Model Computing System for Emergent Infectious Disease Prevention and Control Ability Evaluation of Medical Building Network

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ABSTRACT: *Model computing system for emergent infectious disease prevention and control ability evaluation of medical building network establishes evaluation framework according to fuzzy comprehensive evaluation method, selects evaluation indexes during prevention, treatment and recovery of emergent infectious disease based on the theory of crisis management, and calculates weight coefficient of indexes based on analytic hierarchy process. With the help of data processing and analysis functions of statistical analysis software SPSS, fuzzy comprehensive evaluation matrix model of medical building system was established. Then the model was used for practically evaluating the prevention and control ability of medical building network on emergent infectious disease in typical cities of China. The advantages and disadvantages of cities facing with emergent infectious disease were concluded by stimulating the response process of medical building system when emergent infectious disease burst out in the cities. Finally, the measurement method and application range of model computing system for emergent infectious disease prevention and control ability evaluation of medical building network were clarified.*

Subject Categories and Descriptors
I.6.1[Simulation Theory]: Building network; I**.6.5[Model Development]**: Evaluation model

General Terms: The Safety Prevention and Control, Fuzzy Evaluation

Keywords: Prevention and Control of Emergent Infectious Disease, Medical Building System, Fuzzy Comprehensive Evaluation, Model Computing

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1. Introduction

Infectious disease always threatens the survival and development of human being. Infectious disease changes with the advancement of human society. Epidemic and spreading of SARS in 2003 in China exposed the severe defects of public health system. To be specific, Chinese medical building system has incomplete mechanism while facing with public health events, weak ability for dealing with and managing risks, deficiency in necessary emergency measure when facing with emergent public health events, insufficient preparation for the medical hardware and poor ability of medical building transformation.

In ten years since the SARS risk, Chinese government began to attach much importance to the construction of medical system which has become the foundation facing with emerging public health events. The construction of Chinese medical system emphasized monitoring of emergent public events, information exchange and control, and medical treat and cure. Overall planning on public health event emergency system construction was gradually established. In addition, construction of medical system was integrated with the current medical service system, disease prevention and control system.

Organizations in medical system formulated relative emergency plan and regulated emergency operation procedure based on meeting the requirements of medical system. A set of infectious disease prevention and treatment law system that was conforming to the conditions of China and International advanced level was initially established. Formulation, adjustment and inspection of regulations needs reference for status evaluation of medical building network planning and construction of infectious disease and feasible evaluation method is also needed to obtain accurate evaluation results, thereby providing scientific and high-efficient reference system for establishing medical building network system for emergent infectious disease prevention and control that is conforming to national condition.

In March, 2014, Ebola began to hover in African continent. According to the latest report released by WHO, till Oct. 5th, epidemic situation of Ebola has caused 7399 confirmed cases in Sierra Leone, Guinea, Liberia, Nigeria, Senegal,, Spain and America, among which, 4033 people died. The most severe one is Liberia, with death cases of 2,316. At the end of September and in the beginning of October, patients in Europe and America have been confirmed to be infecting with Ebola virus. Suddenly, the world is uproar. It is a long way to go for human to fight with infectious disease.

2. Model Design

With evaluation theory of fuzzy comprehensive evaluation method as the basis of computing method, risk management theories as the basis of computing index and analytic hierarchy process as the basis of computing weight, and with the help of data processing and analysis function of statistical analysis software SPSS, fuzzy comprehensive evaluation computing model for medical building network is constructed.

2.1 Computing Method

Fuzzy comprehensive evaluation of medical building network is to make comprehensive evaluation on the infectious disease prevention and control ability by fuzzy mathematical tool considering the influence of multiple factors of medical building network system, that is, express the indexes in medical building system by fuzzy set and make comprehensive evaluation through fuzzy computing. Fuzzy comprehensive evaluation method is widely applied in evaluation for medical health system, city construction planning and monomer building design. In the age dominated by common subjective, real law should be excavated from the back of subjective imagination, and suitable model and reasonable algorithm should be applied to obtain scientific judgment.

