

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

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## Research article

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# Abstract

**Background** Socio-Demographic Index (SDI) is an index to evaluate social development. Healthy life expectancy (HLE/HALE) can comprehensively measure the population health. This paper analyzes the relationship and trend of Socio-Demographic Index, life expectancy (LE) and healthy life expectancy, which provides a reference for improving population health.

**Methods** We used R Studio (version 1.2.5033) for correlation matrix analysis of SDI, HALE and LE. Meanwhile, we divided provinces into 3 regions according to the 2019 Chinese Health Statistics Yearbook and analyzed the distribution by ArcGIS 10.5 of healthy life expectancy and SDI of 31 provinces and cities in China.

**Results** From 1990 to 2016, socio-demographic, life expectancy and healthy life expectancy showed a gradual increasing trend, and the level in eastern provinces were higher than western provinces in China. There is a correlation between socio-demographic (included its composition that education for aged 15 and older, Gross Domestic Product and total fertility rates under the age of 25), healthy life expectancy and life expectancy. Total fertility rates under the age of 25 has a negative correlation with other variables.

**Conclusions** There is a strong positive correlation between healthy life expectancy, life expectancy and socio-demographic index. The government should consider take the implementation of personalized policies to steadily improve the development of SDI, at the same time to improve healthy life expectancy from improving maternal health and reducing infant mortality, paying attention to adult health, reducing the early death rate of chronic diseases.

## 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]. Healthy life expectancy, also known as health adjusted life expectancy (HLE/HALE), is a comprehensive evaluation index calculated based on life expectancy (LE) and disability rate[2]. 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[3]. 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[4]. 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 Gross Domestic Product (GDP) per capita, and HDI is calculated by the geometric mean

of these three indicators[5]. The Socio-Demographic Index (SDI) consisted of education for aged 15 and older (EDU15+), lag distributed income (LDI) and total fertility rates under the age of 25 (TFU25), was proposed by Global Burden of Disease (GBD) in 2015 which was based on HDI. 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)[6], and it can be divided into five levels named high SDI, high-middle SDI, middle SDI, low-middle SDI and low SDI.

There are many articles to study healthy life expectancy and socio-demographic index such as Global Burden of Diseases estimated healthy life expectancy and SDI in the countries and regions in the world[7, 8], or used SDI to evaluate the health-related sustainable development indexes[9]. However, there are few studies focus on the association and development trend between SDI or its constituent indicators and healthy life expectancy and life expectancy. In this paper, we aim to analyze the relationship between socio-demographic index, life expectancy and healthy life expectancy, and to analyze their distribution and development, so as to provide reference for evaluating and improving population health.

## Methods And Sources

### Sources

In this paper, the data of socio-demographic index, life expectancy and healthy life expectancy in China from 1990 to 2016 are derived from GBD, which can be found on the public website[10]. 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. Life expectancy and socio-demographic index of provinces in mainland, China are extracted from National Health Commission of the People's Republic of China. The data of fertility, education rate and Gross Domestic Product are from National Bureau of Statistics[11]. 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.

### Statistics

We analyzed the association of socio-demographic, life expectancy and healthy life expectancy by the Corr Test using package 'psych' (R Studio version 1.2.5033; R Foundation for Statistical Computing). We use GDP instead of LDI to express economic development. The value of  $r$  ranges from -1 to 1. If  $r$  greater than 0 indicates that there is a positive correlation between the two variables, and vice versa indicates that there is a negative correlation. The absolute value of  $r$  close to 1 means it has strong correlation. We draw the map by ArcGIS 10.5 to describe the distribution of SDI and HALE. 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 socio-demographic index and life expectancy in China, 1990-2016

**Fig.1** depicts the distribution of SDI of provinces in China from 1990 to 2016. In the past 20 years, the level of SDI in China had risen, with the highest level in the eastern areas, followed by the middle areas and the western areas. In 1990, the lowest was 0.38 in Guizhou province and the highest was 0.68 in Shanghai. In 2016, the lowest was 0.58 in Tibet and the highest was 0.84 in Beijing.

