The Relationship and Trends of Socio-Demographic Index, Healthy Life Expectancy and Life Expectancy in China

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Research article

Keywords: Socio-Demographic Index, healthy life expectancy, life expectancy, population health, China

Posted Date: March 2nd, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-15614/v1>

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Abstract

Background Socio-Demographic Index is an index to evaluate social development. Healthy life expectancy can comprehensively measure the population health. This paper indirectly infers the relationship between SDI and HALE, which provides a reference for improving population health.

Methods We used SAS 9.4 to analyze the relationship between SDI and LE, and the development trend of SDI and LE in 1990-2010. Meanwhile, we divided into 3 regions according to the 2019 Chinese Health Statistics Yearbook.

Results From 1990 to 2010, SDI and LE showed a trend of gradually increasing from west to East. In the regression analysis of SDI and LE, $r=0.90335$, $P<0.0001$, meaning that there was a positive correlation between SDI and LE. The D value of men was lower than that of women. Among the five SDI levels, the high SDI level usually had higher LE, so the D value was relatively high. However, in the middle SDI and low-middle SDI areas, the results showed the opposite situation. The SDI in India is lower than that in China, and the D value of female in China is higher than that in India, which indicates that Chinese elderly women have a long life with disease and disability.

Conclusions Socio-Demographic Index has a positive correlation with life expectancy and healthy life expectancy. Therefore, we can consider improving healthy life expectancy from the components of SDI to improve the healthy level of the population. At the same time, we should pay more attention to the care of the elderly population.

Background

People's health is an important symbol of national prosperity. The Healthy China 2030 Plan, issued by the Party Central Committee and the State Council, proposed that the level of health literacy of Chinese residents will be greatly improved in 2030, and the average healthy life expectancy will be greatly increased with the target value of 79.0 years[1]. Initially, life expectancy as an indicator of population health has been promoted, and it can be calculated by life table. It refers to the average number of years of life expected at birth for each person at a certain level of mortality[2]. As the population suffers more and more from diseases such as chronic diseases, disabilities and accidental deaths, healthy life expectancy arises at the historic moment. Healthy life expectancy estimates the number of years of a person in total healthy life, which means the life expectancy after deducting the effects of deaths in disabilities and diseases[3].

Human Development Index (HDI) is an index in influencing and evaluating population health. HDI is used to assess the level of human welfare in sustainable development, including life expectancy, average years of education and GDP per capita. The geometric mean of the three indicators is the HDI[4]. The Socio-Demographic Index (SDI) was proposed by Global Burden of Disease (GBD) in 2015 which was produced by HDI. The calculation method for SDI is similar to HDI. A certain value is input into each covariate and the score is calculated according to the relative scale. The output of 0 represents the lowest level of each

covariate and the output of 1 represents the highest level of each covariate[5]. SDI ranges from 0 to 1, 0 indicates that health outcomes are at the minimum level of development (lowest income, fewest years of schooling, and highest fertility), and 1 indicates that health outcomes are at the maximum level of development (highest income, most years of schooling, and lowest fertility). The index of final scale which examined by the input variable included the fertility rate, education level and the income. According to SDI value, it can be divided into five levels named high SDI, high-middle SDI, middle SDI, low-middle SDI and low SDI. Initially, the index was consisted of total fertility rate from 15 to 49(TFR), mean education for aged 15 and older (EDU15+) and lag distributed income (LDI) per capita[6]. In 2017, a study found that the total fertility rates under the age of 25(TFU25) continued to decline in recent years, especially in highly developed countries[7]. Fertility age which can better measures the social status of women has an important impact on education and employment. Therefore, GBD update TFR to TFU25 to measure SDI.

Healthy life expectancy (also known as Health Adjusted Life Years, HLE/HALE) is a comprehensive evaluation index of population health based on life expectancy (LE). LE is one of the main indicators to evaluate HDI. SDI is produced by HDI, so we guess SDI will affect the development of LE and HALE. In this paper, we aim to analyze the relationship between SDI and LE, HALE and their development trend, so as to provide reference for evaluating and improving population health.

Methods And Sources

Sources

In this paper, the data of SDI value, life expectancy and healthy life expectancy in provinces in China from 1990 to 2016 are derived from GBD, which can be found on the public website[8]. GBD explains the sources and differences of data in detail and carries out an annual analysis of the health situation of countries and regions as well as the factors which affect health around the world. The latest report of GBD analyzed 359 diseases in 195 countries and regions around the world. The life expectancy values of Chinese provinces from 1990 to 2010 are extracted from the 2019 Health Statistics Yearbook of China[9], which is a national Yearbook reflecting the health status of Chinese residents, compiled by National Health Commission of the People's Republic of China. The data does not include Hong Kong, Macao, Taiwan in China.

