

# The Effect of Population Aging on Healthcare Expenditure from a Healthcare Demand Perspective Among Different Age Groups: Evidence from Beijing City in the People's Republic of China

This article was published in the following Dove Press journal:  
*Risk Management and Healthcare Policy*

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**Background:** With population aging (PA), the healthcare expenditure (HE) increases. The aim of this study is to analyze the HE of different age groups and the effect of age on HE among different age groups.

**Methods:** Combining PA and HE data, this study used the fixed effect model and parameter estimation method to evaluate the influence of different age groups on HE from 2008 to 2014.

**Results:** The age effect of HE for the population aged 65 or over was the most significant among the different age groups. Based on PA and HE data, HE per capita of the age group 65 years or over is 7.25 times as much as the population aged < 25 years, 1.61 times as much as the population aged 25~59 years, and 3.47 times as much as the population aged 60~64 years. Based on the result of the fixed effect model, HE per capita of the age group <25 years was 218.39 Yuan (CNY) (USD \$31.2). HE per capita of the age group 25~59 years old increased to 1,548.62 Yuan (CNY) (USD \$221.2). HE per capita of the 60~64 years age group will be 921.56 Yuan (CNY) (USD \$131.7), 4.22 times as much as that of the age group < 25 years. HE per capita in the age group of 65 years or over is 2,538.88 Yuan (CNY) (USD \$362.7), 11.63 times as much as that of the age group <25 years.

**Conclusion:** The results suggest that PA in China is intensifying. In order to control the rising of HE, the government should not only address the supply side such as reforming medical insurance payment, developing new technologies, but also focusing on solving the demand side such as improving the quality of healthcare services, solving environmental pollution, and improving the residents' health.

**Keywords:** population aging, healthcare demand, healthcare expenditure, different age groups, fixed effect model, parameter estimation method

## Introduction

With social and economic development, people's living conditions and medical technology also improve, lengthening the normal lifespan. Virtually all the countries in the world face population aging (PA), including the People's Republic of China. An individual born today in the People's Republic of China can expect to live to 77 years.<sup>1</sup> This is compared to a life expectancy of 47.3 years for males and 50.5 years for females born between 1953 and 1964.<sup>2</sup> This meets the definition of an aging society in the United Nations World Report on Population Aging (1950–2050), where

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the proportion of the population aged 60 years or over of the total population reaches 10%, or the proportion of the population aged 65 years or over reaches 7%.<sup>3</sup> According to the data of the sixth national census in 2010, those aged 65 years or over accounted for 13.7% of the total population in the People's Republic of China,<sup>4</sup> indicating that the People's Republic of China had become an aging society.

As the data shows in Table 1, by calculation, PA in the People's Republic of China is projected to be 14% in 2025 and 21% in 2035. This defines the People's Republic of China as a deep aging society and super aging society respectively.<sup>5</sup> The data shows that the People's Republic of China became an aging society later than other developed countries. However, the transitional time for different aging population cohorts has been shorter. This illustrates that, compared with other countries, the People's Republic of China is facing a grim situation.

It is well known that the People's Republic of China has experienced an increasing elderly population with high healthcare expenditure (HE), which is a challenge that the People's Republic of China needs to prepare for. Furthermore, the demand for more health resources varies greatly among different age groups in the People's Republic of China. With the development of the economy and the improvement of living conditions, people's pursuit and demand for healthcare has increased. In 2003, the People's Republic of China began to carry out a significant and complex healthcare reform, aiming to improve the accessibility and affordability of healthcare. Since the 21st century, HE in the People's Republic of China has been increasing. HE per capita increased rapidly from 1407.74 Yuan (CNY) in 2008 to 3783.83 Yuan (CNY) in 2017 (in December 16, 2019, USD \$1 equivalent to CNY 6.99).<sup>6</sup> During the same timeframe, the share of the government health expenditures increased from 5.7% to 7.5%, and as a share of overall gross domestic product (GDP) increased from 1.1% to 1.8%.<sup>7</sup>

