# The Determinants of Life Expectancy—A Case of Four Largest Cities in China

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*With the sample data from the four largest cities in China, we have examined various impacts of economic growth and government expenditure in health-related fields on life expectancy. Our analysis shows that several factors have contributed to the increase of average life expectancy. In summary, each additional 100 units of GDP per capita, hospital bed and healthcare technician will improve average life expectancy by 1.6 days, 1.8 days and 1 day respectively. Our research will shed some lights on factors that impact life expectancy in Chinese urbanized areas and also help to make a global comparison between metropolitan cities around the world.*

## INTRODUCTION

Economists have long been interested in economic development, income inequality and public healthcare outcomes. Recently, the attention has turned to economic growth and public health and the effect of government expenditure on public health condition. Life expectancy, an estimate of the average number of years an individual of a particular age can expect to live, is a widely used measurement for overall population health. One of the most commonly used measurements is the average life expectancy at birth, which indicates number of years a newborn can be expected to live. The world has experienced a dramatic increase in average life expectancy since the middle of the 20th century. According to WHO, (2011) the world average of life expectancy increased from 48 in 1950 to 67.2 in 2010, a 40% increase during that time span. Examination of the relationship between economic growth and life expectancy has raised many unanswered questions: How does economic growth contribute to a rise in life expectancy? Will a rise in life expectancy lead to a rise in economic growth?

Public health issues have attracted tremendous political attention from national governments globally. In the 2016 US presidential election, both Republican and Democratic candidates placed public health issue on their agenda. Chinese government approved the Healthy China 2030 plan for health and development. The Healthy China 2030 plan aims to increase the citizens' average life expectancy by 3.5% from the current 76.3 years in 2016 to 79 years in 2030. At the Ninth Global Conference on Health Promotion, a declaration on promoting health in the sustainable development was published. The

declaration called on governments around the world to commit more resources to public healthcare and include health promotion into their development agenda.

Although most public health issues are studied at the national level, the detailed health care policies must be determined and implemented where most people live. So our paper will focus on city-level study. With the consideration of globalization phenomena, we choose four metropolitan cities in China, Shanghai, Beijing, Guangzhou, and Shenzhen. These are the four largest and developed cities in China and comparable to NYC.

Past research studies have examined many factors that might have contributed to an increase in average life expectancy. Mathers, Stevens, Boerma, White, and Tobias (2014) find falling tobacco use (for men only) and cardiovascular disease mortality (for both men and women) are main factors contributing to the higher life expectancy. Gu Xing Yuan and Chen Mai Ling (American Journal of Public Health, (1982) find that there have been "significant improvements in public health status" along with the fast-economic development in Shanghai. Wenhui Li, Gil A. Maduro, and Elizabeth M. Begier, (Journal of Public Health Management & Practice, 2016) find that "a global measure of population health, life expectancy, increased steadily and at a faster rate" in New York City. Mahumud, Rawal, Hossain, Hossain, and Islam (2013) find that one US Dollar (USD) increment in GDP per capita will increase in an average of life expectancy by 33 days in Bangladesh. Acemoglu and Johnson (2007) find that life expectancy led to a significant increase in population and a small positive effect of life expectancy on total GDP, although not on GDP per capita due to a faster increase in population.

Using healthcare expenditure, percentage of government expenditure, concentration of doctors in an area, and literacy rate as independent variables, Deshpande, Kumar, and Ramaswami (2014) find that there is a significant correlation between healthcare spending and life expectancy in developed countries, although no significant correlation has been found in developing countries. Applying similar methods as Deshpande, Kumar, and Ramaswami (2014), we examine how those factors affect the life expectancy at birth for four largest cities in China, Shanghai, Beijing, Guangzhou, and Shenzhen. Many public health issues have been studied at the national level, our paper studies detailed health care policies with city-level data. With the trend of globalization, metropolitans can learn from each other even though under different policy environment.

This study is organized as follows. The section 2 discusses data and parameters. The section 3 develops the model and hypotheses. The section 4 analyzes empirical results. Section 5 offers some concluding remarks.

