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Regional comprehensive assessment on environment–health of China

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Abstract: The aim of the study was to assess the environment-health development in different regions of China. 175 indicators, such as average life expectancy at birth, emission intensity of waste gas, GDP etc. were chosen to describe various aspects of the environment, health and development of China. Of all the indicators, life expectancy can sufficiently reflect health situation of population. Consequently, life expectancy was identified as key indicator, and 42 out of 175 indicators were selected for establishing the environment-health indicator framework with three grades of integrative indices to assess the development of environment-health of China. Based on the hierarchical relation between various grades of indices, the comprehensive environment-health index was calculated and contributed to classify the environment-health situation of 30 provinces, municipalities and autonomous regions in China which were divided into five grades by four predefined limits. Comprehensive assessment indicates that the environment-health situation of the eastern and coastal areas is superior to that of inland which is the western regions with underdeveloped economy and rigorous natural condition. Especially, the Qinghai-Tibet and Yunnan-Guizhou plateaus in southwestern China are most vulnerable in the environment and population health. These fit in with the pattern of national socio-economic development, which fully shows that socio-economic context plays a dominant role in the improvement of environment-health in China.

Key words: environment-health indicators; comprehensive assessment

1 Introduction

Over years, rapid development of Chinese economy is exerting more and more influences on environment and human health than ever. Traditional environmental hazards associated with an agricultural society are still prevalent while, on the other hand, modern environmental threats to health from industrial development can be seen in urban and rural areas. This includes human health and environmental impacts from chemical emissions, air pollution, water pollution, a rise in cardiovascular diseases, cancer and stress-related diseases. Environmental and health pressures and impacts will increase but change in types and characters reflecting implementation of national and local policies. In addition, socio-economic pressures from urbanization also impacts on the environment and human health. What is needed is a clear and concise policy approach on the means and the measures to be used to assess progress of national development. Consequently, it is necessary to have accurate, reliable and relevant information and available data for decision makers to make informed judgments about national policies and plans. Indicators and indices (aggregate indicators) are essential tools for environment and health management.

At the international level there has been ever increasing tendency by international organizations dealing with health to develop and promote health and health-related indicators. A joint working group, sponsored by UNEP, United States EPA and WHO, developed an environment and health indicators and indicator framework based on the Driving Force-Pressure-States-Exposure-Impact-Response model, and the method of health assessment

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(Briggs *et al*., 1996). Some studies on environmental health indicators have been developed since then (Newton *et al*., 1998; Briggs, 1999). A series of hazardous waste indicators and indicator frameworks were proposed for management purposes, which adopted the Pressure-Status-Effect-Response approach (Granados *et al*., 1999). Someone argued that a full risk assessment for chemicals which are considered hazardous normally involved the integration of four steps such as hazard identification, effects assessment, exposure assessment and risk characterization (Fairman *et al*., 1998).

In general, although many approaches to indicators have been developed and applied in national environmental health assessment, practical development and application of health indicators and indicator frameworks are fraught with difficulties for national scale due to the lack of data. More importantly, it is very hard to make meaningful international comparisons between countries for their interests and particular issues that may not necessarily be shared by other nations result in adoption of different indicator definitions and data-analysis methods.

In China, at present, studies on environmental health assessment are still in an exploratory stage, and most works available in the form of publications mainly focus on the small scale regions. The Ministry of Health ever organized health-related institutions to launch a program, namely Study on the Regional Health Classification of China, where the so-called regions were only confined to 50 counties which were too small to cover throughout the country (Su *et al*., 1991; Wang *et al*., 1991). Therefore, more efforts still require to be made on the national environmental health assessment.

In this paper we developed indicators and indicator frameworks used for national environment-health assessment in attempts to classify health situation of China and describe health problems to promote the harmonized development of environment and health.

2 Methods

2.1 Environment–health indicators framework

Quality assurance is an essential component for indicator selection and assessment, the indicators and data must be integrated, representative, comparable and obtainable. According to this, all data of indicators for assessment were collected from China Statistical Yearbook published from 1996 to 2000 (National Bureau of Statistics PRC, 1996, 1997, 1998, 1999, 2000) and China Health Yearbook from 1996 to 2000 (Ministry of Health PRC, 1996, 1997, 1998, 1999, 2000).

In this study, 175 indicators were selected, such as average life expectancy at birth, mortality, emission intensity of SO_2, GDP, etc., which can be used to describe various aspects of environment and population health of China such as life span, diseases, education, natural environment, pollution, economy, and sanitary resources and so on. According to their natures, all the indicators were classified into seven category indices of population growth, health status, educational level, natural condition, environmental pollution, economic context, and health care resources. Of them, three sectors of indices of population growth, health status, and educational level were characterized by the population health while the rest four mainly reflected environmental situation. In short, the selection of indicators is completely based on the interrelation between the environment and population health.

Environmental protection and economic development, aiming at mainly improving the human health status, are centered on environment-health assessment. Of all health indicators, it is only life expectancy at birth that can entirely reflect health situation of population. Therefore, we identified average life expectancy at birth as core indicator. By means of correlation analysis, 42 out of 175 indicators were selected as the character of significant correlation ($P < 0.05$) with life expectancy to establish indices framework for environment-health assessment of China.