In the past few decades, the Chinese government has released several policy documents concerning how to respond to PA with increasing HE. As the 12th Five-Year plan of health development in the People's Republic of China pointed out, one of the most important goals of the healthcare reform was to strengthen supervision over HE and to control unreasonable growth of HE. The reasons why HE is increasing so fast has been investigated widely in the People's Republic of China. Some researchers have concluded that the health policy,<sup>8–17</sup> medical technology advancement, health insurance system,<sup>18–25</sup> drug policy,<sup>26</sup> supplier behavior<sup>27</sup> are factors which make HE increased.

Over the past 50 years, HE has experienced a significant increase with the increase of life expectancy. Getzen<sup>28</sup> used cross-sectional data and time series data of 20 OECD countries from 1966 to 1988 to estimate the effect of PA on HE.<sup>28</sup> He concluded that even with no budget constraints, PA would have increased medical costs. Crivelli et al,<sup>29</sup> using the time series and cross-sectional data of 26 cantons in Switzerland from 1996 to 2002, found that the degree of PA (the proportion of the elderly over 75 years old in the total population) can account for the differences in medical costs among cantons.<sup>29</sup> Di Matteo and Di Matteo<sup>30</sup> used the panel data of five Canadian provinces from 1965 to 1991 and found that the PA could explain 92% of the variation in actual per-capita HE.<sup>30</sup> Tomoko et al<sup>31</sup> used the panel data of 47 prefectures of Japan from 2001 to 2010 to estimate the relationship between HE, GDP and PA. Their findings revealed that PA was the most important factor driving the increase of HE, while GDP had little impact on HE.<sup>31</sup> White<sup>32</sup> carried out an empirical study on the population and medical expense in the United States and other OECD countries in 1970–2002.<sup>32</sup> In this study, it was found that the actual growth rate of per-capita medical cost was 4%–5%, but the proportion of the population over 65 years old was very small, and the age structure contributed only to 0.3%

**Table 1** The Time of Social Development for Aging in Countries (Unit: Years)

	United States	Germany	Japan	China	The World	Developed Countries	Underdeveloped Countries
Entry stage year (7%)	1950	1950	1970	2000	2005	1950	2055
Transition time	65	25	25	<25	35	50	40
Depth stage year (14%)	2015	1975	1995	2025	2040	2000	2095
Transition time	15	35	15	10	40	25	—
Super stage year (21%)	2030	2010	2010	2035	2080	2025	—

**Notes:** In some countries exceptions may occur, such as the introduction of a large number of foreign laborers or the adoption of foreign children in a certain year, which can lead to a more dramatic change in the age of the population. Data source: United Nations, Department of Economic and Social Affairs, Population Division (2015). World Population Prospects: The 2015 Revision, DVD Edition.

~0.5% growth of HE. However, Di Matteo<sup>33</sup> combined the data of the United States and Canada in 2005 to find that the PA did have an impact on the growth of HE, but the impact was relatively small.<sup>33</sup> Furthermore, Di Matteo found that medical technology innovation was the main reason for the growth of HE. Asl and Abbasabadi<sup>34</sup> studied age effects on healthcare expenditures among 165 countries.<sup>34</sup> They found that age effects on healthcare expenditures is significant. Furthermore, the most effective population is aged 45 years or above affecting the health expenditures in a positive way.

With healthcare system reform in the People's Republic of China, the growth of HE has attracted wide attention from Chinese scholars. These experts have conducted many researches on the issue of HE, and made some inroads on factors analysis related to health cost growth with the use of some modern econometric methods, like Grainger causality analysis,<sup>35,36</sup> principal component analysis,<sup>37,38</sup> unit root test<sup>39</sup> and other statistical methods. P.P.H used the cointegration analysis to analyze the data from 1978 to 2003.<sup>40</sup> It found that there was an impact of economic growth on the growth of HE. It also found that PA has a great impact on the growth of HE in the People's Republic of China in the short term, but the impact was not obvious in the long term. From the perspective of urban and rural differences, by analyzing the provincial panel data from 2002 to 2008, Yu<sup>41</sup> found that the impact of PA on medical expenditure was significant, and the contribution ratio in medical expenditure was about 3.8%,<sup>41</sup> similar to that of some experts for OECD national research.<sup>42</sup>