## DATA AND SUMMARY STATISTICS

We chose life expectancy as a general indicator of public health. The life expectancy variable used in our study is the life expectancy at birth. We collect and analyze data from four largest cities in China which are Shanghai, Beijing, Guangzhou, and ShenZhen. The available range of annual life expectancy data for Shanghai, Beijing, Guangzhou are starting from 1978, 1989,1995 respectively, while Shenzhen never consistently produced this statistic but did publish this statistic for certain years during our study period.

Our major data have been collected from Shanghai Statistical Yearbook, Beijing Statistical Yearbook, Guangzhou Statistical Yearbook and Shenzhen Statistical Yearbook. While other data are manually collected from various resources including web searching.

Table 1, 2, 3, and 4 are the summary statistics of all variables used in our study for each city. Given the limited number of observations for each city, we combined all four cities to derive a combined stacked data set and Table 5 are the summary statistics for the combined stacked data.

Figure 1 to 4 show the change of life expectancy over the sample period for Shanghai, Beijing, Guangzhou, and Shenzhen. The earliest data available for life expectancy in Shanghai is in 1978 and by 2014 it was 82.3 years, an increase of 12.2% from 73.35 years. For Beijing, we observe an increase of life expectancy from 70.5 years in 1979 to 81.8 years in 2014, an increase of 16%. We also see an increase of life expectancy from 74.16 years in 1990 to 81.3 years in 2014 for the city of Guangzhou, an

increase of 9.6%, and an increase of life expectancy from 71.4 in 2000 to 79.4 in 2014 in Shenzhen, a 11.6% increase. Overall the life expectancy increased during last three decades.

## MODEL AND HYPOTHESES TESTING

In this study, we hypothesize that government spending in health-related fields would help improve the quality of public health, and in turn will help increase the life expectancy. Given the available government statistics in China, the proxies we used for public government expenditure in healthcare related fields are the number of health technician and the number of hospital bed.

According to The US Department of Health and Human Services 2012 annual report, education will lead to better health habits and a longer life. Deshpande, Kumar, and Ramaswami (2014) used a country's literacy rate as the proxy for level of education to estimate the impact on the life expectancy. There is no literacy data available in China's city statistics book, we use the number of college enrollment in a city as a proxy to represent government investment in higher education and we expect that government's spending in higher education will lead to a better educated population and in turn it will have a positive effect on life expectancy.

We run the following multiple regression model with the natural log of all variables.

$$Ln(LifeExp)= a + \beta1*Ln(GDP) + \beta2*Ln(Highed) + \beta3*Ln(Hospbed)+ \beta4*Ln(HealthTe)$$

Our hypotheses are GDP per capita, government spending and public expenditure in healthcare related field will help improve life expectancy of the population.

## ANALYSIS OF EMPIRICAL RESULTS

We first used SAS program to perform simple regression of life expectancy on each of independent variables, namely, GDP, the number of hospital beds, the number health technicians, and the number of college enrollments. Regression results have been presented in table 6.

Table 6 shows the simple regression results between life expectancy and all the independent variables with Model (1) on GDP per capita, Model (2) on college enrollment, Model (3) on hospital bed, and Model (4) on health care technician. All these models show positive relationship between the dependent variable life expectancy and independent variables.

To test the combined effects of the independent variables on life expectancy, we performed multiple regression analysis. Before we run multiple regression, we perform the correlation analysis between the independent variables to check if there is any multicollinearity. Table 7 indicates there is no perfect collinearity between any two variables. However, there is a high correlation between the variables hospital bed and health technician with a correlation coefficient of .85574. Table 7 is the correlation table of the variables GDP, hospital bed, healthcare technician, and the college enrollment.

To avoid the possibility of incorrect statistical results, we do not include the variables hospital bed and health technician in the same multiple regression model. We run two multiple regression models with life expectancy on GDP, Enrollment of Higher Ed, and the number hospital bed in Model (1) and the other one with life expectancy on GDP, Enrollment of Higher Ed, and the number of health technician in Model (2). Table 8 shows the multiple regression results.