**Fig.2** shows the trend of life expectancy of provinces in China from 1990 to 2016. In the past 20 years, the overall level of life expectancy has gradually increased, with the highest in the eastern areas, followed by the middle areas and the western areas. In 1990, the lowest level was 59.64 year in Tibet and the highest life expectancy was 74.90 year in Shanghai. The lowest life expectancy in 2016 was 69.40 year in Tibet and the highest level was 82.00 year in Shanghai.

The distribution of life expectancy and socio-demographic index as shown in **Fig.3(a)(b)**, and the level of SDI of each province in China depicted in **Fig.3 (c)**. Provinces with higher life expectancy may not have higher SDI levels. Beijing, Tianjin and Shanghai belong to high SDI levels. Most provinces in the eastern part of China present high-middle SDI level, most provinces in the middle and western areas belong to middle SDI level, and Guizhou province and Tibet belong to low-middle SDI level. The distribution of GDP and education for aged 15 and older was shown as in supplementary Fig.S1 and Fig.S2.

### The relationship between socio-demographic index and healthy life expectancy, 1990-2016, China

There is a correlation between each index in 1990-2016, China in **Fig. 4**, and there is a negative correlation between TFU25 and each index. Among them, THU25 and HALE have a strong relationship that  $r = -0.82$  ( $P = 0.05$ ), and EDU15 increases with SDI with  $r = 0.97$  ( $P = 0.01$ ), positive correlation between GDP and EDU15,  $r = 0.93$  ( $P = 0.01$ ).

## Discussion

The Socio-Demographic Index is an emerging indicator of social development, the per capita GDP was also used instead LDI in some countries and cities to represent the level of economic[12]. The population health is an important part of social development, and healthy life expectancy can comprehensively reflect the health level. There is a positive strongly correlation between socio-demographic, life expectancy and healthy life expectancy. In the composition index of socio-demographic index, it also

showed a strong correlation with healthy life expectancy and life expectancy. Therefore, when considering improving healthy life expectancy, we need to consider the direct factors that affect the health status, but the improvement of indirect factors to improve population health can be taken. This article measured health status from the perspective of social development, not quantitative health, which may have a great significance for taking measures to improve healthy life expectancy.

According to GBD, the socio-demographic index in China in 2017 was 0.71 that belongs to the high-middle SDI level[8], and the level of SDI in China was higher than the global level (0.65). Except for Hong Kong, Macao and Taiwan, the level of SDI in Beijing, Shanghai and Tianjin were all above 0.80, which reached high SDI level. While the level of SDI in Tibet and Guizhou were all below 0.6, which were in the middle-low SDI level. There are great differences in SDI among the provinces 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, healthy life expectancy in China in 2016 was 68.7 years old, which was higher than 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], and the fertility rate of under 25-year-old 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].

The development of life expectancy varied in different province in China. Hainan Province, Chongqing and Fujian Province are with high-middle SDI level. Theoretically, life expectancy should consist with this level, while their life expectancy is relatively low. Similarly, the level of life expectancy in Inner Mongolia and Shanxi province do not match their SDI level. This shows that apart from the geographical situation, there is a huge gap in an indicator within the SDI composition, such as the economic situation. From the geographical east to the west of China, the economic level has gradually declined (shows in Supplementary), and the distribution of SDI can also be seen to gradually develop to a low level.

The development of the socio-demographic index affects healthy life expectancy and life expectancy, and the measurement of healthy life expectancy provides a new direction for evaluating population health. According to the Statistical Information Center of the National Health Commission of the People's Republic of China, in some provinces such as Guizhou Province and Tibet in China, 2016, the result showed that life expectancy in 1-year-old group was higher than the 0-year-old group. This showed that the infant mortality rate in these provinces was relatively high, and the level of SDI in Guizhou Province and Tibet was also at the lower level. Therefore, the fertility rate under the age of 25 should be reduced, and take measures to decrease the infant mortality such as maternal health should be strengthened to improve life expectancy and health life expectancy. In some provinces, the development of life expectancy is inconsistent with SDI level, suggesting that while paying attention to social development, we should pay more attention to adult health care, reduce the exposure of health risk factors, regular

physical examination, and decrease the premature death rate of chronic diseases, especially the elderly over 60 years old Health management.