Though there is much research on the effect of PA on HE, there is limited research on the relationship between PA and HE from the perspective of healthcare demand among different age groups. In 2015, the social medical insurance system changed. Urban Residents' Medical Insurance and Cooperative Medical Scheme have merged into Urban and Rural Residents' Medical Insurance. In order to estimate correctly, we used data from 2008 to 2014 to carry out research. The objective of this paper was to analyze the HE of different age groups from 2008 to 2014, and the effect of age on HE among different age groups measured by fixed effect model and semiparametric estimation methods. The aim was to use these findings to shed light on policy suggestions regarding how to deal with the healthcare demand among age groups with higher HE.

## Materials and Methods

### Data Sources and Variables Selection

As the capital of the People's Republic of China, Beijing has been defined as an aging society earlier than the rest of China and has abundant health resources. The People's Republic of China has conducted six national censuses in 1953, 1964, 1982, 1990, 2000, and 2010 respectively. This paper chooses the first census data in 1953 as the observed group. The number of people born in 1953~1964 is considered the first group; 1964~1982 is the second group; 1982~1990 is the third group; 1990~2000 is the fourth group; 2000~2010 is the fifth group and after 2010 is the sixth group. As shown in Table 2,<sup>43</sup> the age demographics of the population of Beijing has experienced a notable change.

Based on data provided by Healthcare Insurance Administration of Beijing, this paper undertakes an empirical analysis about the HE of the population across different age groups. According to the age range of the data collection period, this paper classifies the sample into four age groups, which are: <25 years, 25 to 59 years, 60 to 64 years, and >65 years. For the sake of estimating the impact of aging on rising HE, we regard other variables as controls as described below. The HE per capita calculated in this paper is from the Beijing medical insurance center (the number adjusted for inflation). HE per capita refers to the total HE financed by medical insurance, which mainly includes spending on outpatient visits and inpatient hospital stays. Note that deductibles are not included in the total HE. Control variables are GDP per capita (CNY), the share of the population aged 65 years or over (%), the old-age dependency ratio (%), the child-age dependency ratio (%), total population (per ten thousand), the share of the urban population (%), the coverage rate of medical insurance (%), the share of the population with college degree or above (%), SO<sub>2</sub> emission volume (month/ten thousand tons). These data are obtained from annual publications.<sup>44</sup> Note that, the medical insurance refers to the Urban Employee Basic Medical Insurance (UEBMI) before 1998, but UEBMI and Urban Resident Basic Medical Insurance (URBMI) after 2007. The description of variables is shown in Table 3.

With aging of the population and the decline in health as one ages, consumption will lead to the increase of health demand, which contributes to the increase of HE. This paper adopts two methods to estimate the effect of PA on the HE growth. Firstly, the parametric estimation is

**Table 2** The List of Six Censuses Data in Beijing (Unit: 10,000 Persons)

	1953	1964	1982	1990	2000	2010
Total	276.8	759.7	923.1	1,081.9	1,356.9	1961.2
0–14 years old	83.3	315.3	206.8	218.5	184.5	168.7
15–64 years old	1,84.3	413.3	664.6	795.2	1,058.4	1621.9
65 years old and over	9.1	31.1	51.7	68.2	113.9	170.6
0–14 years old ratio	30.1%	41.5%	22.4%	20.2%	13.6%	8.6%
15–64 years old ratio	66.6%	54.4%	72.0%	73.5%	78.0%	82.7%
65 years old or over ratio	3.3%	4.1%	5.6%	6.3%	8.4%	8.7%

