 0.480| 1.000| 0.037|
|SO₂   | 0.589| 0.369| 0.527 | 1.000| 0.527| 0.480| 0.519| 0.457|
|NO₂   | 0.211| 0.670| 0.682 | 0.527| 1.000| 0.480| 1.000| 0.037|
|CO    | 0.582| 0.692| 0.682 | 0.527| 0.519| 1.000| 0.480| 1.000|
|O₃    | 0.435| 0.442| 0.451 | 0.466| 0.457| 0.480| 1.000| 0.023|

Table 3
Correlation coefficient matrix of disaster causing factors.

|       | PD   | MA   | DP   | NC   | MAP  | NEP  | SR   | PUP  | HH   | EP   |
|-------|------|------|------|------|------|------|------|------|------|------|
| PD    | 1.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000|
|MA    | 0.000| 1.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000|
|DP    | 0.000| 0.000| 1.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000|
|NC    | 0.000| 0.000| 0.000| 1.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000|
|MAP   | 0.000| 0.000| 0.000| 0.000| 1.000| 0.000| 0.000| 0.000| 0.000| 0.000|
|NEP   | 0.000| 0.000| 0.000| 0.000| 0.000| 1.000| 0.000| 0.000| 0.000| 0.000|
|SR    | 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 1.000| 0.000| 0.000| 0.000|
|PUP   | 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 1.000| 0.000| 0.000|
|HH    | 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 1.000| 0.000|
|EP    | 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 1.000|

Table 4
Correlation coefficient matrix of disaster prevention and mitigation capacity.

|       | NPC  | NMO  | NPCI | RSC  | RCIC |
|-------|------|------|------|------|------|
| NPC   | 1.000| 0.300| −0.344| 0.464| 0.351|
|NMO   | 0.300| 1.000| 0.483 | −0.231| −0.074|
|NPCI  | −0.344| 0.483| 1.000| −0.485| −0.318|
|RSC   | 0.464| −0.231| −0.485| 1.000| 0.401|
|RCIC  | 0.351| −0.074| −0.318| 0.401| 1.000|

Table 5
Correlation coefficient matrix of emergency prevention and control capability.

|       | MPC  | N95  | SM   | MPM  | IC   | DMG  | MIS  | DMH  | NMHP | HRC  |
|-------|------|------|------|------|------|------|------|------|------|------|
| MPC   | 1.000| 0.938| 0.803| 0.748| 0.911| 0.094| 0.500| 0.107| −0.193| −0.424|
|N95   | 0.938| 1.000| 0.818| 0.678| 0.850| 0.139| 0.506| 0.184| −0.143| −0.459|
|SM    | 0.803| 0.818| 1.000| 0.665| 0.810| 0.252| 0.481| 0.141| −0.018| −0.436|
|MPM   | 0.748| 0.678| 0.665| 1.000| 0.700| 0.328| 0.308| 0.089| −0.081| −0.253|
|IC    | 0.911| 0.850| 0.810| 0.700| 1.000| 0.030| 0.498| 0.247| −0.273| −0.402|
|DMG   | 0.094| 0.139| 0.252| 0.328| 0.030| 1.000| 0.019| −0.055| 0.098| 0.032|
|MIS   | 0.500| 0.506| 0.481| 0.308| 0.498| 0.019| 1.000| 0.178| −0.370| −0.380|
|DMH   | 0.107| 0.184| 0.141| 0.089| 0.247| −0.055| 0.178| 1.000| −0.188| −0.208|
|NMHP  | −0.193| −0.143| −0.018| −0.081| −0.273| 0.098| −0.370| −0.188| 1.000| 0.101|
|HRC   | −0.424| −0.459| −0.436| −0.253| −0.402| 0.032| −0.380| −0.208| 0.101| 1.000|

4.3. Correlation analysis of various indexes of new coronavirus pneumonia vector

In this paper, the criteria for judging the correlation coefficient are: \(|r| < 0.4\) is low linear correlation; \(0.4 \leq |r| < 0.7\) is significant correlation; \(0.7 \leq |r| \leq 1\) is high linear correlation.

It can be seen from Table 1 that the newly diagnosed number (NCC) is significantly correlated with the newly increased number of deaths (NDN), while the other three indicators are highly linear correlation; the newly increased number of
deaths (NDN) and the newly diagnosed number (NCC) are significantly correlated, while the other three indicators are highly linear correlation; the number of new close contacts (NCC) is related to the other four indicators. The absolute value of the coefficient is between 0.820 \sim 0.852, which means there is a high linear correlation; new suspected cases (NSC) and the number of new deaths (NDN) and the number of people under medical observation (UMO) are significantly correlated, while the other two indicators are highly linear correlation; the number of medical observation (UMO) is significantly related to the new suspected cases (NSC). The other three indexes were highly linear correlation. Therefore, principal component analysis can be used to extract the variables with overlapping information to obtain new variables with inconsistent information.