Framework of fuzzy comprehensive evaluation system for medical building network includes: evaluated object, evaluation index, weight coefficient, comprehensive evaluation model and valuator. Process of fuzzy comprehensive evaluation for medical building network includes: confirm object system, confirm people who involve in comprehensive evaluation, select evaluation principle and relative evaluation model; establish evaluation index system; confirm factor weight; confirm score standard; construct membership function of index; establish judgment matrix; make comprehensive evaluation; output evaluation results.

Procedures for establishing mathematical model of fuzzy comprehensive evaluation of medical building network:

(1) Confirm factor sets of evaluation according to the requirements of medical building environment on prevention and control of emergent infectious diseases.

$$U = \{U_1, U_2, U_3, .., U_m\}$$

(2) Confirm determination set of evaluation according to the index of prevention and control of emergent infectious diseases of practical medical building environment.

$$V = \{V_1, V_2, V_3, .., V_n\}$$

(3) Confirm weight vector of evaluation according to the importance degree between indexes of medical building environment.

$$A = \{a_1, a_2, a_3, .., a_m\}$$

(4) Obtain fuzzy comprehensive evaluation matrix according to fuzzy evaluation of indexes of medical building environment.

$$R = \begin{bmatrix} B_1 \\ B_2 \\ \mathrm{M} \\ B_{\mathrm{m}} \end{bmatrix} = \begin{bmatrix} r_{11}, r_{12}, r_{13}, \mathrm{L}, r_{1n} \\ r_{21}, r_{22}, r_{23}, \mathrm{L}, r_{2n} \\ \mathrm{M} \quad \mathrm{M} \quad \mathrm{M}\,\mathrm{L} \quad \mathrm{M} \\ r_{m1}, r_{m2}, r_{m3}, \mathrm{L}, r_{mn} \end{bmatrix}$$

(5) Obtain comprehensive evaluation results according to fuzzy matrix computing.

$$B = A \circ R$$

(6) Calculate comprehensive score of medical building network evaluation.

Convert fuzzy result of medical building network evaluation B into comprehensive score M. Make further analysis such as sorting based on the size of M value and make intuitive analysis and comparison on prevention and control ability of emergent infectious diseases of medical building network, thus to provide accurate guidance for further design.

2.2 Computing Index

Computing index of medical building network of prevention

and control of emergent infectious disease uses process management theory of emergency management. In the perspective of the basic concept of process of medical building network preventing and controlling emergent infectious disease and according to the characteristics of stages of public health event management, we construct computing index of medical building network in preventing and controlling emergent infectious diseases. The key of comprehensive evaluation is to establish a set of clear, definite, scientific and feasible index system of medical building network evaluation for preventing and controlling infectious disease.

(1) Selecting Representative Evaluation Index: Select indexes which can sufficiently represent the ability of project for single project during evaluation. The indexes should not only comprehensively reflect the prevention and control ability of medical building network for emergent infectious disease but also be restrained in amount to avoid repeating measurement.

(2) Select Comparable Evaluation Index: Select evaluation indexes that can be compared on the same platform according to the property and level difference of the cities to be evaluated. The indexes should not only represent the prevention and control requirements of emergent infectious disease on cities of different levels but also avoid losing comparability due to the difference of level.

(3) Select Evaluation Index that can Cover the Overall Situation: when emergent infectious disease burst out, all social life is bound to be threatened and damaged. Select comprehensive evaluation index according to all the social areas involved in medical building system in the whole process of emergent infectious disease, so as to motivate all emergency power to ensure city life.

(4) Select Quantitative and Qualitative Index: Some projects are quantitative in medical building network for preventing and controlling emergent infectious disease, which can be directly measured by number with definite unit. Some projects are abstract and hard to be measured. They control the prevention and control ability of medical building network at the same time. Quantitative index and degree concept index all need to become fuzzy evaluation index applying mathematical method, and to be evaluated on the same platform.