**Note:** Data sources: Annual statistical yearbooks of Beijing.

**Table 3** Description of Variables

Variables	Mean	SD
Healthcare expenditure per capita(CNY)	2,094.46	903.80
Per-capita GDP (CNY)	81,046.29	13,358.60
The share of the population aged 65 years or over (%)	9.08	0.77
The old-age dependency ratio(%)	11.34	1.11
The child-age dependency ratio (%)	11.74	0.60
Total population (per ten thousand)	1,985.3	124.7
The share of the urban population (%)	85.84	0.62
The coverage rate of medical insurance (%)	94.66	3.32
The share of the population getting bachelor or above(%)	30.67	4.33
SO <sub>2</sub> emission volume (month/ten thousand tons)	13.4	4.25

**Note:** Data sources: Annual statistical yearbooks of Beijing.

employed using the least square method. To estimate the effect of PA on the HE growth, other variables are used as controls. Because the estimation of age also includes the birth group effect, (which has the risk of randomness and unpredictability), these need to be controlled using the fixed effect model. Secondly, the semiparametric estimation method is used to exclude age and birth group effects between HE and age using non-parametric estimation.

## Methodology

### Parametric Estimation

According to the theoretical analysis of the relationship between PA and HE, we specify the following model equations (1).

$$\ln(exp_{ct}) = B_0 + \sum B_j age_{jct} + X_{ct}\beta + \delta period_{ct} + \mu_c + \vartheta_{ct} \quad 1$$

This equation is called the fixed effect model. In this model,  $exp_{ct}$  denotes HE per capita. This is calculated using medical insurance fund outpatient and hospitalization expenditures;  $age_{jct}$  is a dummy variable denoting age;  $age_{jct}$  is regarded as other controllable factors. This

model controls the coverage rate of medical insurance and GDP per capita. We also add the time variable in the model. The time variable mainly controls for the impact of policy changes and medical technology progress. In this model,  $\mu_c$  denotes age fixed effect, and  $\vartheta_{ct}$  is the random error term.

### Semiparametric Estimation

Based on semiparametric estimation, the estimated equations (2) and (3) are as follows.

$$\ln(exp_{ct}) = \beta_0 + \sum \gamma_j Dcohort_{jct} + X_{ct}\beta + \delta period_{ct} + \varepsilon_{ct} \quad (2)$$

Where  $m$  (age) denotes age function and  $Dcohort_{jct}$  is a dummy variable for the birth group. For the nonparametric estimation part, the Epanechnikov kernel function for age function  $m$  (age) is as follows.

$$K_h(u) = \frac{0.75}{h} \left(1 - \left(\frac{u}{h}\right)^2\right) * I\left(\left|\frac{u}{h}\right| \leq 1\right), u = (age - age_c) \quad (3)$$

This function corresponds to the weighted average of the function values near the observation points, in order to improve the accuracy of the prediction and facilitate the prediction of HE at that age point. In semiparametric estimation, the Epanechnikov kernel function gives a higher estimation weight to the value nearer to the observation point. Far values are assigned lower weights. The  $H$  is a window width. For the sake of satisfying the requirement of smoothness and applicability of the function, a suitable window width is selected for semi-parametric estimation, so that the weighted average of local neighborhood observation points (ie, logarithmic HE per capita) can reach the expected accuracy and smoothness. At the same time, the dummy variables such as birth group, period and other variables ( $X$ ) are used as the parameter part which is estimated by equations (1) and (2), and the

traditional least square method is used to estimate it. Parametric and nonparametric estimations are carried out simultaneously, and these two methods complement each other. Finally, nonparametric function  $m(\text{age})$  and the parametric partial coefficient are obtained. This method of estimating the age effect approximates the trend of age effect.

## Results

### Results of Mixed Cross Section Data

It is found that HE increases significantly with age increases (see Table 3 for the regression results). In general, the age effect of HE for the population aged 65 years old or older was the most significant. As shown in Table 4, HE of those aged >65 years old per capita is 7.25 times greater than the population aged <25 years old, 1.61 times greater than the population aged 25~59 years old, and 3.47 times greater than the population aged 60~64 years old. Apart from that, the time dummy variable was significantly positive, indicating that the growth of HE after 2008 increased dramatically.