Quality Control

The database of GBD comes from World Health Organization, World Bank or other databases. National health database is collected, collated and analyzed for publicity and reliability by the National Health Commission of the People's Republic of China. The data is also used to report information to the World Health Organization, so the data is comparable.

Methods

We used SAS 9.4 to analyze the relationship between SDI and LE. $P < 0.05$ indicates that it is significant in statistics. According to the 2019 Chinese Health Statistics Yearbook, China is divided into 3 regions. There are 11 provinces, municipalities and autonomous regions in east include Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan. There are 8 provinces, municipalities and autonomous regions in central include Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan. There are 12 provinces, municipalities and autonomous regions in west include Inner Mongolia, Chongqing, Guangxi, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang. This study analyzed all regions of China, excluding Hong Kong, Macao and Taiwan province.

Results

Trends of the SDI value in China, 1990-2010

Fig.1 depicts the SDI level of provinces in China from 1990 to 2010. In the past ten years, the level of SDI in China had risen, with the highest level in the eastern region, followed by the central region and the western region. The level of SDI in China increased from west to East. In 1990, the lowest was 0.38 in Guizhou province and the highest was 0.68 in Shanghai. In 2010, the lowest was 0.54 in Tibet and the highest was 0.79 in Beijing.

Trends of life expectancy in China, 1990-2010

Fig.2 shows the trend of life expectancy of provinces in China from 1990 to 2010. In the past 10 years, life expectancy level has increased year by year. From West to east, the overall level of life expectancy has gradually increased, with the highest in the eastern region, followed by the central region and the western region. In 1990, the lowest level was 59.64 in Tibet and the highest life expectancy was 74.90 in Shanghai. The lowest life expectancy in 2010 was 68.17 in Tibet and the highest level was 80.26 in Shanghai.

Fig.3 presents a three-dimensional map of life expectancy in China. The low and high levels show different colors and dispersion. It can be seen that the overall level of life expectancy is gradually increasing from the west to the east. In the past 10 years, Beijing, Shanghai are still at a higher level, while Tibet and Qinghai are at a lower level.

The relationship between SDI and LE

We used SAS 9.4 to probe into the relationship between SDI and LE. The sample of SDI was 672, and the sample of life expectancy was 92. The value of SDI level of each province in China from 1990 to 2010 and the life expectancy of each province in China in 1990, 2000 and 2010 were tested by Shapiro-Wilks normality test. The statistical results showed $W_{SDI}=0.995866$, $P_{SDI}=0.0730 > 0.05$; $W_{LE}=0.984582$, $P_{LE}=0.3521 > 0.05$, indicating SDI and LE both obeyed normal distribution. We selected Pearson analysis

of using CORR process for SDI and LE showed that $r=0.90335$ $P<0.0001$, meaning that there was a positive correlation between SDI and LE.

The D value in different SDI level

The Differences Value (D), the differences between LE and HALE, in five SDI levels and Asian countries in 1990, 2006 and 2016. D represents the year of lost, which means the loss year of diseases, disabilities, accidental injuries or other situations and it is customary to call disability adjusted life year (DALY). DALY includes the year of life lost (YLL) and the year lived with disability (YLD), which is usually used to evaluate the improvement of people's health and the economic burden of disease.[10]

Table 1 shows the D in different SDI level. In the same level, D is increasing with the year, and the difference of D value of each level is shrinking. The loss years of men in the same age group were generally lower than women. Among the five SDI levels in the same year, the region with high SDI also has high LE, so the D value is relatively high. However, in the middle SDI and low-middle SDI areas, the results showed the opposite situation. Except for the 65 years old in women in 2006, the D-0 and D-65 in the middle SDI level areas were lower than those in the low-middle SDI areas, which indicated that the harm of diseases and disabilities in the middle SDI level areas was lower than that in the low-middle SDI areas. In China and India, for example, life expectancy in India is much lower than China, but the years of health loss were higher. Between 1990 and 2016, the DALY gap at birth between the two countries decreased from 1.25 years to 0.79 years for men and 0.85 years to 0.79 years for women. In the 65 years old group, the DALY gap in male was reduced from 0.80 years to 0.46 years, and the DALY gap in female was reduced from 0.43 to -0.21 (the negative value -0.21 represents that the DALY in female at the age of 65 in China was higher than that India).

Discussion

The Socio-Demographic Index is an emerging indicator of social development, which takes into account the per capita GDP of each region, education level and birth rate[11]. The population health is an important part of social development, and healthy life expectancy can comprehensively reflect the health level. There is a positive correlation between SDI and LE, and healthy life expectancy is the life year which removed the impairment of life expectancy, so it can also be inferred that there is a positive correlation. Therefore, improving the healthy life expectancy, we can not only control the health factors, but improve the related indexes of health.