Evaluation model makes overall design of evaluation index system in the perspective of basic process of prevention and control of emergent infectious disease of medical building network, studies control indexes for prevention and control of emergent infectious disease of medical building network according to the characteristics of emergent public health event management, and designs a set of medical building network evaluation index system preventing and controlling emergent infectious diseases from prevention before disaster, rescue during disaster and recovery after disaster. Medical building network evaluation index system for preventing and controlling emergent infectious disease is shown in Figure 1:

2.3 Computing Weight

Fuzzy comprehensive evaluation weight vector of medical building network reflects the importance degree of indexes in the process of evaluation and comprehensively measures the subjective evaluation and objective reflection for the relative important degree of indexes in the evaluation of emergent infectious disease prevention and control ability. Analytic hierarchy process is applied to confirm weight vector of fuzzy comprehensive evaluation of medical building network. Through analyzing factors and interactive relationship contained in medical building network system, network system is decomposed into different elements. In addition, these elements are put under different levels. Pairwise comparison and judgment is performed in elements from every level. Judgment matrix is established based on certain scale algorithm. Importance order of elements in different levels are obtained through calculating maximum eigenvalue and its relative feature vector of the judgment matrix., thereby establishing weight vector. Sum and product method is used to calculate weight vector and characteristic root. Calculation results are as follows:

2.4 Computing Model

Medical building network evaluation model for preventing and controlling emergent infectious disease refers to the research method of data statistics subject. Starting from data processing process of prevention and control index of emergent infectious disease of medical building network and according to the measured results of these indexes, a medical building network evaluation computing model for preventing and controlling emergent infectious disease is constructed. Computing method of medical building network evaluation model for preventing and controlling emergent infectious disease is based on statistical analysis software Statistical Product and Service Solutions (SPSS) which is a software used in statistical analysis computing, data mining and evaluation analysis. Variable codes of SPSS is used to complete quantitative value and data non dimensionalization of medical building network evaluation factor, case weight function of SPSS to carry out weight calculation of medical building network evaluation; compute variable function of SPSS to calculate medical building network evaluation results. Data processing interface of medical building network evaluation model for preventing and controlling emergent infectious disease in SPSS is shown in Figure 2:

3. Data Trail Testing

Fuzzy comprehensive evaluation model for preventing and controlling emergent infectious disease is applied to comprehensively evaluate the medical building network of the typical Chinese city Suzhou. The medical building network of Suzhou is performed quantitative value based on the index project of fuzzy comprehensive evaluation model for preventing and controlling emergent infectious disease. The data is input for calculation of evaluation