In accordance with the above regression results, this paper predicted HE of different age groups which are shown in Table 5. HE per capita of the group < 25 years old is 506.47 Yuan (CNY) (USD \$72.4). The average HE per capita in the age group of 25~59 years old is 2,286.18 Yuan (CNY) (USD \$326.6). HE per capita of the age group 60~64 years old is 1,058.31 Yuan (CNY) (USD \$151.2). HE per capita of the age group of 65 years old or over is 3,673.48 Yuan (CNY) (USD \$524.8). These findings indicate that the age effect of HE is significant. HE per capita in the group aged 60 years or over is 1.69 times higher than the group aged under 60 years, which

**Table 5** Predictive Value of Healthcare Expenditures for Different Age Groups (Cross Sectional Data)

Age Group	Healthcare Expenditure per Capita
<25 years old	506.47
25~59 years old	2,286.18
60~64 years old	1,058.31
65 years old and above	3,673.48

**Note:** According to the regression results in Table 4, the predicted values of healthcare expenditure in different age groups are significant at 1% level.

shows that most medical resources are consumed by the elderly.

### The Estimation Results of the Fixed Effect Model

Table 6 shows the regression results of the fixed effect model. When estimating the effect of age on HE, the influence of age group variables on the birth group effect is considered. Therefore, excluding the influence factors of the age effect of the birth groups is consistent with the change rule of the cost of Chinese medicine in the whole life. The increase in the cost of traditional Chinese medicine is remarkable. After controlling for GDP per capita and healthcare insurance coverage, the age effect decreased sharply, indicating that the change in HE is influenced by healthcare conditions and physical health levels at birth as well, and that this health demand is due to individual health level, not age.

The regression results predicting the HE of different age groups are shown in Table 7. It was found that HE per capita of the age group <25 years old is 218.39 Yuan (CNY) (USD \$31.2). HE per capita for the age group 25~59 years old increases to 1,548.62 Yuan (CNY) (USD \$221.2). HE per capita for the 60~64 years old age

**Table 4** Age Effect of Regression of Mixed Cross Section Data

	Model (1)	Model (2)
25~59 years old	1.268***	0.966***
60~64 years old	1.806***	1.831***
65 years old and above	2.369***	2.596***
2008~2013	0.869***	0.679*
Population ratio over 65 years of age		-0.012
Ln (per capita GDP)		-0.099
Coverage of medical insurance		1.384**
Constant term	2.964***	3.896
Adjust R <sup>2</sup>	0.88	0.91

**Notes:** The control group is the age group 25 years old and below. \*\*\*Significant at 1%, \*\*Significant at 5%, \*Significant at 10%.

**Table 6** Age Effect of the Fixed Effect Model

	Model (1)	Model (2)
25~59 years old	1.164**	1.652***
60~64 years old	2.396***	2.869***
65 years old and above	3.759***	3.829***
2008~2013	0.941***	0.963**
Population ratio over 65 years of age		-0.034
Ln (per capita GDP)		-0.438
Coverage of medical insurance		1.4464**
Constant term	2.361***	6.643**
Adjust R <sup>2</sup>	0.81	0.85

**Notes:** The control group is the age group 25 years old and below. \*\*\*Significant at 1%, \*\*Significant at 5%.



**Table 7** Predictive Value of Healthcare Expenditure for Different Age Groups (Panel Data)

Age Group	Healthcare Expenditure per Capita
<25 years old	218.39
25~59 years old	1,548.62
60~64 years old	921.56
65 years old and above	2,538.88

**Note:** According to the regression results in Table 6, the predicted values of healthcare expenditure in the different age groups are significant at the 1% level.

group is 921.56 Yuan (CNY) (USD \$131.7), 4.22 times higher than the age group <25 years old. Furthermore, the HE per capita in the age group of 65 years old or over is 2,538.88 Yuan (CNY) (USD \$362.7), 11.63 times as much as that of the age group of 25 years old and below. This phenomenon indicates that with increasing age, the impact of age on HE is significant. It is also found that the HE per capita for those aged 60 years or over is 1.96 times as much as those younger than 60 years.

