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Analysis of the evolution of health system resilience in the context of natural disasters based on information entropy

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01

PART ONE

Introduction

01 / Introduction

- ✓ The natural disaster situation in China is complex and severe.
- ✓ In 2020, various natural disasters caused a total of 94.94 million people affected, 792 people were killed or missing.
- ✓ The direct economic loss was 286.4 billion yuan.
- ✓ Natural disaster events cause direct damage to the health system and a double crisis of catastrophic medical demand surge.

01 / Introduction

- ✓ Health system resilience is defined by the World Health Organization as "the ability of a system, community or society to be exposed to danger, maintain the basic structure and function of the system, resist, absorb, adapt and recover quickly and efficiently from disasters"
- ✓ Resilient health system can defuse the risks caused by natural disasters and promote the healthy development of the health system.

This topic will

- ✓ explore the orderliness of the time series of the health system under natural disasters by calculating the entropy flow of the health system.
- ✓ provide a certain scientific basis for exploring the development model of the health system in response to disasters and improving the health system resilience .

02

PART TWO

Method

02 / Method

Design of the entropy index system of health system under the natural disaster situation.

- Based on the entropy theory and the health system resilience evaluation framework in the context of catastrophic medical demand surge, this research divides the indicators of entropy of the health system into“stress-type positive entropy $d_i s$” and “support-type negative entropy $d_e s$”.
- “$d_i s$ ”represents the pressure of natural disasters on the health system, which is the positive entropy increase composed of casualties caused by various natural disasters.
- “$d_e s$” represents the support and inheritance of the health system from the outside world, including the economy and resource subsystems load capacity.

02 / Method

Design of the entropy index system of health system under the natural disaster situation.

Target layer	Tactor layer	Indicator layer
Negative entropy	Human entropy	Number of health workers (10,000 people)
	Material entropy	Number of medical institutions with equipment of more than 10,000 yuan (pieces)
		Building area of medical and health institutions
		Number of beds in medical and health institutions (10,000)
	Mechanism entropy	Number of medical and health institutions (pieces)
	Funding entropy	Government health expenditure (100 million yuan)
Positive entropy	Earthquake entropy	Casualties (person)
	Geological disaster entropy	Casualties (person)
	Flood entropy	Affected population (10,000 people)
	Grought entropy	Population with difficulty in drinking water (10,000 people)
	Marine disaster entropy	Casualties (person)
	Forest fire entropy	Casualties (person)

02 / Method

Calculation of information entropy

The year-based information entropy

$$S_j = -\frac{1}{\ln m}\sum_{i=1}^{n}\frac{x_{ij}}{x_j}\ln\frac{x_{ij}}{x_j}$$

Information entropy is used to measure the degree of ordering of the system. The lower the information entropy of a system, the more orderly the system; conversely, the higher the information entropy, the more chaotic the system.The pressure-type positive entropy flow $d_i s$ and the support-type negative entropy flow $d_e s$ are obtained in each year during the study period, and the total entropy of the system can be obtained as ds=dis+des.

The indicator-based information entropy

$$E_j = -\frac{1}{\ln m}\sum_{i=1}^{m}\frac{x_{ij}}{x_j}\ln\frac{x_{ij}}{x_j}$$

Calculate the indicator-based information entropy, which reflects the degree to which each entropy index dominates or affects the entropy. The larger the value, the more important the index is.

02 / Method

Calculation of disturbance coefficient k

- To further explore the evolution direction of health system resilience under natural disaster scenarios, a set of discriminant models that define the evolution direction of entropy flow are as follows:

$$d_i s = \frac{d_i s_t - d_i s_{t-1}}{d_i s_{t-1}}$$

$$d_e s = \frac{d_e s_t - d_e s_{t-1}}{d_e s_{t-1}}$$

- Definition $k = \Delta \mathrm{d_i} s - \Delta \mathrm{d_e} s$, where k is called the disturbance coefficient, which is used to characterize the disturbance ability of natural disasters to the health system.

Data Collection

- Related data between 2010 and 2019 were collected in this study from the China Health Statistics Yearbook and other official Chinese public data between 2010 and 2019.