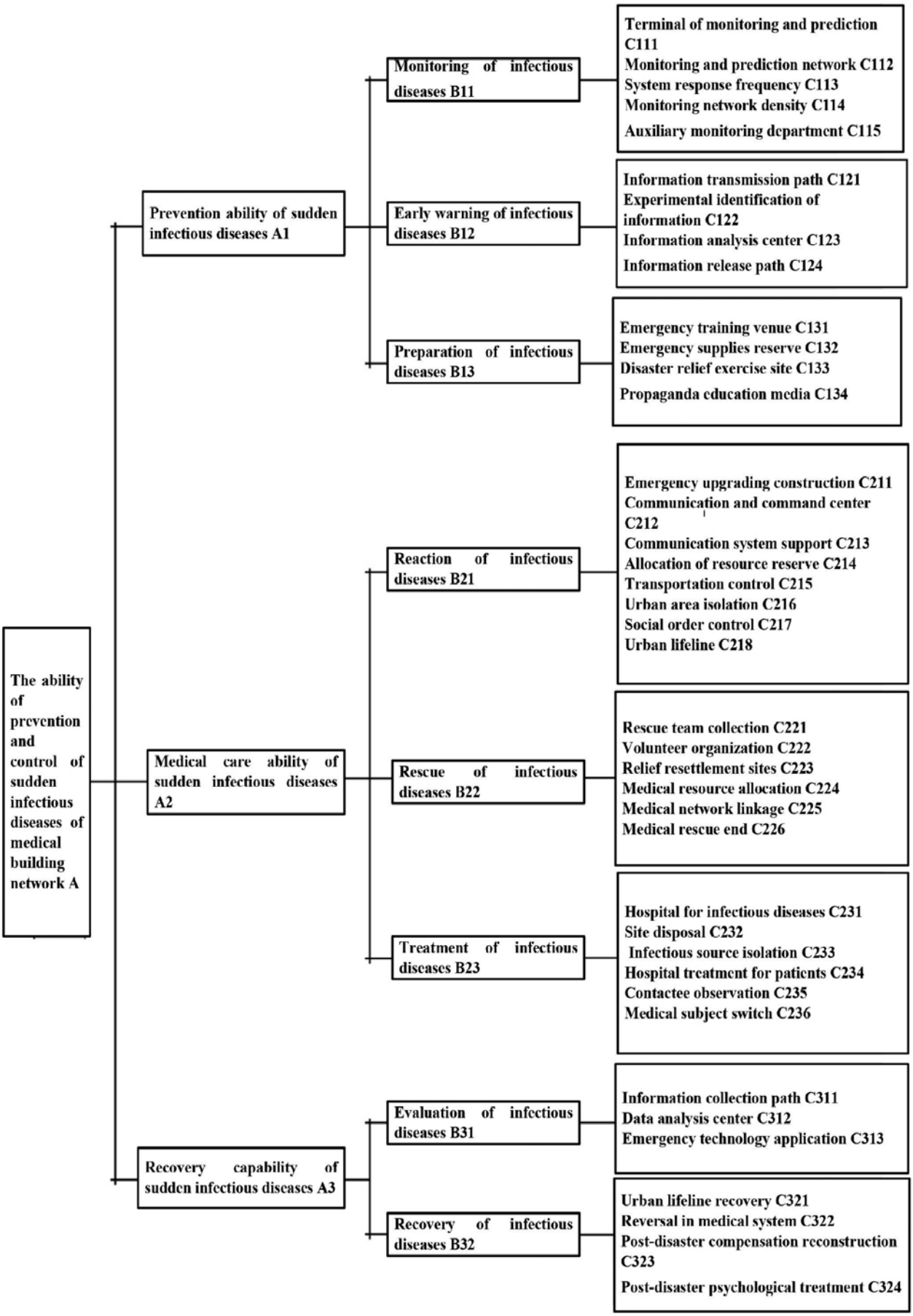

Figure 1. Evaluation index system of medical facility network for emergent infectious disease prevention and control

1.00(A)							
0.26(A1)			0.63(A2)			0.11(A3)	
0.43(B11)	0.43(B12)	0.14(B13)	0.26(B21)	0.11(B22)	0.63(B23)	0.25(B31)	0.75(B32)
0.23(C111)	0.10(C121)	0.10(C131)	0.06(C211)	0.08(C221)	0.40(C231)	0.20(C311)	0.49(C321)
0.23(C112)	0.25(C122)	0.55(C132)	0.28(C212)	0.08(C222)	0.04(C232)	0.60(C312)	0.17(C322)
0.23(C113)	0.55(C123)	0.10(C133)	0.06(C213)	0.25(C223)	0.09(C233)	0.20(C313)	0.17(C323)
0.23(C114)	0.10(C124)	.25(C134)	0.06(C214)	0.25(C224)	0.19(C234)		0.17(C324)
0.08(C115)			0.06(C215)	0.25(C225)	0.09(C235)		
			0.14(C216)	0.08(C226)	0.19(C236)		
			0.06(C217)				
			0.28(C218)				

Table 1. Evaluation index weight table of medical facility network for emergent infectious disease