### Semiparametric Estimation Results

The age parameter  $m(\text{age})$  is drawn from semiparametric estimation results. The blue curve removes the relationship between the age of the birth group and the age effect on HE as seen in Figure 1. The orange curve is used to distinguish the age effect, the age of birth group and the age of time effect on the HE in Figure 1.

Based on the results of the semiparametric estimation, it can be seen that HE increases with increasing age. Furthermore, the increase range is greater than the age

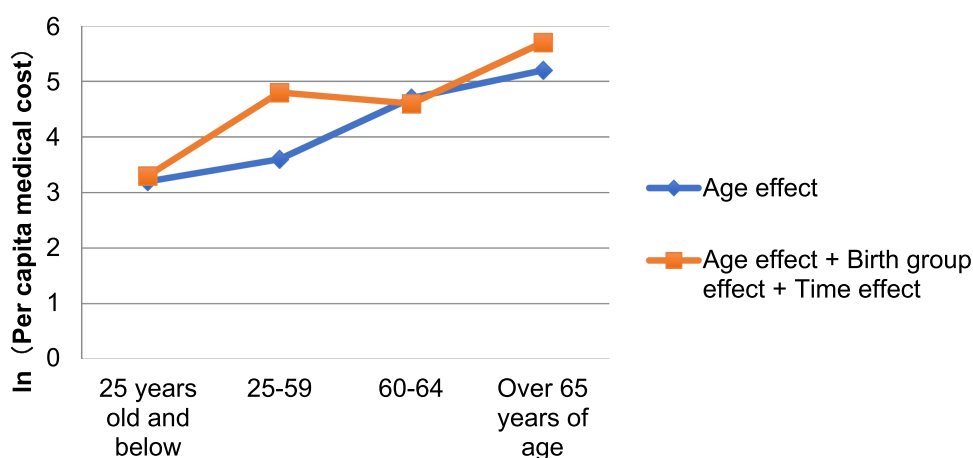
effect, which is the same as the results of the fixed effect model. By examining the age effect, we can find that there is a great difference in the HE per capita among different age groups. There is a positive correlation between the HE per capita and the age groups. The increase in age significantly drives HE increase, and the increase range is greatest among those aged 65 years old or over.

### Discussion

Although the relationship between PA and HE has attracted great attention from scholars all over the world, there are only a few studies examining the healthcare demand perspective among different age groups, especially using the fixed effect model and semiparametric estimation method to evaluate the impact on the HE. The semiparametric estimation has advantages vs parametric estimation. It combines parametric and nonparametric estimation. Furthermore, the nonparametric part assumes that the relationship between economic variables is unknown. Therefore, it can reasonably estimate the results and reduce the error versus the traditional parametric estimation, which reflects the linear trend of age effect more accurately.<sup>45</sup> Combining PA data and HE data, we evaluated the effect of PA on HE from the healthcare demand perspective among different age groups. This paper introduced the different age groups to the research field of the influence of the PA on HE, and revealed some important findings.

Based on the data of mixed cross sections, the age effect of HE for the population aged 65 or over is the

## Semi Parametric Estimation Results

**Figure 1** The result of the semiparametric estimation.

**Note:** The Y-axis shows the  $\ln$  (healthcare expenditure per capita) and the X-axis shows the age.

most significant among the different age groups (Table 4). HE per capita of those aged 65 years or over is 7.25 times greater than the population aged <25 years old, 1.61 times greater than the population aged 25–59 years old, and 3.47 times greater than the population aged 60–64 years old. HE per capita for the group <25 years old is 506.47 Yuan (CNY) (USD \$72.4). The average HE per capita in the age group of 25–59 years old is 2,286.18 Yuan (CNY) (USD \$326.6). HE per capita at the age group 60–64 years old is 1058.31 Yuan (CNY) (USD \$151.2), and HE per capita of the age group of 65 years old or over is 3,673.48 Yuan (CNY) (USD \$524.8) (Table 5).