03

PART THREE

Results

03 / Results—Analysis of weights of indicators

Target layer	Factor layer	Indicator layer	Weight
Negative entropy	Human entropy	Number of health workers (10,000 people)	0.0676
	Material entropy	Number of medical institutions with equipment of more than 10,000 yuan (pieces)	0.3610
		Building area of medical and health institutions	0.0849
		Number of beds in medical and health institutions (10,000)	0.1198
	Mechanism entropy	Number of medical and health institutions (pieces)	0.0015
	Funding entropy	Government health expenditure (100 million yuan)	0.3652
Positive entropy	Earthquake entropy	Casualties (person)	0.4611
	Geological disaster entropy	Casualties (person)	0.1075
	Flood entropy	Affected population (10,000 people)	0.0466
	Drought entropy	Population with difficulty in drinking water (10,000 people)	0.1640
	Marine disaster entropy	Casualties (person)	0.1324
	Forest fire entropy	Casualties (person)	0.088 4

03 / Results-Analysis of Change Trend of Entropy

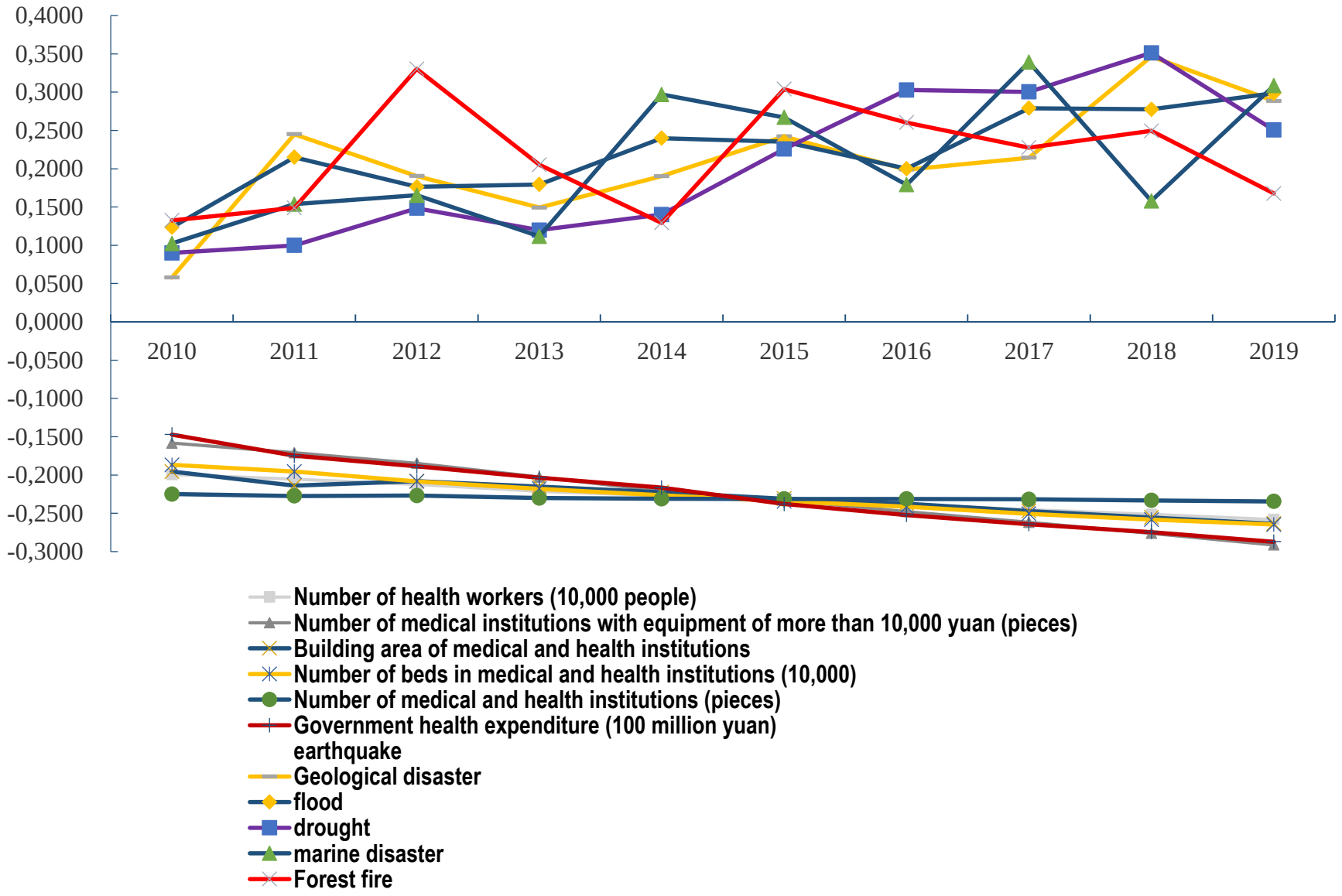
Year	positive entropy	negative entropy	total entropy
2010	0.6669	-0.7500	-0.0831
2011	0.7152	-0.7582	-0.0430
2012	0.6507	-0.7638	-0.1131
2013	0.6628	-0.7678	-0.1051
2014	0.6475	-0.7714	-0.1239
2015	0.7164	-0.7743	-0.0579
2016	0.7493	-0.7762	-0.0269
2017	0.7131	-0.7773	-0.0642
2018	0.7409	-0.7779	-0.0370
2019	0.7210	-0.7782	-0.0572