The results of life expectancy and healthy life expectancy calculations show that life expectancy in some regions of China has reached a high SDI level. At the same time, the shortcomings factors affecting life expectancy and healthy life expectancy in some regions are still very prominent. Individualized policies should be implemented for regions and improve the development of socio-demographic index in order to steadily affect the development of healthy life expectancy.

## Conclusion

There is a strong positive correlation between healthy life expectancy, life expectancy and socio-demographic index. The distribution of SDI in different provinces in China is different, and there are also differences in life expectancy. There is also a correlation between the composition of SDI (EDU15+, TFU25 and GDP or LDI), life expectancy and healthy life expectancy. The government should consider take the implementation of personalized policies to steadily improve the development of SDI, at the same time to improve life expectancy and healthy life expectancy from improving maternal health and reducing infant mortality, paying attention to adult health, reducing the early death rate of chronic diseases.

## Abbreviations Table

Term	Abbreviation
Socio-Demographic Index	SDI
healthy life expectancy	HLE/HALE
life Expectancy	LE
Human Development Index	HDI
Gross Domestic Product	GDP
Global Burden of Disease	GBD
education for aged 15 and older	EDU15+
lag distributed income	LDI
total fertility rates under the age of 25	TFU25

# Declarations

## Ethics approval and consent to participate

Not applicable

## Consent for publication

Not applicable

## Availability of data and materials

The datasets analysed during the current study are available in GBD repository and National Healthy Commission of the People's Republic of China, <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.

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## 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.

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## Table

Please see the supplementary files section to access the table.