These findings indicate that the age effect on HE is significant. HE per capita for the group aged 60 years or over is 1.69 times greater than the group aged under 60 years, which shows that most medical resources are consumed by the elderly and the medical resources allocation is unfair among different age groups. The unfair distribution of medical resources among the population should be one of the key directions in the future healthcare system reform. There are many factors affecting HE. By adding per capita GDP and coverage rate of medical insurance in the equation, it can be found that medical insurance coverage has an enormous impact on the increasing HE in urban areas, which indicates that medical insurance has a positive effect on the rise of HE. Besides, the impact of per capita GDP on HE is small, which is consistent with the conclusions of previous studies.<sup>31</sup> On the one hand, the economic development has raised the per capita income and improved medical treatment, making the HE increased synchronously. On the other hand, due to the improvement of medical conditions caused by the progress of medical technology, the morbidity and mortality declined.<sup>46,47</sup> Therefore, the impact of per capita GDP on HE is not substantial.

Fuchs<sup>48</sup> found a significant correlation between age and HE by employing the 1984 data from the United States.<sup>48</sup> Compared with the population under the age of 65, the increase of HE of the elderly is larger. Denton et al<sup>49</sup> used the healthcare data of Ontario in Canada and constructed the age/cost profile to find that the per capita healthcare costs increased with age.<sup>49</sup> However, Zweifel et al<sup>50</sup> found that age had no impact on medical demand after controlling for the remaining time to death.<sup>50</sup> The results also showed that the HE in the terminal stage of life (near to death) are similar at age 60 or 90. Many empirical results showed that the proximity to death is the main factor affecting the increase of HE while age itself has a minor impact.<sup>51</sup> Many scholars found

that age was still an important factor affecting HE by using data from different countries and time periods.<sup>52–54</sup> Lubitz et al<sup>55</sup> used sample data of 129,166 Medicare beneficiaries over 65 years old who died between 1989–1990 to analyze this further. The results showed that HE decreased as patients' age increased in the last months of life.<sup>55</sup> The same results were also found by Felder et al,<sup>56</sup> and Colombier et al.<sup>53</sup> These findings can be explained differently. From a supply side perspective, physicians make decisions based on the patient's condition including age. For patients with the same disease, compared with young patients, physicians may not be willing to provide costly healthcare services for elderly patients with terminal disease.<sup>54,57,58</sup> From a demand perspective, one theory holds that an individual's willingness to pay for survival is hump-shaped. In one's youth, the willingness to pay for survival increases with the increases of age. The willingness to pay for survival peaks in middle age, and declines when one becomes older. Therefore, after a certain age, the cost of death decreases as patients become older.<sup>59</sup>

Based on the regression result of the fixed effect model, the age effect of HE for the population aged 65 years old or over is the most significant among different age groups (Table 6 Appendix 6). This may be related to a sharp increase in healthcare demand caused by the high incidence of diseases in this age group. As can be seen in Table 7, HE per capita in the age group of 65 years old or over is 2,538.88 Yuan (CNY) (USD \$362.7), 11.63 times as much as that of the age group of 25 years old and below. In terms of health demand, there are significant differences among different age groups, especially for the elderly (over 65 years). Age is an important factor in terms of the growth of HE, but the factors driving the increase of HE are complex, such as supplier-induced demand, over-prescription behavior, etc. These factors can lead to unreasonable growth of HE. However, it is noteworthy that the developed countries focus on healthcare system construction (eg, the law, policy and measures for healthcare reform) such as determining the benchmark value of the growth of HE. On the one hand, healthcare system construction can meet the health demand for different age groups. On the other hand, the healthcare system construction can keep HE growth within a reasonable range.