- From 2010 to 2019, the total entropy was all negative, and the absolute value of the negative entropy was greater than that of the positive entropy.

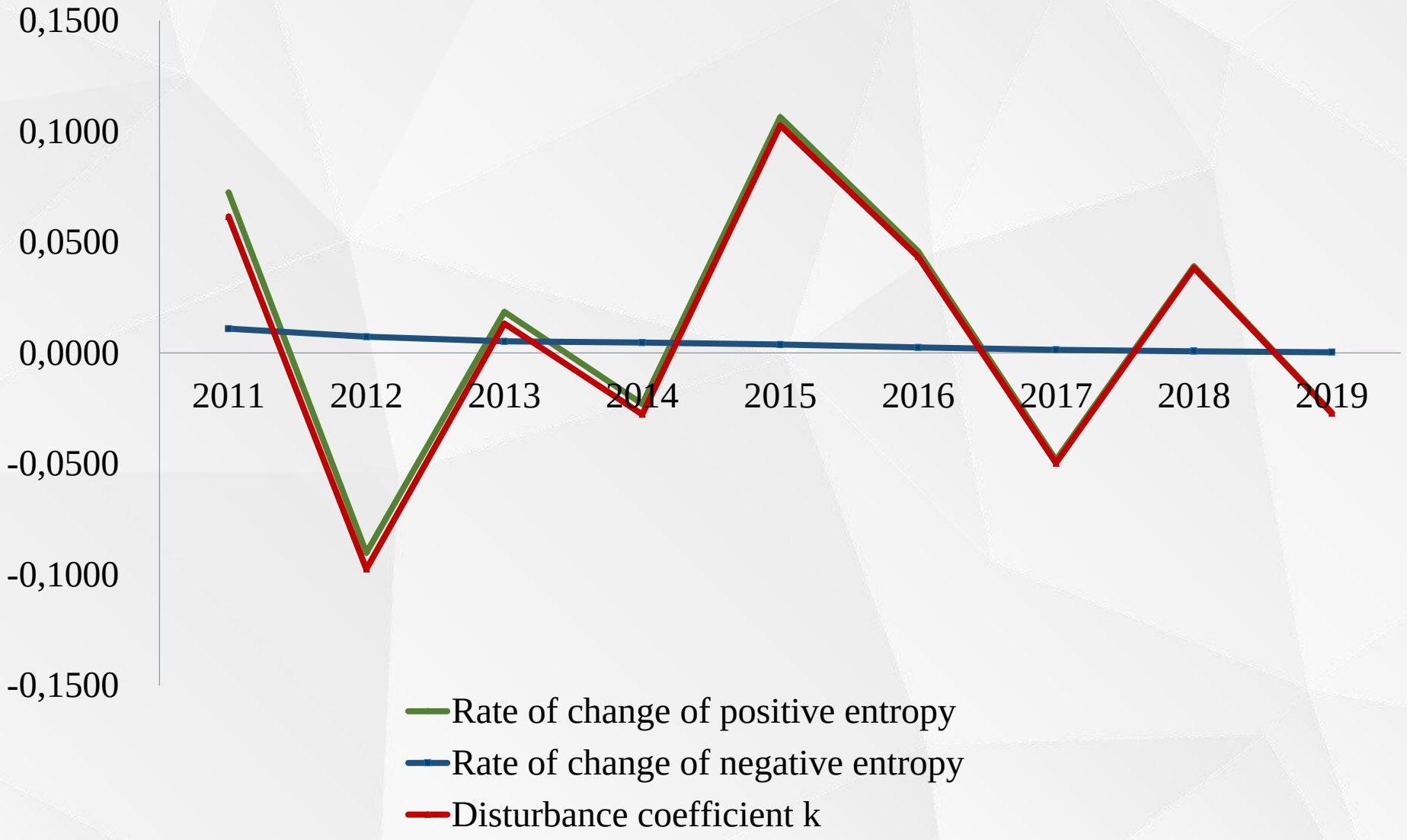
02 / Results-Analysis of Change Trend of index information entropy