It can be seen from Table 2 that daily average temperature (AT) is significantly correlated with air quality index (AQI) and carbon monoxide (CO), and has a low linear correlation with other indicators; air quality index (AQI) has a high linear correlation with PM2.5 and PM10, a significant correlation with nitrogen dioxide (NO\textsubscript{2}), and a low linear correlation with other four indicators; PM2.5 and air Quality index (AQI) and PM10 were highly linear correlation, significant correlation with nitrogen dioxide (NO\textsubscript{2}) and low linear correlation with other four indicators; PM10 was highly linear correlation with air quality index (AQI) and PM2.5, significant correlation with nitrogen dioxide (NO\textsubscript{2}) and low linear correlation with other four indicators; sulfur dioxide (SO\textsubscript{2}) was highly linear correlation with air quality index (AQI) and PM2.5. The results showed that there was a low linear correlation with air quality index (AQI), PM2.5 and PM10, and a high linear correlation with the other four indicators; a high linear correlation was found between nitrogen dioxide (NO\textsubscript{2}) and daily average temperature (AT) and ozone (O\textsubscript{3}), and a low linear correlation between nitrogen dioxide (NO\textsubscript{2}) and other four indicators; a low linear correlation between carbon monoxide (CO) and ozone (O\textsubscript{3}) and the other 6 indicators all the indexes were significantly correlated.

It can be seen from Table 3 that these 10 indicators are not related to other indicators. Because the intensity of correlation among the 10 indicators of disaster causing factors is very low, that is, there is little overlapping information between indicators, so it is not necessary to extract principal components by principal component analysis. In addition, these 10 indicators have little change within the specified time, so the disaster causing factors can be regarded as constant and the value is 1.

It can be seen from Table 4 that the number of new cured patients (NPC) is significantly correlated with the number of severe cases reduced (RSC), and it is a low-level linear correlation with the other three indicators; the number of newly released medical observation (NMO) is significantly related to the number of centralized isolation (NPCI), and it is a low-level linear correlation with the other three indicators; the number of centralized isolation (NPCI) and the number of new cured people are significantly correlated NPC and RSC were significantly correlated with the other 2 indicators, RSC was low linear correlation with NMO, and was significantly correlated with other three indicators; RSCI was significantly correlated with RSC and RSC For significant correlation, it has low linear correlation with the other three indicators; it can be seen that there is correlation between indicators, and there is information overlap, so we need to re-extract the variables with repeated information.

It can be seen from Table 5 that medical protective clothing (MPC) has significant correlation with medical isolation shoe cover/boot cover (MIS) and donated materials (HRC), and has low linear correlation with disposable medical gloves (dmg), disposable medical hat (DMH) and the number of medical staff in Hubei Province (NMHP), and has a high linear correlation with other four indicators; medical N95 mask (N95) has a high linear correlation with medical use Protective clothing (MPC) and medical surgical mask (SM) were highly linear correlated with disposable medical gloves (dmg) and highly linear with other five indicators; medical surgical masks (SM) had low linear correlation with disposable medical hat (DMH) and medical staff number (NMHP) in Hubei Province, and had low linear correlation with medical protective clothing (MPC) Medical protective mask (MPM) was highly linear correlated with medical protective clothing (MPC) and isolation clothing (IG), and was significantly correlated with medical N95 mask (N95) and medical surgical mask (SM), and was low linear with other five indicators Isolation clothing (IG) and disposable medical gloves (dmg), disposable medical hat (DMH), the number of medical staff in Hubei Province (NMHP) were low linear correlation, and the medical isolation shoe cover/boot cover (MIS) and donated materials (HRC) were significantly correlated, and there was a high linear correlation between IG and the other four indicators. Therefore, principal component analysis should be used to extract principal components.

5. Principal component expression and index model establishment

To extracted the characteristics of five carriers of COVID-19, namely vulnerability of disaster bearing body, instability of pregnant environment, disaster causing factors, disaster prevention and mitigation ability and emergency prevention and control ability, and established the corresponding vector index model of COVID-19.

