

Research on influence of physical activity on medical expenditure in the elderly in China—Based on CHARLS in 2015

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Abstract

Becoming more and more serious of such problems as acceleration of aging and high medical burden of the elderly in China, research on the influence of physical activity on medical expenditure in the elderly has attracted a lot of attention. In this work, Tobit model is established based on the data from China Health and Retirement Longitudinal Study in 2015 and Behavioral Model of Health Services Use theoretical framework. Compared with the inactive elderly, the medical expenditure of the elderly who participate in the level 4, 3, 2 physical activity decreasing step by step. After involving need factors in the model, the influence of physical activity on medical expenditure varies from significant to insignificant. The medical expenditure of the elderly who meet the physical activity amount is negatively correlated with the physical activity amount, and is lower than that of the elderly who don't meet physical activity amount. Physical activity will not directly affect medical expenditure, but will affect medical expenditure through chronic diseases and self-rated health status. Our results provide theoretical analysis and empirical test for enriching physical activity guidelines and Behavioral Model of Health Services Use in the elderly in China.

Introduction

In recent years, the aging speed in China continues to accelerate. According to the latest data released in January 2020 by the National Bureau of statistics, by the end of 2019, the population aged 60 and above has reached 253.88 million, accounting for 18.1% of the total population, far exceeding 10% of the social standard line for aging. The aging population has brought a serious burden to our society. According to the latest data of the National Bureau of statistics, the total national medical expenditure in 2018 was about 5.9 trillion yuan, increasing by 12.4% compared with that in 2017, and the per capita health expenditure was 4237.0 yuan, increasing by 12.0% compared with that in 2017¹⁻². The factors influencing medical expenditure are complex, and physical activity is one of the changeable factors. In the field of sport science research, Yang Guang et al.³ conducted a factor analysis on the influence of physical activity on medical expenses in the elderly in Hegu area of Sendai Japan, through questionnaire survey; Li Wenchuan⁴ conducted an empirical study on the reduction of medical expenditure by physical exercise of the elderly in Shanghai. Lehnert t et al.⁵ pointed out that the utilization of medical services is mainly related to physical factors in health conditions, rather than psychological factors. Physical factors mainly refer to chronic disease conditions, physical function conditions and physical activities. Guo Jialiang et al.² believe that among the many factors influencing the health and health expenditure of the elderly, physical activity is also becoming one of the main influencing factors. Compared with other factors, physical activity is the most promising factor to be improved through action⁶.

Based on the cross-sectional data of China Health and Retirement Longitudinal Study (CHARLS) in 2015, this paper uses the Behavioral Model of Health Services Use (BMHSU) and Tobit model to study the relationship between physical activity and medical expenditure of the elderly, and try to analyze the

relationship between the frequency, intensity, duration and form of physical activity and medical expenditure of the elderly.

Methods

Study design. When studying the influencing factors of personal medical expenditure, health status is regarded as the most direct influencing factor. Hu Hongwei et al. believe that chronic diseases and self-rated health significantly affect the medical expenditure of the elderly^{7,8}. In addition to health status factors, Liu Guoen et al. believe that the income, medical insurance and pension of the elderly will also influence their medical expenditure⁹⁻¹¹. In addition, education level, marital status, age, gender and urban and rural identity will also influence medical expenditure^{7,11}. According to the research on the impact of physical activity on medical expenditure of the elderly, scientific physical activity has significant effect on reducing the incidence of diseases, reducing medical demand and saving medical expenditure¹².

According to the intensity, amount and duration of exercise, Yang Guang³ divided the amount of physical activity of the elderly over 70 years old in the Hegu area of Sendai Japan into three levels. With the decrease of intensity and amount of exercise, there are significant differences in medical expenditure among the three groups.