# Figures

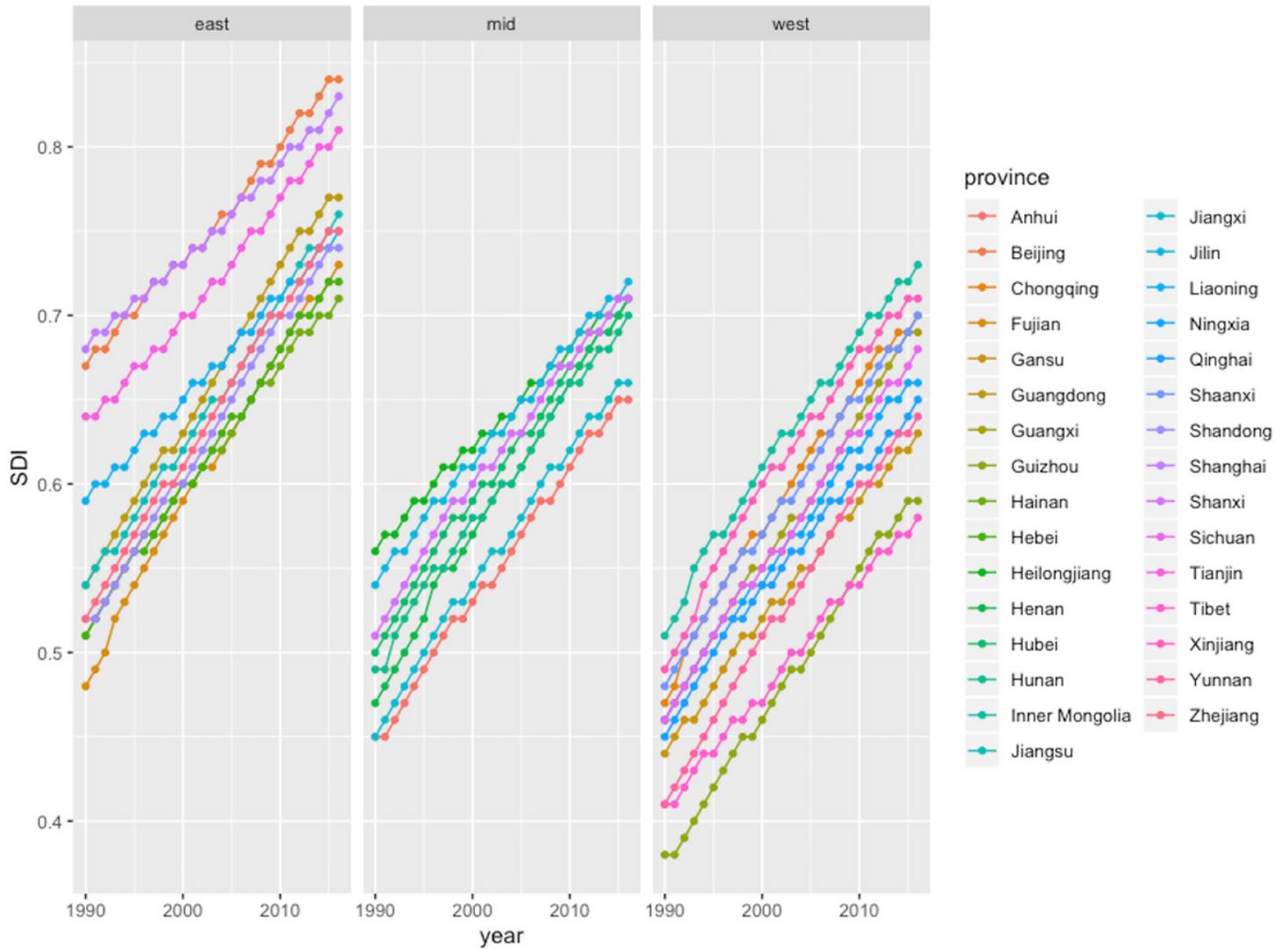


Figure 1

Trends of socio-demographic index in China, 1990-2016

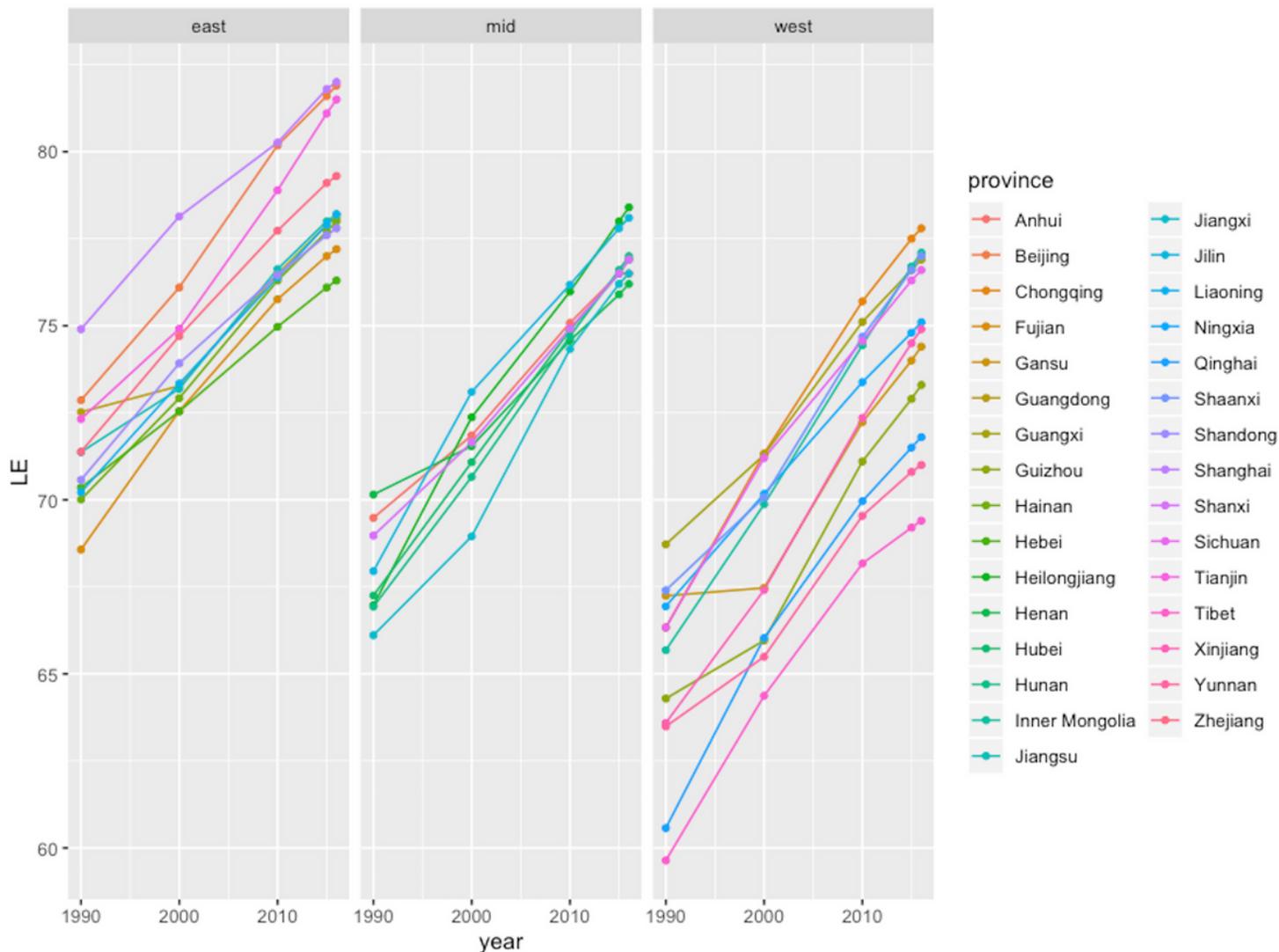


Figure 2

Trends of life expectanc in China, 1990-2016

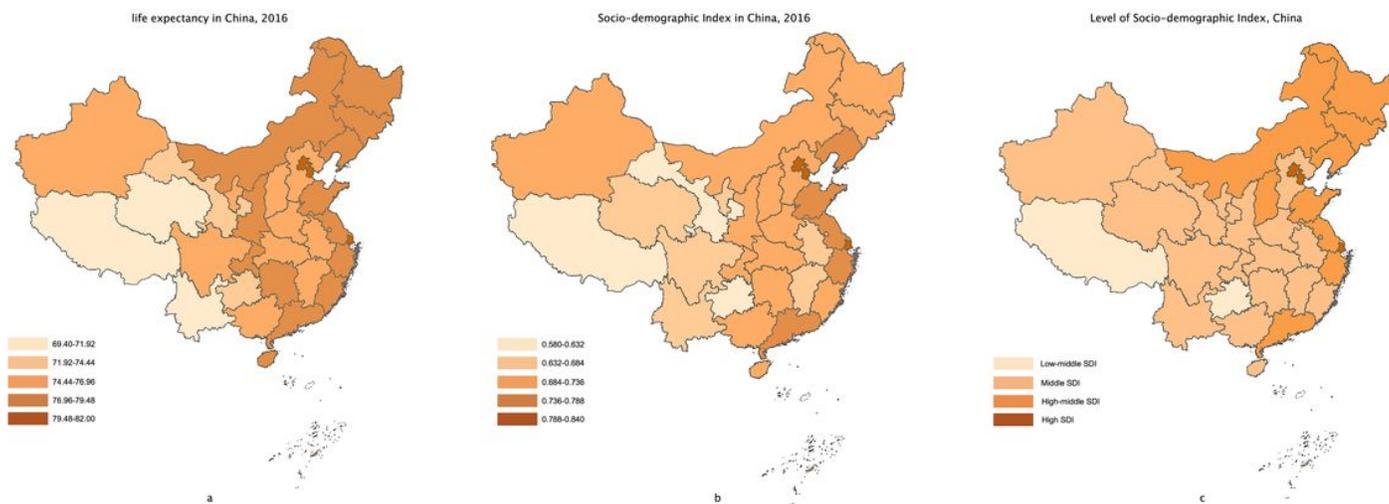
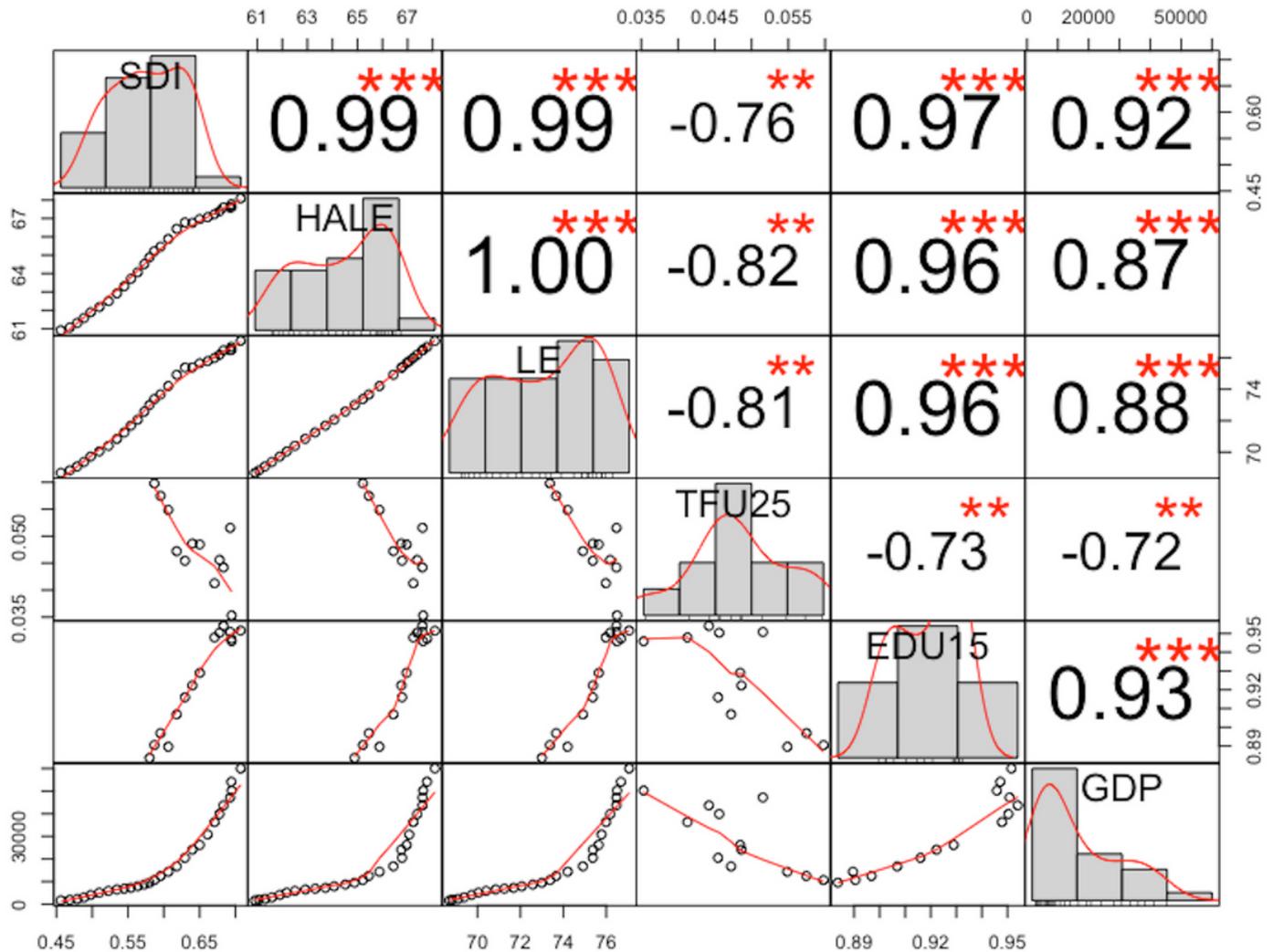


Figure 3

The distribution of life expectancy and socio-demographic index 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.



**Figure 4**

The relationship between socio-demographic index and healthy life expectancy, 1990-2016, China SDI, socio-demographic index. HALE, healthy life expectancy. LE, life expectancy. TFU25, total fertility rates under the age of 25. EDU15, education for aged 15 and older. GDP, Gross Domestic Product. Diagonal line represents the distribution of variables. The lower left part of represents the fitted bivariate scatter plot, and the upper right part represents the variable correlation coefficient and significance level.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Table.docx](#)
- [Supplementary.pdf](#)