5.1. Vulnerability index model of disaster bearing body

5.1.1. Eigenvalue, variance contribution rate and cumulative variance contribution rate

The eigenvalue, variance contribution rate and cumulative variance contribution rate of vulnerability of disaster bearing body are calculated as shown in Table 6.
Table 6
Eigenvalue, variance contribution rate and cumulative variance contribution rate of vulnerability of disaster bearing body.

| Variable | Eigenvalue | Variance contribution rate % | Cumulative variance contribution rate % |
|----------|------------|------------------------------|----------------------------------------|
| $\lambda_1$ | 4.109 | 82.184 | 82.184 |
| $\lambda_2$ | 0.587 | 11.732 | 93.916 |
| $\lambda_3$ | 0.163 | 3.262 | 97.178 |
| $\lambda_4$ | 0.089 | 1.789 | 98.967 |
| $\lambda_5$ | 0.052 | 1.033 | 100.000 |

Table 7
Principal component coefficient (eigenvector) and standard deviation of vulnerability of disaster bearing body.

| Variable | Corresponding eigenvector $\lambda_1$ | Standard deviation |
|----------|---------------------------------------|--------------------|
| $x_1$    | 0.220                                 | 1328.964777        |
| $x_2$    | 0.215                                 | 49.3008254         |
| $x_3$    | 0.235                                 | 3997.587781        |
| $x_4$    | 0.211                                 | 950.0009004        |
| $x_5$    | 0.222                                 | 27045.31353        |

Table 8
Eigenvalue, variance contribution rate and cumulative variance contribution rate of vulnerability of disaster bearing body.

| Variable | Eigenvalue | Variance contribution rate % | Cumulative variance contribution rate % |
|----------|------------|------------------------------|----------------------------------------|
| $\lambda_1$ | 4.146 | 51.824 | 51.824 |
| $\lambda_2$ | 1.824 | 22.806 | 74.630 |
| $\lambda_3$ | 1.004 | 12.555 | 87.186 |
| $\lambda_4$ | 0.554 | 6.921 | 94.106 |
| $\lambda_5$ | 0.262 | 3.278 | 97.384 |
| $\lambda_6$ | 0.139 | 1.742 | 99.126 |
| $\lambda_7$ | 0.066 | 0.827 | 99.953 |
| $\lambda_8$ | 0.004 | 0.047 | 100.000 |

5.1.2. Principal component expression of vulnerability of disaster bearing body
According to Table 6, the cumulative variance contribution rate of the first eigenvalue $\lambda_1$ is 82.184% > 80%, so we can think that the first principal component can reflect the information of the original variable, so we can use the first principal component to replace the original information. Therefore, in the eigenvalues in Table 7, only the eigenvectors corresponding to the eigenvalues $\lambda_1$ of the correlation coefficient matrix of the environmental instability of the pregnant environment are needed. The eigenvectors corresponding to the eigenvalues $\lambda_1$ are shown in Table 7.

Therefore, can established the expression of vulnerability $F_1$ is:

$$F_1 = 0.220X_1 + 0.215X_2 + 0.235X_3 + 0.211X_4 + 0.222X_5 \quad (2)$$

5.1.3. Establish vulnerability index model of disaster bearing body
According to Table 7, the standard deviation of variable $x_1$ is 1328.964777. We take the standard deviation of the variable $x_1$1328.96 as the coefficient of the first principal component $F_1$, so we can establish the mathematical model of the vulnerability index $V$ of the disaster bearing body of the COVID-19 as follows:

$$V = 1328.96F_1 \quad (3)$$

5.2. Instability of pregnant environment index model

5.2.1. Eigenvalue, variance contribution rate and cumulative variance contribution rate
The eigenvalue, variance contribution rate and cumulative variance contribution rate of environmental instability of disaster pregnant are shown in Table 8.

5.2.2. Principal component expression of instability of pregnant environment
According to Table 8, the cumulative variance contribution rate of the first eigenvalue $\lambda_1$ is 51.824% < 85%. The sum of the cumulative variance contribution rates of the first eigenvalue $\lambda_1$ and the second eigenvalue $\lambda_2$ is 74.630% < 85%, but the sum of the cumulative variance contribution rates of the first eigenvalue $\lambda_1$, the second eigenvalue $\lambda_2$ and the third eigenvalue $\lambda_3$ is 87.186% > 85%. So, we can think that the first principal component, the second principal component and the third principal component can reflect the information of the original variable, so we can use the first principal component, the second principal component and the third principal component to replace the original information.
Therefore, in the eigenvalues in Table 8, only the eigenvalues \( \lambda_1, \lambda_2 \) and \( \lambda_3 \) of the correlation coefficient matrix and the corresponding eigenvectors are needed. The eigenvalues \( \lambda_1, \lambda_2 \) and \( \lambda_3 \) corresponding eigenvectors are shown in Table 9.