The Results from table 8 with multiple regression models indicate the positive relationship between life expectancy and GDP per capita is statistically significant at the 1% level. Similarly, we observe the positive relationship between life expectancy and the number of hospital bed as well as positive effect of life expectancy on the number of health technician, which is also statistically significant at 1% level.

In both models, we have not found the college enrollment variable has any significance to life expectancy, which is away from our expectation. We speculate that higher education of the population will certainly help train them with better health knowledge. However, the education may have lagged effects on life expectancy. Given our limited sample size, we are unable to conduct a regression analysis

on the lagged effect of higher education investment. We need to expand our sample size so that we may get more meaningful statistical results.

Table 9 reports the regression results without the college enrollment variable. Again, we perform two multiple regression models with life expectancy on GDP and the number hospital bed in Model (1) and the other one with life expectancy on GDP and the number of health technician in Model (2). Both models show a strongly significant positive relationship between life expectancy and GDP per capita as well as positive impacts of number of hospital beds and of healthcare technicians on the life expectancy. An increase of 100 Chinese Yuan in GDP per capita will increase the average life expectancy for 1.6 days[1], an increase of 100 hospital beds will prolong life expectancy for an average of 1.7 days, and an increase of 100 healthcare technician will prolong life expectancy about 1 day.

## CONCLUSION

In this study, we have examined the impact of economic growth and government expenditure in health-related fields on life expectancy in four largest cities in China. Using both simple regression and multiple regression analysis, we find that life expectancy is statistically significant and positive correlated with GDP per capita, the number of hospital beds, and the number of health technicians. These results indicate that the high growth of GDP will lead to a rise in life expectancy. In addition, the government expenditure in health care related fields such as the expenditure in hospital beds and health technicians also improve the life expectancy. Our finding is consistent with Mahumud, Rawal, Hossain, Hossain, and Islam (2013) and Deshpande, Kumar, and Ramaswami (2014).

Under the trend of globalization, big cities around the world share more and more similar features such as lower AM(Avoidable Mortality) ratios and etc., although under different health care system. With the sample data from the most urbanized cities from China, our paper explores the significant roles of investments in public health infrastructure and will help for the study of social welfare cost and benefit. Shanghai, Beijing, Guangzhou, and Shenzhen are the four largest cities in China and comparable to New York City. Our study will lay a foundation for future comparative studies to help review on policy implementation and efficient governmental spending and help related government agencies and decision makers to learn from each other to improve the general public health condition.

We have encountered some issues during our research that we have not attempted to solve yet. Some of them are mentioned below for further study in the future. (I) Our results do not indicate a positive relationship between the life expectancy and the number of college enrollment. We speculate that the higher education of the population will certainly help them for a better health knowledge. However, the investment in higher education might have a lagged effect on life expectancy. Given our limited sample size, we are unable to conduct the regression analysis on the lagged effect of higher education investment. We need to expand our sample size so that we may get more meaningful statistical results. (ii) Our data include the time series data for each of the largest four cities in China. We could have run the regression on the first difference of the time series data (period to period change of the time series data). Again, due to our limited sample size, the further study of the impact of the difference of the data on life expectancy is left to the future work.

## ENDNOTES

1. Note that our regression is a log-log regression. A regression coefficient β in a log-log regression indicates a β percent change in y given a one percent change in x. For GDP impact on life expectancy, we perform the following calculation: β from Model (1) from Table 9 is 0.02453. An increase of 100 Chinese Yuan in GDP will result in an increase of 0.2263% in GDP (using average of 44198 in GDP from Table 5). Thus an increase of 100 Chinese Yuan in GDP per capita will increase the average life expectancy for 1.6 days (.02453*.2263%*77.43*365=1.6)