In summary, the factors that affect the personal medical expenditure of the elderly in China are relatively complex, involving health status, economic conditions, social security, socio-demographic characteristics, physical activities and many other aspects. Professor Andersen's BMHSU provides a comprehensive and systematic theoretical framework for the research in this field. In this dynamic and interactive relationship model (Figure 1), demographic characteristics affect medical expenditure, and personal health practices affect demographic characteristics. Demographic characteristics include three aspects: need factors, enabling resources and predisposing characteristics¹³. In addition to the medical service utilization behavior, the health behavior in the theoretical model also includes personal health practices, such as diet and exercise¹⁴. Domestic scholars have systematically introduced the theoretical model^{13,15}. Song Lu et al. used the model to explore the influencing factors of rural elderly medical expenditure from the perspective of gender difference¹⁶; Liu Guoen et al.⁹ empirically analyzed the impact of medical security on medical service demand of the elderly's from three dimensions of need, enabling resources and predisposing characteristics based on the theoretical model. Ma Aixia et al.⁷ established Tobit model about influencing factors of medical expenditure of the elderly in China based on the model framework. However, no studies have yet incorporated physical activity into the theoretical model.

Taking Andersen theoretical model as the research framework, on the premise of controlling predisposing characteristics, enabling resources and need factors, this paper will conduct empirical research on the correlation between physical activity variables in personal health practices and medical expenditure, promote the further improvement of the theoretical model, and provide reference for the development of related research in China.

Data source. The data used in this paper are the cross-sectional data of China Health and Retirement Longitudinal Study (CHARLS) of National School of Development of Peking University in 2015. The sample covers 21000 respondents from 12400 families. The survey subjects are mainly the micro data of families and individuals aged 45 and above in China and the survey contents include basic information, health status and function, medical care and insurance, work, retirement and pension, of which physical activity variable is a secondary sampling survey. After excluding the samples under 60 years old and lack of relevant variables and secondary sampling, 4093 samples are eventually used in this paper.

Selection of variables. The per capita medical expenditure of the elderly is the dependent variable of this study, which is the sum of the monthly outpatient expenditure and the annual hospitalization expenditure in the questionnaire^{7,17}, including the reimbursement of medical insurance and the part of individual self-payment.

According to BMHSU, fifteen variables including need factors, enabling resources, predisposing characteristics, personal health practices and the use of medical services are selected as independent variable and control variable (Table 1), of which personal health practices mainly select sports dimension, including four levels of physical activity. Physical activity refers to any physical activity that results in energy consumption caused by skeletal muscle contraction, which is composed of four types of physical activities: occupational, traffic, housework and leisure^{18,19}. Intensity, duration weekly and duration each time are used as index to measure physical activity²⁰. The impact of physical activity on health depends on the way, intensity, duration, frequency and total amount of physical activity²¹.

In this study, the selection of independent variable —four levels of physical activity is derived from the question of "physical activity" in the 2015 CHARLS questionnaire: "How long do you usually take in these activities (including high intensity, medium intensity and walking) in a week?". According to WHO physical activity guidelines for the elderly²⁵, Chinese adult physical activity guidelines of at least 30 minutes per day, Chinese Ministry of Health's proposal of "ten thousand steps per day", and the related research on physical activity amount, the independent variables are divided into four levels³, and the level 4 physical activity group includes: high intensity exercise (more than 75 minutes per week, no less than 10 minutes each time), moderate intensity exercise (more than 150 minutes per week, no less than 10 minutes each time), and walking (210 minutes a week, no less than 10 minutes each time); The level 3 physical activity group includes: no high intensity exercise, moderate intensity exercise (more than 150 minutes per week, not less than 10 minutes each time), walking (210 minutes a week, not less than 10 minutes each time); The level 2 physical activity group includes: no high and moderate intensity exercise, walking (210 minutes a week, not less than 10 minutes each time); The level 1 physical activity group includes: the elderly who doesn't meet the above three levels of intensity. The level 1 physical activity group doesn't meet the physical activity, the other three groups meet the physical activity.