Therefore, can established the expression of the principal component \( E_1, E_2 \) and \( E_3 \) of the instability of pregnant environment as follows:

\[
E_1 = 0.105X_1 + 0.214X_2 + 0.206X_3 + 0.221X_4 + 0.148X_5 + 0.197X_6 \\
+ 0.166X_7 + 0.070X_8
\]

\[
E_2 = 0.429X_1 - 0.226X_2 - 0.258X_3 - 0.111X_4 + 0.335X_5 - 0.070X_6 \\
+ 0.140X_7 + 0.313X_8
\]

\[
E_3 = -0.162X_1 + 0.153X_2 + 0.083X_3 + 0.206X_4 - 0.040X_5 - 0.149X_6 \\
- 0.572X_7 + 0.739X_8
\]

5.2.3. Establish vulnerability index model of disaster bearing body

According to Table 8, the standard deviation of variables \( x_1 \) is 4.227937, the standard deviation of variables \( x_2 \) is 24.86442, and the standard deviation of variables \( x_3 \) is 19.58984. We take the standard deviation of variable \( x_1 \) 4.23 as the coefficient of the first principal component \( E_1 \), the standard deviation of the variable \( x_2 \) 24.86 as the coefficient of the second principal component \( E_2 \), and the standard deviation of the variable \( x_3 \) of 19.59 as the coefficient of the third principal component \( E_3 \). Therefore, we can establish the mathematical model of vulnerability index \( D \) of COVID-19 as follows:

\[
D = 4.23E_1 + 24.86E_2 + 19.59E_3
\]

5.3. Intensity index model of disaster causing factors

According to the analysis in Section 3.2, the principal component analysis method used in this paper mainly analyzes the disaster loss data of COVID-19 from January 21st to March 18th in Hubei Province. Considering that the changes of 10 indexes of the disaster causing factor strength of one of the five major carriers of COVID-19 in a short period of time is very small, so the disaster causing factor intensity of COVID-19 can be seen in this paper. Therefore, the mathematical model of disaster causing factor intensity index \( P \) can be expressed as follows:

\[
P = 1
\]

5.4. Index model of disaster prevention and mitigation capability

5.4.1. Eigenvalue, variance contribution rate and cumulative variance contribution rate

The eigenvalues, variance contribution rate and cumulative variance contribution rate of correlation coefficient matrix of disaster prevention and mitigation capability are shown in Table 10.
Table 11
Principal component coefficient (eigenvector) and standard deviation of vulnerability of disaster bearing body.

| Variable | Corresponding eigenvector $\lambda_1$ | Corresponding eigenvector $\lambda_2$ | Standard deviation |
|----------|--------------------------------------|--------------------------------------|--------------------|
| $x_1$    | 0.278                                | 0.475                                | 849.12012          |
| $x_2$    | $-0.154$                             | 0.650                                | 3908.284627        |
| $x_3$    | $-0.353$                             | 0.242                                | 4741.851695        |
| $x_4$    | 0.364                                | 0.031                                | 458.734461         |
| $x_5$    | 0.294                                | 0.145                                | 139.013            |

Table 12
Eigenvalue, variance contribution rate and cumulative variance contribution rate of vulnerability of disaster bearing body.

| Variable | Eigenvalue | Variance contribution rate % | Cumulative variance contribution rate % |
|----------|------------|------------------------------|----------------------------------------|
| $\lambda_1$ | 4.859      | 48.585                       | 48.585                                 |
| $\lambda_2$ | 1.426      | 14.258                       | 62.844                                 |
| $\lambda_3$ | 0.925      | 9.249                        | 72.092                                 |
| $\lambda_4$ | 0.891      | 8.914                        | 81.006                                 |
| $\lambda_5$ | 0.748      | 7.485                        | 88.491                                 |
| $\lambda_6$ | 0.510      | 5.098                        | 93.589                                 |
| $\lambda_7$ | 0.308      | 3.076                        | 96.665                                 |
| $\lambda_8$ | 0.194      | 1.937                        | 98.603                                 |
| $\lambda_9$ | 0.106      | 1.061                        | 99.664                                 |
| $\lambda_{10}$ | 0.034     | 0.336                        | 100.000                               |

5.4.2. Principal component expression of disaster prevention and mitigation capability

According to Table 10, the cumulative variance contribution rate of the first eigenvalue $\lambda_1$ is 44.968% < 70%. But the sum of the cumulative variance contribution rate of the first eigenvalue $\lambda_1$ and the second eigenvalue $\lambda_2$ is 72.405% > 70%, so we can think that the first principal component and the second principal component can reflect the information of the original variable, we can use the first principal component and the second principal component to replace the original information. Therefore, in the eigenvalues of Table 10, only the eigenvalues $\lambda_1$ and $\lambda_2$ of the correlation coefficient matrix and the corresponding eigenvectors are needed. The eigenvalues $\lambda_1$ and $\lambda_2$ corresponding eigenvectors are shown in Table 11.