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**APPENDIX**

**TABLE 1**
**DESCRIPTIVE STATISTICS FOR SHANGHAI CITY DATA**

| *Variables* | *LifeExp* | *GDP* | *Hospbed* | *Highed* | *HealthTe* |
|---|---|---|---|---|---|
| Mean | 77.478 | 30177 | 77735 | 247408 | 110781 |
| Standard Error | 0.534302 | 4931.536 | 2934.309 | 28397.02 | 3811.15 |
| Median | 76.26 | 20647 | 71000 | 147900 | 108900 |
| Mode | 75.97 | #N/A | 70000 | 506600 | #N/A |
| Standard Deviation | 3.25003 | 29997.36 | 17848.7 | 172732.3 | 23182.32 |
| Sample Variance | 10.5627 | 899841796 | 318576231 | 29836461877 | 537419909.9 |
| Kurtosis | -1.45919 | -0.50005 | -0.49615 | -1.43565 | 6.550705 |
| Skewness | 0.237146 | 0.896267 | 0.781217 | 0.600693 | -1.10133 |
| Range | 9.36 | 94885 | 62800 | 465100 | 144800 |
| Minimum | 73.14 | 2485 | 54700 | 50600 | 19200 |
| Maximum | 82.5 | 97370 | 117500 | 515700 | 164000 |
| Sum | 2866.71 | 1116569 | 2876200 | 9154100 | 4098900 |
| Count | 37 | 37 | 37 | 37 | 37 |

**TABLE 2**
**DESCRIPTIVE STATISTICS FOR BEIJING CITY DATA**

| *Variables* | *LifeExp* | *GDP* | *Hospbed* | *Highed* | *HealthTe* |
|---|---|---|---|---|---|
| Mean | 78.3255 | 45887.2 | 77110.35 | 418954.4 | 140195.8 |
| Standard Error | 0.787038 | 7127.003 | 4621.902 | 42974.41 | 10559.33 |
| Median | 80 | 43454.5 | 78213 | 518484.5 | 118242 |
| Mode | 80.1 | #N/A | #N/A | #N/A | #N/A |
| Standard Deviation | 3.519742 | 31872.93 | 20669.77 | 192187.4 | 47222.78 |
| Sample Variance | 12.38858 | 1015883466 | 427239549 | 36935994116 | 2229990800 |
| Kurtosis | 0.181502 | -1.14159 | 0.644974 | -0.97969 | 0.179788 |
| Skewness | -1.22464 | 0.142719 | -0.77596 | -0.79418 | 0.970796 |
| Range | 11.3 | 98637 | 79558 | 539541 | 170792 |
| Minimum | 70.5 | 1358 | 30231 | 55073 | 72131 |
| Maximum | 81.8 | 99995 | 109789 | 594614 | 242923 |
| Sum | 1566.51 | 917744 | 1542207 | 8379087 | 2803916 |
| Count | 20 | 20 | 20 | 20 | 20 |

**TABLE 3**
**DESCRIPTIVE STATISTICS FOR GUANGZHOU CITY DATA**

| *Variables* | *LifeExp* | *GDP* | *Hospbed* | *Highed* | *HealthTe* |
|---|---|---|---|---|---|
| Mean | 76.76905 | 55051.19 | 48878.05 | 551476.8 | 72300.24 |
| Standard Error | 0.568368 | 8108.335 | 3134.763 | 67766.92 | 5054.677 |
| Median | 77.1 | 45906 | 45687 | 589234 | 59943 |
| Mode | 75.5 | #N/A | #N/A | #N/A | #N/A |
| Standard Deviation | 2.604588 | 37157.06 | 14365.29 | 310547.1 | 23163.44 |
| Sample Variance | 6.783879 | 1380646916 | 206361505.4 | 96439472724 | 536544916.6 |
| Kurtosis | -1.19077 | -0.86614 | -0.84861 | -1.13221 | -0.55863 |
| Skewness | 0.041799 | 0.577196 | 0.6186 | -0.20866 | 0.917585 |
| Range | 8.38 | 123060 | 47081 | 953826 | 72639 |
| Minimum | 72.92 | 5418 | 29930 | 65465 | 48276 |
| Maximum | 81.3 | 128478 | 77011 | 1019291 | 120915 |
| Sum | 1612.15 | 1156075 | 1026439 | 11581012 | 1518305 |
| Count | 21 | 21 | 21 | 21 | 21 |