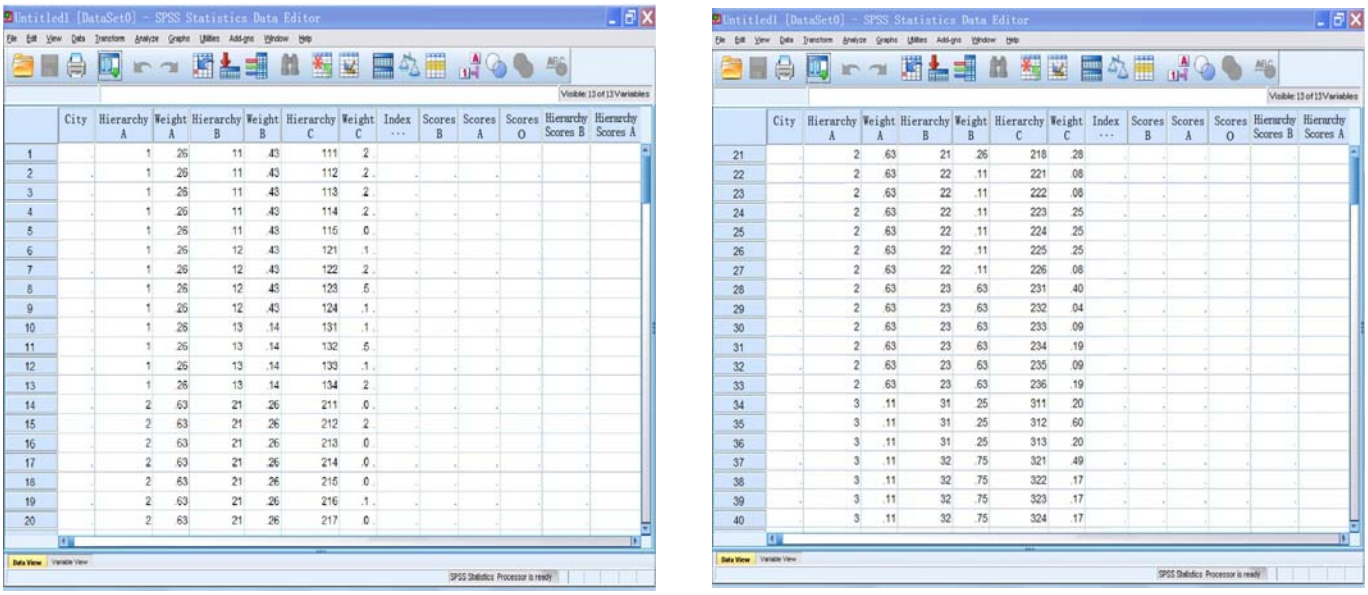

Figure 2. SPSS data window: evaluation model data calculation of medical facility network for emergent infectious disease prevention and control