Table 1 Definition of variables

Measured content	Variables	Measured index
Need factors	Self-rated health	Excellent=4 Good=3 Normal=2 Bad=1 Very bad=0
	Disability	Yes=1 No=0
	Chronic disease	Yes=1 No=0
Enabling resources	Medical insurance	Yes=1 No=0
	Pension	Yes=1 No=0
Predisposing characteristics	Personal income	All income in last year (continuous variable)
	Gender	Male=1 Female=0
	Age	60-69=0, 70-79=1, 80 and above=2
	Education level	Illiterate=0, Primary school (including private school)=1, Middle school=2, High school and above=3
	Marital status	Married and cohabiting with spouse =1, Others=0
	City or rural	City=1, Rural=0
	4 levels physical activity	Level 4 PA group=3, Level 3 PA group=2, Level 2 PA group=1, Level 1 PA group=0
Personal health practices	Monthly outpatient expenditure and annual inpatient expenditure	Annual per capita medical expenditure (continuous variable)
Per capita medical expenditure		

Tobit Model. Based on the data characteristics and the application study of Tobit model by demography related scholars^{7,22,23}, this paper will establish Tobit model of influencing factors of the elderly medical expenditure.

$$y^* = ax + b \quad (1)$$

$$y = \max(0, y^*) \quad (2)$$

Ethics approval and consent to participate. For all experiments on humans, we confirm that all methods were carried out in accordance with relevant guidelines and regulations. The CHARLS received ethics approval from both a national government administration and an institutional review board or ethics committee. Only adolescents who provided written/verbal consent participated. As the current study used retrospective publicly available data, we did not require ethics approval from any Institutional Ethics Review Committee for this secondary analysis.

The CHALRS questionnaire refers to international experience, including the American Health and Retirement Survey (HRS), the British Elderly Tracking Survey (ELSA), and the European Health, Old Age and Retirement Survey (SHARE), etc. Multi-stage sampling is adopted in the project, and PPS sampling method is adopted in both county/district and village sampling stages. The response rate and the quality of CHARLS data are among the best in similar projects in the world, and the data has been widely used and recognized in academia.

Results

Comparison of physical activities of the elderly with different characteristics

The data shows that there are significant differences in medical expenditure, gender, education level, marital status, pension, self-rated health status, and whether there is disability or not (Table 2).

The medical expenditure and physical activity of the elderly who meet the physical activity shows a negative correlation trend; the proportion of men in level 4 physical activity group is higher than that in the other three groups; the education level of the elderly who meet the physical activity amount is higher than that in the elderly with insufficient physical activity; the self-rated health status of the elderly who meet the physical activity amount is more positive than that in the elderly who doesn't meet the physical activity.

For the elderly who don't meet the physical activity amount, the majority of them are women, whose age are higher than the average age, which is 70.52 years old. Their education levels are mainly below primary school, and cohabiting with spouse are also below the average level. The proportion of buying medical insurance and insurance is relatively low, and the personal income is lower than the average level. The self-rated health status is relatively negative, and the proportion of disabled people is more than a half. According to the physical activity of the disabled elderly, 80.41% of them meet the physical activity, and the number of persons participating in the second, third and fourth level physical activity is distributed more evenly, which indicates that most of the disabled elderly have certain demand for physical activity. For the elderly patients with chronic diseases, 84.48% of the elderly meet the physical activity level, and the number of persons participating in the second, third and fourth level of physical activity is distributed more evenly. Among the four groups of elderly physical activity, there are no statistically significant differences in the comparison of physical intensity in the five indicators of age, urban and rural household registration, personal income, medical insurance and whether there is chronic disease.

Table 2 Group difference of four levels of physical activity in the elderly

Measured content	Variables	Average value				F/X ² value	
		Meet physical activity amount		Do not meet physical activity amount			
		Level 4 PA	Level 3 PA	Level 2 PA	Level 1 PA		
	Numbers[N/%)	1205 [29.44]	1088 [26.58]	1174 [28.68]	626[15.29]		
Independent variable	Annual medical expenditure	9061	23479	26165	22509	12.40***	
Predisposing characteristics	Male[%]	57.43%	43.47%	49.40%	45.85%	16.65***	
	Age	66.25	67.38	69.38	70.52	85.40	
	Education level	1.00	1.15	1.12	0.86	19.34***	
	Married with spouse [%]	83.98	77[30	76.40	72.04	13.55***	
	Urban residence	0.12	0.33	0.34	0.21	70.62	
Enabling resources	Medical insurance[%]	92.45	94.67	92.08	87.22	10.29	
	Pension[%]	74.19	75.92	70.70	69.65	4.10***	
	Personal income[1000]	2061.87	1437.71	1426.50	1344.10	4.96	
Need factors	Self-rated health	2.18	2.16	2.08	1.86	20.11***	
	Disability(%)	39.17	34.65	41.65	52.08	17.43***	
	Chronic disease [%]	72.86	74.45	71.81	74.28	0.82	