**TABLE 4**
**DESCRIPTIVE STATISTICS FOR SHENZHEN CITY DATA**

| *Variables* | *LifeExp* | *GDP* | *Hospbed* | *Highed* | *HealthTe* |
|---|---|---|---|---|---|
| Mean | 76.64143 | 80920.29 | 19367.29 | 52875.29 | 41281.29 |
| Standard Error | 1.042473 | 15582.32 | 2714.576 | 9746.193 | 8030.059 |
| Median | 77.53 | 76273 | 18086 | 58910 | 46877 |
| Standard Deviation | 2.758124 | 41226.95 | 7182.092 | 25786 | 21245.54 |
| Sample Variance | 7.607248 | 1699661182 | 51582450.24 | 664917916.9 | 451372966.9 |
| Kurtosis | 1.579027 | -0.36549 | -0.42089 | -0.84039 | -1.89243 |
| Skewness | -1.26553 | 0.551464 | 0.399732 | -0.35385 | -0.03941 |
| Range | 8.3 | 116695 | 20748 | 73551 | 54216 |
| Minimum | 71.4 | 32800 | 10294 | 14123 | 15720 |
| Maximum | 79.7 | 149495 | 31042 | 87674 | 69936 |
| Sum | 536.49 | 566442 | 135571 | 370127 | 288969 |
| Count | 7 | 7 | 7 | 7 | 7 |

**TABLE 5**
**DESCRIPTIVE STATISTICS FOR COMBINED STACKED DATA**

| *Variables* | *LifeExp* | *GDP* | *Hospbed* | *Highed* | *HealthTe* |
|---|---|---|---|---|---|
| Mean | 77.43365 | 44198 | 65651.96 | 346874.4 | 102471.6 |
| Standard Error | 0.340253 | 3902.714 | 2723.371 | 28162.2 | 4606.345 |
| Median | 77.53 | 33958 | 69600 | 299037 | 107100 |
| Mode | 80.1 | #N/A | 70000 | 506600 | #N/A |
| Standard Deviation | 3.136978 | 35981.24 | 25108.24 | 259642.6 | 42468.4 |
| Sample Variance | 9.840631 | 1294649832 | 630423506 | 67414285377 | 1803564936 |
| Kurtosis | -1.09101 | -0.32424 | -0.44786 | -0.49807 | 1.707948 |
| Skewness | -0.16969 | 0.689293 | -0.14311 | 0.613357 | 0.669942 |
| Range | 12 | 148137 | 107206 | 1005168 | 227203 |
| Minimum | 70.5 | 1358 | 10294 | 14123 | 15720 |
| Maximum | 82.5 | 149495 | 117500 | 1019291 | 242923 |
| Sum | 6581.86 | 3756830 | 5580417 | 29484326 | 8710090 |
| Count | 85 | 85 | 85 | 85 | 85 |

**TABLE 6**
**RESULTS FOR SIMPLE REGRESSION OF LIFE EXPECTANCY ON THE INDEPENDENT VARIABLES.**

| Dependent variable LnLifeExp | Model (1) | Model (2) | Model (3) | Model (4) |
|---|---|---|---|---|
| Constant | 4.07274*** | 3.9611*** | 3.84883*** | 3.78964*** |
| LnGDP | 0.02714*** | | | |
| LnHighed | | 0.03128*** | | |
| LnHealthTe | | | 0.04371** | |
| LnHospbed | | | | 0.05084** |
| $R^2$ | 0.6843 | 0.5417 | 0.2898 | 0.3798 |
| *,**, and *** indicate significance level at 10%, 5% and 1%, respectively. | | | | |