Therefore, the expression of principal component $K_1$ and $K_2$ of disaster prevention and mitigation ability can be established as follows:

$$K_1 = 0.278X_1 - 0.154X_2 - 0.353X_3 + 0.364X_4 + 0.294X_5$$  \hspace{1cm} (9)

$$K_2 = 0.475X_1 + 0.650X_2 + 0.242X_3 + 0.031X_4 + 0.145X_5$$  \hspace{1cm} (10)

5.4.3. Established the index model of disaster prevention and mitigation capability

According to Table 10, the standard deviation of variables $x_1$ is 849.12012, and the standard deviation of variables $x_2$ is 3908.284627. We take the standard deviation of variables $x_2$ 849.12 as the coefficient of the first principal component $K_1$, and the standard deviation of the variable $x_2$ 3908.28 as the coefficient of the second principal component $K_2$, so we can establish the mathematical model of the disaster prevention and mitigation ability index $R$ of COVID-19 as follows:

$$R = 849.12K_1 + 3908.28K_2$$  \hspace{1cm} (11)

5.5. Index model of emergency prevention and control capability

5.5.1. Eigenvalue, variance contribution rate and cumulative variance contribution rate

The eigenvalues, variance contribution rate and cumulative variance contribution rate of correlation coefficient matrix of emergency prevention and control capability are shown in Table 12.

5.5.2. Principal component expression of emergency prevention and control capability

According to Table 12, the cumulative variance contribution rate of the first eigenvalue $\lambda_1$ is 48.585% < 60%, but the cumulative variance contribution rate of the first eigenvalue $\lambda_1$ and the second eigenvalue $\lambda_2$ is 62.844% > 60%. So, we can think that the first principal component and the second principal component can reflect the information of the original variable, so we can use the first principal component and the second principal component to replace the original information. Therefore, in the eigenvalues of Table 12, only the eigenvalues $\lambda_1$ and $\lambda_2$ corresponding eigenvectors of the correlation coefficient matrix of emergency prevention and control capability are required. The eigenvalues $\lambda_1$ and $\lambda_2$ corresponding eigenvectors are shown in Table 13.
Table 13
Principal component coefficient (eigenvector) and standard deviation of vulnerability of disaster bearing body.

| Variable | Corresponding eigenvector $\lambda_1$ | Corresponding eigenvector $\lambda_2$ | Standard deviation |
|----------|---------------------------------------|---------------------------------------|--------------------|
| $x_1$    | 0.195                                 | 0.052                                 | 8.346653748        |
| $x_2$    | 0.192                                 | 0.050                                 | 15.71440463        |
| $x_3$    | 0.182                                 | 0.149                                 | 105.576471         |
| $x_4$    | 0.160                                 | 0.236                                 | 1.670752558        |
| $x_5$    | 0.191                                 | −0.039                                | 5.914474752        |
| $x_6$    | 0.036                                 | 0.445                                 | 42.13756039        |
| $x_7$    | 0.129                                 | −0.258                                | 3.983588332        |
| $x_8$    | −0.051                                | 0.453                                 | 112.2446716        |
| $x_9$    | −0.112                                | 0.176                                 | 2658.898691        |

Therefore, the expression of principal components $L_1$ and $L_2$ of emergency prevention and control capability can be established as follows:

$$L_1 = 0.195x_1 + 0.192x_2 + 0.182x_3 + 0.160x_4 + 0.191x_5 + 0.036x_6$$
$$+ 0.129x_7 + 0.051x_8 - 0.051x_9 - 0.112x_{10}$$

$$L_2 = 0.052x_1 + 0.050x_2 + 0.149x_3 + 0.236x_4 - 0.039x_5 + 0.445x_6$$
$$- 0.258x_7 - 0.340x_8 + 0.453x_9 + 0.176x_{10}$$