According to GBD, the SDI in China in 2017 was 0.71, which was higher than the global level (0.65). China belongs to the high-middle SDI level, India belongs to the low-middle SDI level (0.55), and Japan belongs to the high SDI level (0.87) [12]. Except for Hong Kong, Macao and Taiwan, the SDI levels of Beijing, Shanghai and Tianjin were all above 0.80, which reached high SDI level. While the SDI of Tibet and Guizhou were all below 0.6, which were in the middle and low SDI level. There are great differences in SDI among the regions in China, so strategies should be made considering with the local condition to improve the health level of each region.

According to National Health Commission of the People’s Republic of China, the healthy life expectancy of China in 2016 was 68.7 years old, which was higher than that of the United States (countries with high SDI level) for the first time. And the latest data showed that life expectancy in China in 2018 was 77 years, an increase of 12.3 years compared with 1990[13]. In 2017, the education rate of 6-year-old and above was about 94.72% (per 1000 population), which was 4.95% higher than that of 2002 (89.77%)[14]. The fertility rate of 25-year-old and below decreased with year. The increase of education rate, the increase of per capita income and the decrease of fertility rate increase the composite index SDI, which is closely related to life expectancy and healthy life expectancy that based on the population[15].

D Value is a comprehensive measure of the number of years of life and the quality of life in terms of time. It can be used to evaluate the health of the population and describe the healthy life years lost in the state of death and disability[16]. The increase of the D also means that the longer people live with diseases and suffer from diseases, the lower the quality of life among people. To some extent, the difference of DALY can indicate the extent of the loss of disease damage in the two regions. The SDI level of China is higher than India, while the D in India is higher than China. It indicates that Indian suffering the diseases and disabilities for a longer living time. It is worth noting that the DALY of women over 65 years old in China is higher than that India, which shows that the degree of disease damage to the elderly over 65 years old in China is higher. GBD 2017 research presents that the DALY value of 65 years old female people in China is still higher than that in India by 0.2[15], so we should pay more attention to elderly care. The DALY in male is generally lower than female. In the gender difference, it may be caused by the gradual change of social responsibilities and the gradual increase of female pressure after the change of women's social status.

Conclusion

By proving the relationship between Socio-Demographic Index and life expectancy, this paper indirectly infers that there is a positive correlation between SDI and healthy life expectancy, and there are differences in healthy life expectancy between regions with different SDI levels. We can start from improving SDI index to improve HALE. The Socio-Demographic Index is a composite index of fertility rate, education rate and income. The government can improve the quality of life from three aspects. At the same time, we should strengthen the care for the elderly.

Abbreviations Table

Term	Abbreviation
Socio-Demographic Index	SDI
Healthy life expectancy	HLE/HALE
Life Expectancy	LE
Human Development Index	HDI
Global Burden of Disease	GBD
total fertility rate	TFR
education for aged 15 and older	EDU15+
lag distributed income	LDI
total fertility rates under the age of 25	TFU25
The Differences Value	D
disability adjusted life year	DALY
year of life lost	YLL
year lived with disability	YLD

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

The data in this paper comes from GBD public database, and the relevant data can be downloaded through the following address, <http://ghdx.healthdata.org/gbd-2017/data-input-sources>. The Health Statistics Yearbook of China is an annual Yearbook describing the state of China's health service, which can be checked by readers.

Competing interests

The authors declare that they have no competing interests.

Funding

Funding Supported by Dalian Science and Technology Bureau for development and research of digital hospital, Grant number: 2008J99JH119.

Authors' Contributions

XL M analyzed the data and wrote the manuscript of the report. Prof G modified and guided SAS analysis procedure and process. Ms. C helped find relevant data. Ms. Z participated in the design of the project research and gave the follow-up guidance to the articles. Prof M put forward the design and modification of the article. All authors revised and approved the final report. All authors read and approved the final manuscript.

Acknowledgements

Not applicable.

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Table

Please see the supplementary files section to access the table.

Figures

Figure 1

Trends of the SDI value in China, 1990-2010

Figure 2

Trends of life expectancy in China, 1990-2010

Figure 3

life expectancy in 1990 and in 2010. Fig 3 shows the spatial description map of life expectancy in 1990 (left) and 2010 (right). This map is drawn by SAS 9.4 which uses the program of Proc gmap. Different degrees of dispersion in the figure are presented in 3D. The blue part indicates the area with the lowest life expectancy, followed by the red part, the green part indicates the higher life expectancy, and the brown part indicates the area with the highest life expectancy. The range of life expectancy values is indicated in the legend. (The data analysis does not include Hong Kong, Macao and Taiwan in China). Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

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