**TABLE 7**
**CORRELATION COEFFICIENT TABLE BETWEEN DEPENDENT VARIABLES**

| Pearson Correlation Coefficients, N = 85 | | | | |
|---|---|---|---|---|
| | LnGDP | LnHospbed | LnHighed | LnHealthTe |
| LnGDP | 1 | | | |
| LnHospbed | 0.16037 | 1 | | |
| LnHighed | 0.62847 | 0.64943 | 1 | |
| LnHealthTe | 0.13484 | 0.86574 | 0.54244 | 1 |

**TABLE 8**
**REGRESSION RESULTS OF LIFE EXPECTANCY ON GDP, ENROLLMENT OF HIGHER ED, THE NUMBER HOSPITAL BED AND NUMBER OF HEALTH TECHNICIANS**

| Dependent variable LnLifeExp | Model (1) | Model (2) |
|---|---|---|
| Constant | 3.618*** | 3.69289*** |
| LnGDP | 0.02788*** | .0244*** |
| LnHospbed | 0.04976*** | |
| LnHighed | -0.0081 | 0.00187 |
| LnHealthTe | | 0.03363*** |
| $R^2$ | 0.935 | 0.8705 |
| *,**, and *** indicate significance level at 10%, 5% and 1%, respectively. | | |

**TABLE 9**
**REGRESSION RESULTS OF LIFE EXPECTANCY ON GDP,THE NUMBER HOSPITAL BED AND THE NUMBER HEALTH TECHNICIAN**

| Dependent variable LnLifeExp | Model (1) | Model (2) |
|---|---|---|
| Constant | 3.64907*** | 3.68873*** |
| LnGDP | 0.02453*** | 0.02522*** |
| LnHospbed | 0.04095*** | |
| LnHealthTe | | 0.03529*** |
| $R^2$ | 0.9243 | 0.8698 |
| *,**, and *** indicate significance level at 10%, 5% and 1%, respectively. | | |