5.5.3. Establishing index model of emergency prevention and control capability

According to Table 12, the standard deviation of variables $x_1$ is 8.346653748, and the standard deviation of variables $x_2$ is 15.71440463. We take the standard deviation of variables $x_1$ 8.35 as the coefficient of the first principal component $L_1$, and the standard deviation of the variable $x_2$ of 15.71 as the coefficient of the second principal component $L_2$, so we can establish the mathematical model of the emergency prevention and control ability index $E$ of COVID-19 as follows:

$$E = 8.35L_1 + 15.71L_2$$

6. Comprehensive index model and calculation of disaster loss

6.1. Establishment of comprehensive index model

In 2002, the United Nations International Strategy for disaster reduction (UNISDR) adopted the term “resilience” and defined it as the capacity of a system, community, or society to resist or change to achieve an acceptable level of function and structure. This is determined by the capacity of the social system to be self-organizing, to increase learning and adaptability (including the ability to recover from disasters). The expression of risk measure is (Xiang, 2007):

$$\text{Risk} = \text{Disaster causing factors} \times \text{Vulnerability} \div \text{Resilience}$$

Also, the risk index model of typhoon disaster system, pointed out that the formation of typhoon disaster risk depends on the stability of disaster pregnant environment, vulnerability of disaster bearing body, risk of disaster causing factors and disaster prevention and mitigation ability, and these four indicators interact and interact with each other (UNISDR, 2002). The risk index model of typhoon disaster system is as follows:

$$\text{Risk degree} = \text{Stability} \times \text{Danger} \times \text{Vulnerability} \times \text{Disaster prevention and mitigation capability}$$

Based on the paper (Xiang, 2007) and (UNISDR, 2002), the damage risk index of COVID-19 in Hubei Province was studied. The risk in this paper refers to the COVID-19 disaster risk which can lead to loss. Therefore, the vulnerability of the disaster bearing body ($V$), the instability of pregnant environment ($D$), the intensity of disaster causing factors ($P$), the ability of disaster prevention and mitigation ($R$) and the ability of emergency prevention and control ($E$) are selected as the influencing factors of the disaster loss index of COVID-19 The larger the three, the greater the loss. And the ability of disaster prevention and mitigation and emergency prevention and control can reduce disaster losses to a certain extent, and have a negative correlation with disaster losses. The disaster loss index model of COVID-19 is established as follows:

$$\text{COVID-19 disaster loss index} = \frac{V \times D \times P}{R \times E}$$

$I$ is used to represent the COVID-19 disaster loss index, the loss index model of COVID-19 in Hubei Province can be expressed as follows:

$$I = \frac{V \times D \times P}{R \times E}$$
Table 14  
Comprehensive index of loss caused by new coronavirus pneumonia in Hubei Province.

| Data      | Composite index | Data      | Composite index | Data      | Composite index |
|-----------|-----------------|-----------|-----------------|-----------|-----------------|
| 21-Jan    | 0.000402563     | 10-Feb    | 1.39239E−07     | 1-Mar     | 1.68882E−06     |
| 22-Jan    | 0.000369947     | 11-Feb    | 3.60107E−08     | 2-Mar     | 1.09112E−06     |
| 23-Jan    | 0.000501018     | 12-Feb    | 6.74188E−08     | 3-Mar     | 8.90788E−07     |
| 24-Jan    | 4.60029E−05     | 13-Feb    | 3.08988E−08     | 4-Mar     | 2.51686E−06     |
| 25-Jan    | 9.79052E−06     | 14-Feb    | 1.09297E−07     | 5-Mar     | 3.41518E−06     |
| 26-Jan    | 1.50272E−06     | 15-Feb    | 5.13259E−08     | 6-Mar     | 4.33368E−06     |
| 27-Jan    | 3.08586E−06     | 16-Feb    | 9.51555E−08     | 7-Mar     | 5.4143E−07      |
| 28-Jan    | 9.61494E−07     | 17-Feb    | 1.08154E−07     | 8-Mar     | 4.6164E−06      |
| 29-Jan    | 1.23844E−06     | 18-Feb    | 7.8745E−07      | 9-Mar     | 6.25264E−06     |
| 30-Jan    | 1.23844E−06     | 19-Feb    | 1.44805E−07     | 10-Mar    | 8.3192E−06      |
| 31-Jan    | 1.02388E−06     | 20-Feb    | 1.06264E−07     | 11-Mar    | 7.97005E−06     |
| 1-Feb     | 2.25471E−06     | 21-Feb    | 1.22288E−07     | 12-Mar    | 9.472E−06       |
| 2-Feb     | 3.20143E−07     | 22-Feb    | 9.40985E−07     | 13-Mar    | 8.15988E−06     |
| 3-Feb     | 4.73349E−07     | 23-Feb    | 2.84146E−07     | 14-Mar    | 1.49525E−05     |
| 4-Feb     | 3.02195E−07     | 24-Feb    | 1.92533E−06     | 15-Mar    | 3.35136E−06     |
| 5-Feb     | 2.37628E−07     | 25-Feb    | 1.63966E−06     | 16-Mar    | 6.98332E−05     |
| 6-Feb     | 8.9405E−08      | 26-Feb    | 8.58832E−07     | 17-Mar    | 4.76336E−05     |
| 7-Feb     | 3.51442E−08     | 27-Feb    | 7.49517E−07     | 18-Mar    | 0.0001          |
| 8-Feb     | 2.058E−07       | 28-Feb    | 1.32606E−07     |           |                 |
| 9-Feb     | 3.39854E−08     | 29-Feb    | 1.00095E−06     |           |                 |