The indices system could be divided into two sectors of health and environment, and into seven sub-sectors (Table 1).

Further, the seven integrative indices were incorporated into two integrative indices of health

Table 1 Indicators and indices for environment-health assessment of China

Indicators of health	Indicators of environment
Population growth	**Natural condition**
Mean life expectancy	Annual mean temperature
Ratio of elder population	Annual mean precipitation
Population mortality	Annual mean relative humidity
Infant mortality	Altitude above sea level
Population birth rate	Ratio of forest coverage
Population growth rate	**Environmental pollution**
Health status	Emission intensity of waste gas
Mortality due to respiratory diseases	Emission intensity of SO_2
Mortality due to infectious diseases	Discharge intensity of waste water
Mortality due to digestive system diseases	Discharge ratio of industrial waste water
Mortality due to tuberculosis	Generation intensity of industrial solid waste
Mortality due to malignant tumors	Discharge ratio of industrial solid waste
Mortality due to cardiopathy	Purification ratio of industrial waste gas
Mortality due to cerebrovascular disease	Emission ratio of industrial smoke and dust
Morbidity of hypertension	**Economic context**
Educational level	Gross domestic product per capita
Ratio of junior high school graduates	Gross industrial product Per capita
Ratio of senior high school graduates	Gross agricultural product per capita
Ratio of college graduates	Personal income of urban resident per capita
Comprehensive educational index	Personal income of rural resident per capita
Illiteracy ratio of population aged 15 years and over	**Health care resources**
	Number of hospital beds
Expenditure on education	Number of health professionals
	Hospital capacity
	Expenditure on health

Table 2 The index framework of environment-health assessment of China

Comprehensive environment-health index	
Thematic index of integrative health indices	Thematic index of integrative environment indices
Population growth index	Natural condition index
Health status index	Environmental pollution index
Educational level index	Economic context index
	Health care resources index

and environment, and in the same way, these two indices were incorporated into unique criteria to comprehensively assess the environment-health status, which intensively reflected effects of all environmental factors on population health. Based on the interrelations among the selected indicators and the integrative indices as well, the hierarchical indices framework of environment and health assessment of China was constructed. The individual index of each indicator, the thematic index of integrative indices and the comprehensive index of environment-health were estimated (Table 2).

2.2 Calculation of index

The calculation was conducted in three steps. The first step was to define measure of deprivation for 42 indicators. This study adopted the Human Development Index method to have deprivation indicators (UNDP, 1991).

$$P = \frac{M_i - N_0}{M_h - N_0} \times 100\%$$

where P is deprivation indicator, M_i is actual value of indicator, M_h is maximum of indicator, and N_0 is minimum of indicator.

The second step was to counterpoise coefficient estimation. The impacts of various indicators on life span are different, which form the basis to identify their weights. Therefore, the correlation coefficients of indicators to the core indicator of life expectancy were calculated as their counterpoise coefficient.

In the third step, the index (score) of each indicator was computed with the principle of progressive increase. Based on hierarchical relations among integrative indices, we calculated the integrative index by the formula:

$$V = \frac{\sum_{i=1}^{n} p_i}{n} \quad (i = 1, 2, 3 \ldots n)$$

where V is integrative index (score), p_i is deprivation indicator, and n is numbers of data.

3 Results and discussion

Integrative index of health and integrative index of environment for various provinces, municipalities and autonomous regions were obtained, of which comprehensive environment-health index is the unique criteria to qualify environment and health. The comprehensive health-environment index (score) of 30 provinces, municipalities and autonomous regions of China is placed in range from maximum to minimum (Table 3). The health-environment status of China by means of Jenks Optimization (Karnes, 1998) is divided into five classes based on four predefined index criteria of 33.0, 29.4, 25.9 and 21.5.

According to the comprehensive environment-health index, the 30 provinces, municipalities and autonomous regions were classified into five regional types of environment-health (Figure 1).

Type One ($p > 33.0$), excellent environment-health status, includes three metropolises of Beijing, Shanghai and Tianjin, and three provinces of Guangdong, Zhejiang and Liaoning which all lie in the northeastern and southeastern coastal developed areas of China. Their long life expectancy of above 70 years, low mortality and the successfully under-controlled population growth are the main characters of health. Advancement of technology and high efficiency of waste gas purification and industrial waste water treatment contribute to comparatively low

Table 3 The comprehensive health-environment index of China

Provinces, municipalities, autonomous regions	Index (score)	Provinces, municipalities, autonomous regions	Index (score)
Type I		Type III	
Beijing	43.3	Guangxi	29.4
Shanghai	40.3	Shanxi	29.1
Tianjin	36.8	Hunan	28.8
Guangdong	35.4	Hubei	28.3
Zhejiang	35.1	Henan	28.0
Liaoning	34.8 (>33.0)	Anhui	27.9
		Inner Mongolia	27.7
		Shaanxi	27.2
		Jiangxi	26.5 (>25.9)
Type II		Type IV	
Hainan	33.0	Sichuan	25.9
Heilongjiang	32.3	Gansu	24.6
Jiangsu	31.6	Ningxia	24.3
Shandong	31.5	Xinjiang	23.6 (>21.5)
Hebei	30.7	Type V	
Jilin	30.7	Yunnan	21.5
Fujian	30.4 (>29.4)	Guizhou	20.8
		Qinghai	19.4

mortality of common diseases, which indicates high efficiency of protection and control of illness. But the higher discharge intensity of industrial wastes and higher death rate of cerebrovascular, cardiopathy and hypertension could impact the environment and health of this region. Additionally, the population aging is one of the challenges that this region is facing. It is especially in Shanghai where negative population growth has occurred.