**FIGURE 1**
**LIFE EXPECTANCY OVER THE SAMPLE PERIOD IN SHANGHAI**

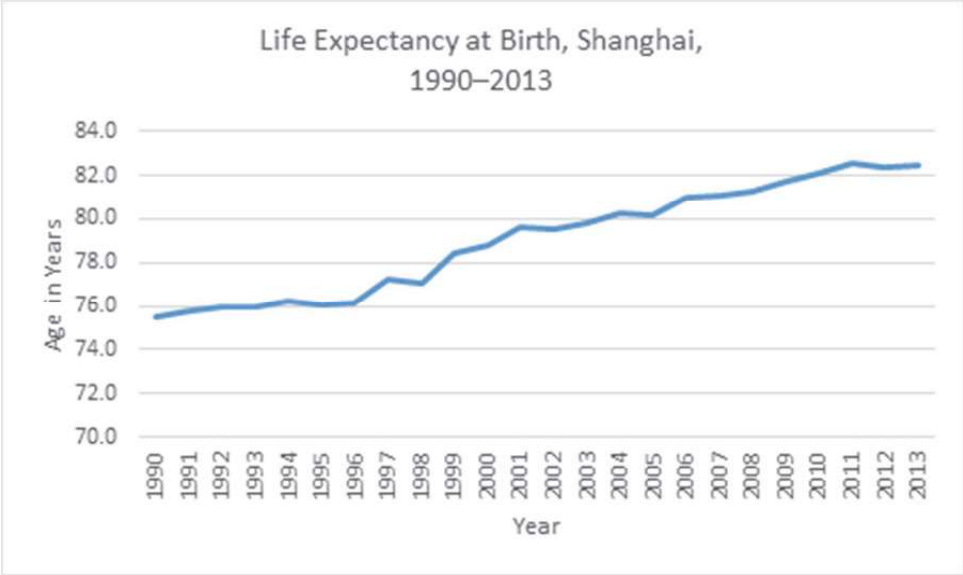


**FIGURE 2**
**LIFE EXPECTANCY OVER THE SAMPLE PERIOD IN BEIJING**

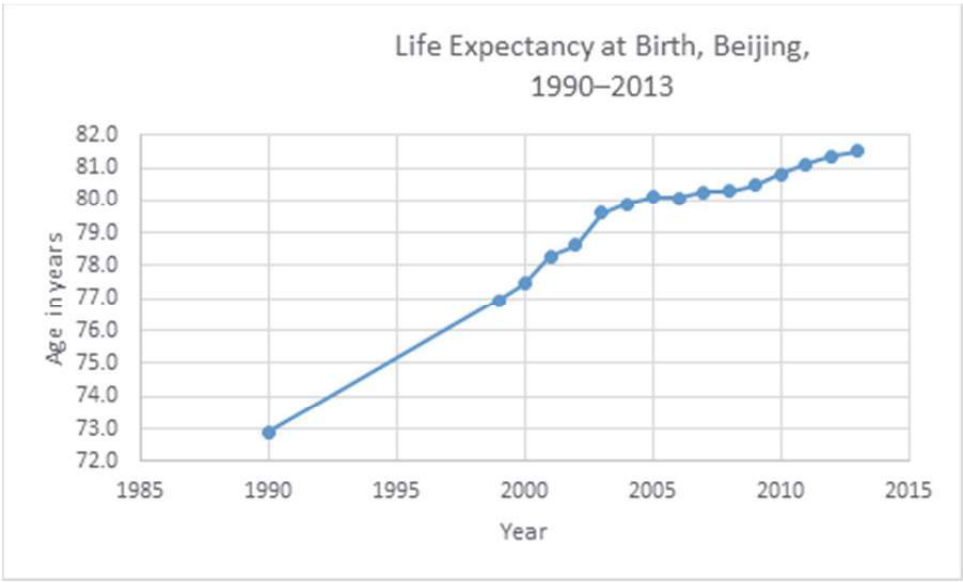

**FIGURE 3**
**LIFE EXPECTANCY OVER THE SAMPLE PERIOD IN GUANGZHOU**

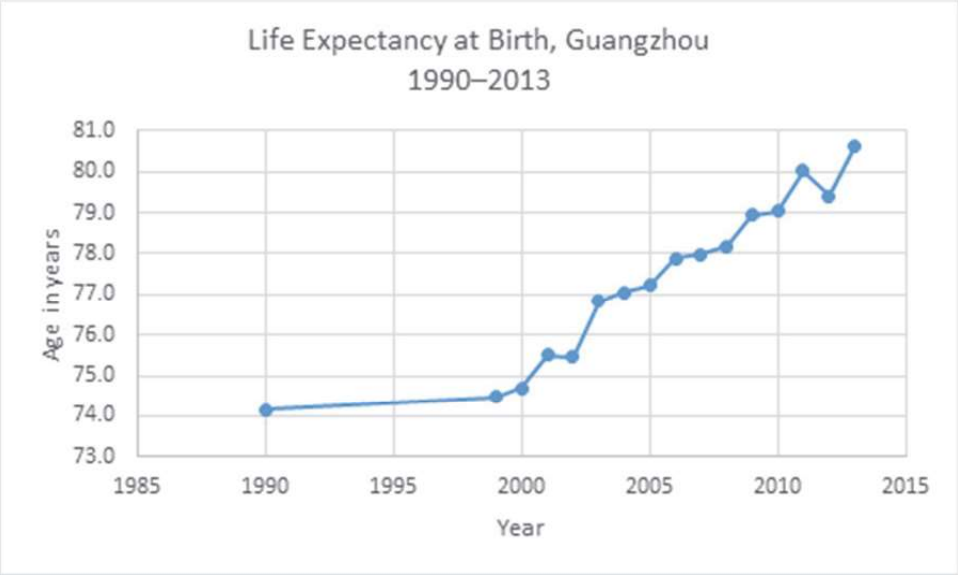


**FIGURE 4**
**LIFE EXPECTANCY OVER THE SAMPLE PERIOD IN SHENZHEN**