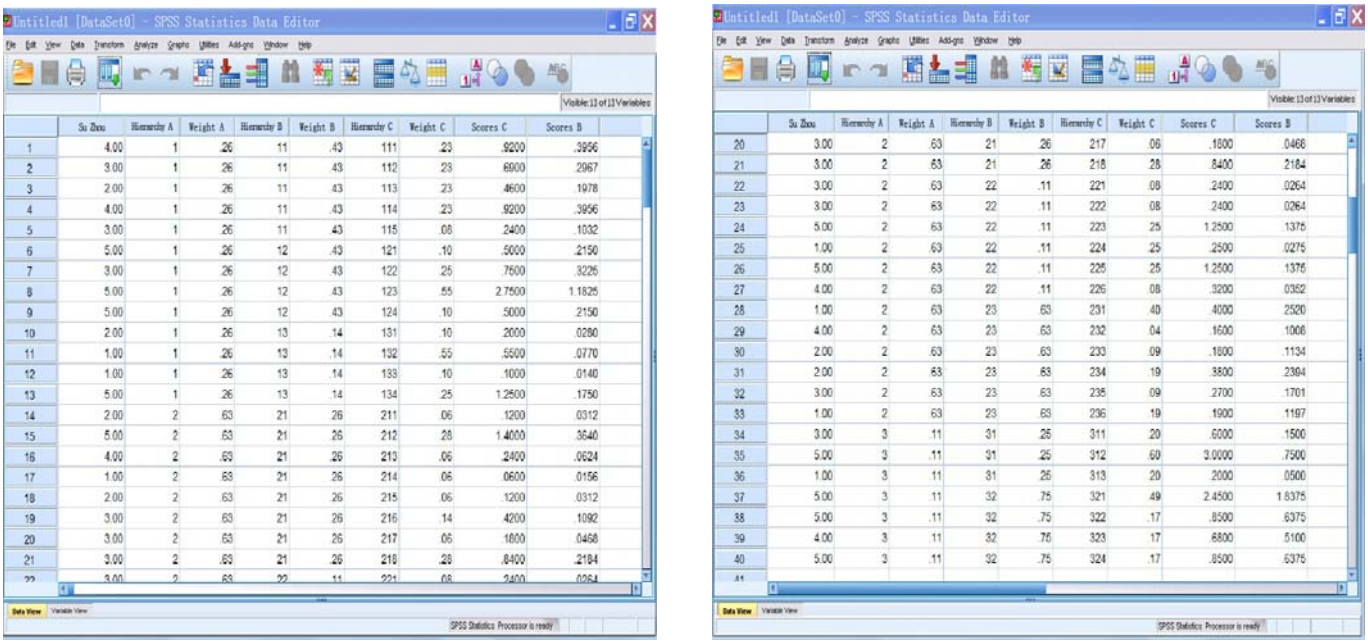

Figure 3. SPSS data window: Suzhou medical facility network evaluation model data calculation

numerical values.

3.1 Computing Process

Suzhou located in the southeast of Jiangsu is the megacity that is closest to Shanghai and with much development potential, the national historic city and important scenic tourist city and one of the important center cities of Yangtze River delta. In the perspective of Yangtze River delta, Suzhou is the important increasing area in Shanghai-Nanjing-Hangzhou region and its functions in that area increases day by day. Suzhou has a permanent population of 4.1671 million and urban area of 1,169 thousand square kilometers. Basic data of original information statistics of evaluation come from NationalDisease Monitoring Information Reporting and Management System, Jiangsu Health Network, Suzhou Statistical Survey Public Network, Emergency Management of Suzhou Governmental Information Public Network and Drug Information Network. Data processing interface of medical building network evaluation model for preventing and controlling emergent infectious disease in Suzhou in SPSS is shown in Figure 3:

Data description function of SPSS is applied to output computing results of medical building network evaluation model for preventing and controlling infectious disease in classification:

	Descriptive Statistics						
	N	Sum	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Standard error	Statistic	Standard error
Index Scores O	40	2.32	.003	1.907	.374	4.449	.733
Index Scores C	40	26.9700	.486	2.077	.374	4.285	.733
Index Scores B	40	10.4551	.123	2.964	.374	10.545	.733
Index Scores A	40	2.8704	.004	1.771	.374	3.787	.733
Valid N	40						

Report			
Index Scores C			
Hierarchy B	**N**	**Mean**	**Sum**
11	5	.646000	3.2300
12	4	1.125000	4.5000
13	4	.525000	2.1000
21	8	.422500	3.3800
22	6	.591667	3.5500
23	6	.263333	1.5800
31	3	1.266667	3.8000
32	4	p1.207500	4.8300
Sum	40	.674250	26.9700

Report			
Index Scores B			
Hierarchy A	N	Mean	Sum
1	13	.278300	3.6179
2	0	.113235	2.2647
3	7	.653214	4.5725
Sum	40	.261377	10.4551

Table 2. Computing results of medical building network evaluation for preventing and controlling emergent infectious disease

3.2 computing analysis

Relative analysis function of SPSS is applied to make layered statistics on the data of different levels of medical building network evaluation model and data characteristics are described by strip scatter diagram, as shown in Fig. 4.