The trend analysis of the negative entropy index from 2010-2019.

Change trend analysis of positive entropy index from 2010-2019.



03 / Results-Analysis of disturbance coefficient k



04

PART FOUR

Discussion

04 / Discussion Analysis of the evolution law of health system resilience

- ✓ The evolution law of support-type negative entropy is consistent with the status quo of the sustainable and healthy development of medical and health services in China.
- ✓ More and more resources are input into the health system to ensure emergency response work such as medical first aid in the health system and epidemic prevention in disaster areas.
- ✓ Material entropy and funding entropy are necessary conditions to quickly respond to sudden natural disasters and crises.

04 / Discussion Analysis of the evolution law of health system resilience

- The evolution law of the pressure-type positive entropy is consistent with the frequent occurrence of natural disasters in recent years.
- Unreasonable human activities such as excessive exploitation and utilization of nature continue to increase, causing irreversible damage to nature and increasing the probability, frequency and degree of harm of natural disasters.
- The frequent occurrence of catastrophic events has caused the health system to face the dual challenges of immediate devastating damage and catastrophic surge in medical demand, and the pressure on the health system has increased.

04 / Discussion Analysis of the evolution law of health system resilience

Health System Resilience Indicators

The total entropy of the system

- The representation of the order degree of the system
- The total entropy flow is all negative.
- Health system is in an orderly state as a whole, and the health system has a certain degree of resilience.

The disturbance coefficient k

- Used to characterize the disturbance ability of natural disasters to the health system or the ability of the health system to absorb, adapt and transform in response to natural disasters.
- The disturbance coefficient changes in a fluctuating manner.
- Health systems are less stable in the face of shocks from natural disasters.

05

PART FIVE

Recommendations

05 / Recommendations

01 Improve the construction of emergency medical supplies.

- ✓ It is clear that sufficient material reserves are the basis for ensuring that the health system can exert its emergency material support capacity.
- ✓ According to the principle of taking into account both peace and war in material reserves, during the daily operation of the health system, ensure that medical equipment is advanced, the beds in medical institutions are sufficient, and the supply of medicines is timely to prevent major crises.
- ✓ In the event of natural disasters, it is necessary to build an overall national emergency material assistance network and social resource support network, and to distribute and dispatch materials in a multi-system and unified manner to improve the material resilience of the health system.

05 / Recommendations

02 Ensure the sustainability of health funding.

- ✓ It is imperative to establish a long-term sustainable development mechanism led by government health investment.
- ✓ Special expenditures for natural disasters and public health emergencies should be coordinated as a whole, and the use of medical security funds should be regulated.
- ✓ While emphasizing the financial guarantee for the health system, the financing sources of health funds should be broadened, and social capital should be properly guided to flow into the health system, so as to enhance the financial resilience of the health system.

05 / Recommendations

03 Strengthen the construction of emergency personnel.

- ✓ A comprehensive and high-quality emergency medical rescue team that runs through all aspects of "prevention, control, and rescue" is the key to emergency response.
- ✓ On the one hand, various medical and health institutions at all levels should set up professional emergency medical rescue teams, regularly conduct disaster relief knowledge and skill training, and emergency drills to effectively improve emergency response capabilities.
- ✓ On the other hand, strengthen the backup personnel for health emergency, improve the education concept of health emergency personnel, and cultivate compound health emergency professionals.

THANKS