Put vulnerability index of disaster bearing body (Equal. 3), pregnant environment instability (Equal. 7), disaster causing factor intensity (Equal. 8), disaster prevention and mitigation capacity index (Equal. 11) and emergency prevention and control capacity index (Equal. 14) into Eq. (18), the disaster loss index model of COVID-19 in Hubei Province established in this paper can be further expressed as follows:

\[
I = \left( \frac{(1422.78F_1)(909.19E_1 + 2324.95E_2)}{(746.36K_1 + 20311.55K_2)(72449.08L_1 + 131481.35L_2)} \right) ^{0.5}
\]

(19)

6.2. Methods and steps of environmental risk assessment

The research mainly studies environmental risk assessment and comprehensive index model of disaster loss on spread of novel coronavirus pneumonia (COVID-19). The methods and steps of environmental risk assessment process are as follows:

Step 1: Considering the main carrier of COVID-19 in the process of environmental transmission.
Step 2: For each carrier, the index system of environmental risk is established.
Step 3: In the study area, the data of COVID-19 were collected.
Step 4: The correlation coefficient matrix of each carrier is established.
Step 5: Using principal component analysis to establish principal component expression.
Step 6: Establishing the index model of each carrier.
Step 7: The comprehensive index model of disaster loss is established.
Step 8: The comprehensive index of disaster loss of COVID-19 in the region was calculated.
Step 9: Assess the environmental risk of the area.

7. Model application and data analysis

7.1. Calculation of composite index model

This paper use formula (19) to calculate the total data sample, that is, the COVID-19 disaster loss index of Hubei Province from January 21st to March 18th, 2020. The calculation results with three decimal places are shown in Table 14. Table 14 shows that the higher the disaster loss index of COVID-19, the higher the risk of COVID-19.

7.2. Composite index analysis

Since the beginning of the COVID-19, due to people's ignorance of the new infectious virus and the population flow during the Spring Festival transportation, the epidemic situation has developed rapidly. Facing the severe situation of the development of the epidemic situation, the Central Committee of the Communist Party of China has made a quick response in order to make the epidemic situation stable and contracted in the fastest time. This paper studies the environmental risk of the spread of COVID-19 and establishes the disaster loss comprehensive index model Type.

In this paper, the factors affecting the COVID-19 are divided into five vectors and 38 indexes, and a comprehensive index model is established and calculated according to the collected data. We draw the comprehensive index data of
COVID-19 disaster loss calculated above. All the data, namely, the comprehensive index curve of COVID-19 disaster loss in Hubei Province from January 21 to March 18, 2020, is shown in Fig. 4.

From Fig. 4, we can see that the loss index of COVID-19 in Hubei Province started from January 21st to a high-risk index, reached the peak on January 23rd, and then dropped to a lower level on January 25th, and maintained a low level. Since the risk index has been maintained at a low level since January 25th, in order to see the trend of risk index more clearly, we divided it into three stages for analysis, namely, the first stage (January 21st–January 25th) as shown in Fig. 5, the second stage (January 26th–March 4th) as shown in Fig. 6, and the third stage (March 5th–March 18th) as shown in Fig. 7.

As can be seen from Fig. 5, the COVID-19 began on January 21, and gradually increased until it reached the peak on January 23, with the composite index of 0.000500187, and then decreased until January 25 to a low and stable situation.

From the actual situation of Hubei Province, in the face of the severe situation of epidemic development, on January 23, Wuhan was completely “closed down” to create conditions for the national epidemic prevention and control, so the risk index was increasing before January 23; on January 24, the national medical staff began to rush to Hubei Province, and the epidemic risk index began to decline; on January 25, the Standing Committee of the Political Bureau of the CPC Central Committee held a meeting It was decided that the CPC Central Committee should set up a leading group to deal with the epidemic situation, and send a guidance group to Hubei and other areas with serious epidemic situation, so as to promote the relevant local governments to comprehensively strengthen the front-line work of prevention and control. Under the unified guidance and deployment of the CPC Central Committee, the composite index fell to a low and stable level on January 25.