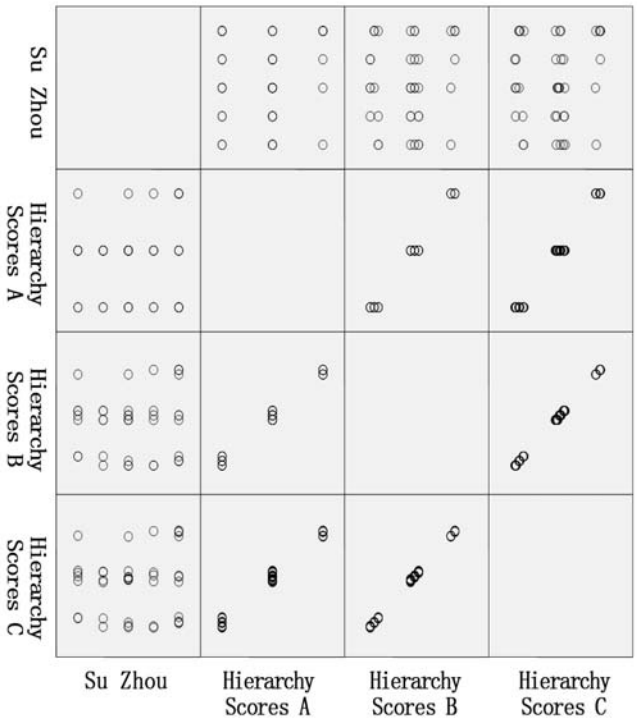

Figure 4. The Scatterplots of Suzhou's each level data

We can clearly master the prevention and control ability of Suzhou medical building network facing with emergent infectious disease according to the mean analysis figure: the system of Suzhou basically possesses the ability of prevention and control, but the allocation of medical building network resources is uneven. To be specific, based on the tables and figures, it is found that data of city show insignificant nonlinear relationship with all levels, and level score B also shows unconspicuous linear relationship with its level project. It illustrates that, in emergent infectious disease prevention and control subsystems in different levels, prevention and control ability of medical building network system is uneven and irregular, which is in a poor situation.

Based on the analysis of evaluation analysis, it is suggested that, rescue ability establishment of emergent infectious disease should be enhanced during occurrence of emergent infectious disease. It detailed represents as establishment indexes of infectious disease hospital (C231), medical subject switch (C236) are too low. Suzhou developed quickly in recent years. During city expansion, establishment of new district absorbs the latest achievements of city planning, functional matching of city is according to the old district, which is more scientific and reasonable, comprehensive command center of emergency is established, as well as training center, hence providing reliable guarantee. However, scale of infectious disease specialist hospital of city is insufficient compared to the rapidly expanded land scale, leading to the poor rescue ability for emergent infectious disease.

4. Conclusion

This paper generates the model for medical building network evaluation system for preventing and controlling emergent infectious disease by establishing the theoretical system of medical building network evaluation system for preventing and controlling emergent infectious disease, and practices the evaluation method, so as to perfect the theoretical system of medical building network planning and establishment for infectious disease, and provide feasible practical method and scientific decision basis for evaluation of planning and establishment of the network.

Fuzzy comprehensive evaluation method that is suitable for medical building network evaluation is selected as the evaluation tool. The model applies risk management theory to study index system for the whole process of prevention, rescue and recovery of emergent infectious disease, quantizes evaluation index and weight system according to a wealth of count and researches on the existing medical building system for infectious disease and regulations for prevention and cure of infectious disease, and a scientific, suitable and perfect evaluation model is formed. At the same time, the model evaluates the prevention and control ability of medical building network for emergent infectious disease in a typical city of China, and stimulates the response process of the medical building system when emergent infectious disease burst out. Finally, it is concluded out the advantages and disadvantages of the city facing with emergent infectious disease and illustrates the measured method and

application range of the model.

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