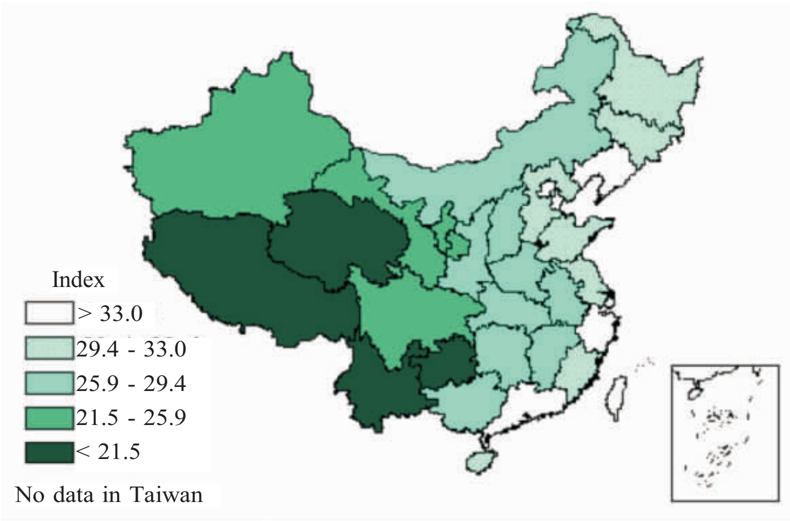

Figure 1 Map of comprehensive regional types of environment-health of China

Type Two ($29.4 < p < 33.0$), better environment-health status, includes seven provinces of Hainan, Heilongjiang, Jiangsu, Shandong, Hebei, Jilin and Fujian, which are mainly located in the northeast, eastern and southern coastal areas of China. With comparatively developed economy in this region, life expectancy ranges from 68 to 70 years, and the death rate of population is lower. Compared with Type One, this region has lower level of education and less available health professionals and suffers from respiratory diseases and infectious diseases, which constitutes primary obstacles to improve the environment-health status.

Type Three ($25.9 < p < 29.4$), moderate environment-health status, includes nine provinces and autonomous regions of Guangxi, Shanxi, Hunan, Hubei, Henan, Anhui, Inner Mongolia, Shaanxi and Jiangxi, which are distributed in the central part of China and the Inner Mongolia Plateau. Different from Type Two, its weaker industrialization, higher illiterate rate, and digestive system diseases and tuberculosis play a vital role in population death. The moderate life expectancy from 65 to 68 years and the natural environment could be referred to as the potentialities of environment-health development.

Type Four ($21.5 < p < 25.9$), limited development in environment-health status, in which four provinces (autonomous regions) of Sichuan, Gansu, Ningxia and Xinjiang are involved. They are situated in the southwestern and northwestern developing areas of China. Low life expectancy from 61 to 66 years in this region mostly results from digestive diseases, infectious diseases and tuberculosis and inefficiency of health services. Developing local economy and increasing investments to education and public health service may approach to overcome the environment-health problems.

Type Five ($p < 21.5$), poor environment-health status and life expectancy less than 61 years, includes four provinces (or autonomous regions) of Yunnan, Guizhou, Qinghai and Xizang (Tibet) on the Qinghai-Xizang and Yunnan-Guizhou plateaus where inhabited by minority nationalities with less developed economy. Because of limited educational and sanitary resources, and acute natural condition of high altitudes and stony mountains, people suffer mostly from many kinds of diseases such as respiratory diseases, digestive system diseases, infectious diseases and plateau cardiopathy. Therefore, improvement of the environment-health condition here should be resorted to increase investments in education and health services and devote to rapid development of local economy.

4 Conclusions

According to study of the indicators system and methodology of environment-health assessment, some conclusions can be drawn as follows:

(1) From the two aspects of environment and health, this study selected the 42 assessment indicators and established the assessment index system based on the principle of hierarchy. As far as the index system is concerned, this study has two distinct characteristics: reflecting the interrelation between the environment and health, and emphasizing position of human by identifying the average life expectancy as core indicator to assess the environment-health status.

(2) According to the comprehensive index of the 30 provinces, municipalities and autonomous regions, the environment-health status of China was classified into five types, which reflect actually their health and environment problems respectively. It is helpful to manage the environment-health development of China.

(3) This study explored the methodology of regional environment-health assessment and developed the method of the comprehensive environment-health assessment, which adopted individual index, thematic index and comprehensive index. Regional comprehensive assessment is a suitable method for China and probably developing countries.

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