Then, from January 26, the risk index has been at a reduced level. Although the composite index has a certain fluctuation since January 26, it has been in a downward trend. Although there is a small fluctuation behind, it has been in a lower level.

According to the actual situation of Hubei Province, on February 2, Huoshenshan hospital delivered the medical staff to Wuhan, and medical equipment and materials were also supporting Hubei Province. The comprehensive index was further reduced to a lower level. Under the national epidemic prevention measures, the control of epidemic transmission sources has achieved initial results. With the continuous optimization and improvement of health and medical programs, as well as nationwide the prevention and control measures taken to fully play the role of the epidemic prevention and control.

In the last stage, the composite index from March 5 to March 14 was at a low level. The risk index rose slightly from March 15 to March 16, reaching a maximum value of 6.98332e−05, but it was still at a low level.
According to the actual situation in Hubei Province, since March 15, the epidemic situation has been effectively controlled in all parts of the country, including Wuhan City, which is a severe epidemic area in Hubei Province. However, at the same time, the global epidemic situation is particularly grim. 159 countries and regions have reported cases, and the total number of confirmed cases is more than 180,000. With the rapid spread of global epidemic situation, China is faced with huge import pressure and risk, while achieving the goal of complete control of the COVID-19 epidemic is still arduous. Due to the emergence of asymptomatic infected persons and the increase of overseas import, the composite index also rose. However, due to the sufficient response measures and emergency supplies, the risk index is still in a very low and controllable range. Therefore, the government and other relevant departments to do effective emergency measures and policies, while continuing to strengthen and consolidate the effectiveness of prevention and control, at the same time, the epidemic situation of COVID-19 in Hubei Province will be controlled at a low level in a very short period.

8. Conclusions

In the context of the rapid development of the global epidemic, the research on the loss index model of COVID-19 based on risk assessment system is conducive to the rapid and accurate assessment of the disaster severity, and provides scientific support and decision-making basis for reducing the disaster risk of COVID-19, reducing the vulnerability of the disaster bearing body, and enhancing the ability of disaster prevention and mitigation in Hubei Province. This paper combined with the risk management theory and risk model of natural disasters at home and abroad, the risk index system of COVID-19 in Hubei Province is constructed. It not only considers the strength of the disaster causing factors and the vulnerability of the disaster bearing body, but also considers the instability of the pregnant environment, the ability of disaster prevention and mitigation and the ability of emergency prevention and control. Based on the data of COVID-19 from January 21st to March 18th in Hubei Province, we calculated the disaster loss index of COVID-19 in Hubei Province by principal component analysis method, and constructed the disaster loss model of COVID-19 in Hubei Province.

In this paper, the epidemic situation was divided into three stages according to the calculation results of comprehensive index

(1) The first stage (January 21–January 25): it increases from January 21 to January 23, and then decreases until January 25. On January 23, Wuhan was completely “closed” to create conditions for epidemic prevention and control. On January 24, the national medical staff began to rush to aid Hubei Province, so the comprehensive index dropped to a low and stable level from January 25.

(2) The second stage (January 26–March 4): from January 26, the risk index is at the reduced level. Although there is a small fluctuation behind, it has been in a lower level. On February 2, the Huoshenshan hospital delivered the medical staff
to Wuhan, and the medical materials and equipment were also supporting Hubei Province. The composite index dropped to a lower level.

(3) The third stage (March 5–March 18): the composite index from March 5 to March 14 is at a low level. From March 15, the risk index has increased slightly, but it is still at a low level. Since March 15, the national epidemic situation has been effectively controlled, but the global epidemic situation is particularly severe. Due to the emergence of asymptomatic infected persons and the increase of overseas import, the comprehensive index has also increased. However, due to the sufficient response measures and emergency supplies, the risk index is still in a very low and controllable range.

The disaster loss index model of COVID-19 in Hubei Province is put forward based on the risk model formula put forward by scholars at home and abroad, and the statistical data of COVID-19 disaster in Hubei Province. It provides support for forecasting and reducing epidemic disasters.

**CRediT authorship contribution statement**

**Sulin Pang:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing - review & editing. **Xiaofeng Hu:** Writing - original draft, Table, Formal analysis, Software. **Zhiming Wen:** Formal analysis, Investigation, Methodology.

**Declaration of competing interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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