Gao and Yao<sup>60</sup> studied the data of 8,414 samples of 1,428 farmers in eight provinces in China, finding that the medical costs of young and middle-aged people aged 25–34 were considerably less than those of the children and the elderly, with the HE of the elderly group >65 years old demonstrating

a declining trend.<sup>60</sup> Yan and Chen<sup>61</sup> performed a sampling survey in four counties of Hubei and Sichuan Province, and found that, compared with the non-elderly group (<65 years old), the elderly group was 5% lower in hospitalization rate but 30% higher in self-reported prevalence rate as answered in a survey by the elderly people.<sup>61</sup> Simultaneously, they found that the per-capita hospitalization expenses and outpatient expenses of the elderly group decreased by 775 Yuan (CNY) (USD \$110.7) and 328 Yuan (CNY) (USD \$46.9) respectively. Xu and Chen<sup>62</sup> used the Bayesian quantile regression (BQR) method to predict the long-term care costs from the demand side. The results showed that future LTC cost increases will be enormous with the population aging.<sup>62</sup> From the supply side, Chen et al<sup>63</sup> found that family members, income, area of residence and health insurance are the factors influencing the availability of long-term care services.<sup>63</sup>

Finally, compared with developed countries, there are two main characteristics of the impact of domestic PA on HE. Firstly, the aging population (>65 years of age) has increased significantly in the recent past. The rapid increase in the elderly population has brought about a significant demand for medical services. Secondly, population aging in the People's Republic of China is different from other countries in the world. A great number of scholars have studied the impact of PA on HE by using summary data of a certain period in the region, but unfortunately, most of them ignore the healthcare demand and expenditure differences among different age groups. In this analysis we have done so.

Our research has several advantages. This study examines the impact of PA on HE growth from the perspective of age differences and enriches the research on the related topic. At the same time, this study adopted a more scientific and appropriate research methodology using parametric estimation and semiparametric estimation. This was an innovative approach to ensure new insights can be gained that are applicable to this growing problem.

## Conclusion

Based on the data of previous population censuses, this paper has constructed different birth groups. According to the social and economic development characteristics of each birth group, using the fixed effect model and parametric estimation, it evaluates the impact of PA and the elderly's healthcare demand on the HE growth. The results showed that with the PA and the HE increasing, HE of the population aged 65 or over increases significantly. The growth rate of HE per capita has accelerated since 2008. HE of the elderly population aged

65 or over is 11.63 times greater than the population aged <25 years old. Scientific and rational response to the PA and the growth of HE will be a major challenge for future economic and social development in the People's Republic of China. In the process of reducing HE, the government should focus on supply and demand factors such as reform of the medical insurance payment, new technologies, and equipment.

Our study also has some limitations. Due to the limitations of the data, HE growth is predicted only for the age group, and the government investment growth for healthcare is not considered, so HE growth may be underestimated. HE growth for different age groups is synchronous with time. In reality, the HE growth for people aged 65 or over is obviously faster than that of other age groups, so the increase of HE per capita aged 65 or over may be underestimated. Secondly, the current HE did not include ER visits or medications. We cannot estimate the effect of population aging on the cost of ER visits or medications. Thirdly, comorbidity is not available in the data and we cannot control comorbidity. Further research for HE growth with healthcare reform in the People's Republic of China is needed in the future, and is certainly one of the key directions for future research.

## Abbreviations

PA, population aging; HE, healthcare expenditure; GDP, gross domestic product; UEBMI, Urban Employee Basic Medical Insurance.

## Data Sharing Statement

Data and materials accessed from the Healthcare Insurance Administration of Beijing are freely available.

## Ethics Approval and Consent to Participate

The study was exempt from human subjects' approval (non-identifiable data; not human subjects).

## Acknowledgments

We thank the Healthcare Insurance Administration of Beijing for cooperation and organizing data collection. We would also like to thank all study participants for their time while being interviewed.

## Author Contributions

All authors made a significant contribution to the work reported, whether that was in the conception, study design,



execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

## Disclosure

The authors report no conflicts of interest.

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