Note: ***: P<0.001; **: P<0.05; *: P<0.1

Results of Tobit model

According to model 1, physical activity of the elderly will significantly influence the medical expenditure of the elderly in China. The lower the physical activity, the higher the medical expenditure of the elderly (Table 3). In model 2, predisposing characteristics are included. The results show that all levels of physical activity still had significant impact on medical expenditure of the elderly in model 2. In model 3, the enabling resources are also included in the model to analyze the influence of various dimensional variables on medical expenditure of the elderly when they access to medical services and resources. The results show that personal income will significantly influence the medical expenditure of the elderly, which is consistent with that personal income is the most important factor in relevant research ²³; the medical expenditure of the elderly with income is 1.03 times as much as that of the non-income, while physical activity, education level, marital status and urban or rural identity still have a significant impact on the medical expenditure of the elderly. Compared with the elderly with the level 1 physical activity, the elderly who participate in level 4, level 3 and level 2 physical activity will reduce medical expenditure by 15134.92 yuan, 10828.5 yuan and 3903.13 yuan respectively. Participating in physical activities will reduce the medical expenditure by 5298.67 yuan.

In model 4, the need factors were included in the post analysis, and the self-rated health status of the elderly significantly influences the medical expenditure of the elderly in China. In addition, disease is the most direct influencing factor, and the average annual medical expenditure of elderly patients with chronic diseases is 2965.51 yuan, while that of the elderly without chronic diseases is only 1637.52 yuan. Whether or not suffering from disability has no significant impact on the medical expenditure of the elderly. It is worth noting that education level, marital status, personal income, self-rated health status, whether suffering from chronic diseases still have significant impact on medical expenditure of the elderly in model 4, but physical activity has no significant impact on medical expenditure of the elderly. In the related research on the influencing factors of medical expenditure of the elderly, the two-categorical variable of physical exercise—"yes or no" is included in the model study, and the result is also not significant²⁴.

Table 3 Tobit model of medical expenditure of the elderly in China

Variables	Model 1	Model 2	Model 3	Model 4
Independent variable				
Physical activity	-4865.68***	-5555.37***	-5298.67***	-2756.12
Level 2 PA	-4368.31*	-4269.57*	-3903.13*	1894.832
Level 3 PA	-10905.07*	-11393.51*	-10828.5*	-3077.957
Level 4 PA	-14055.53**	-15947.47**	-15134.92***	-6550.634
Predisposing characteristics				
Gender		-4728.08	-3610.24	-1371.10
Age		-98.70	203.80	-712.19
Education level		3038.37*	3249.54*	4351.12*
Marital status		10520.69**	10369.45**	10108.73**
Urban or rural		-9778.96**	-9937.97**	-4214.77
Enabling resources				
Medical insurance			-7757.82	-8164.82
Pension			2400.06	2339.13
Personal income			-1308.75**	-883.20*
Need factors				
Self-rated health status				-25757.08***
Disability				2395.01
Chronic disease				14458.73***
N	4093	4093	4093	4093
Logarithm Likelihood function	-7602.5799	-7597.026	-7593.3991	-7507.2194
P-value	0.0043	0.0037	0.0017	0.0000

Note: ***: P<0.001; **: P<0.05; *: P<0.1

Discussion

In the whole life course, physical activity is closely related to health. A large number of cross-sectional studies and longitudinal studies have shown that the relative risk of limited activity function is reduced by 50% among people who regularly participate in at least moderate intensity of physical activity. For the elderly, physical activity can reduce anxiety and depression and improve self-confidence by maintaining muscle strength and cognitive ability. Randomized controlled trials show that physical activity can increase social participation, maintain social networks and intergenerational connectivity. In addition, a large number of literature shows that physical activity has an impact on health status, but this study concluded that due to the impact of health, the influence of physical activity on medical expenditure is significant or insignificant.

In Tobit model 4, after adding the need factors, there are statistical effects on influence of health and whether suffering from chronic diseases on the elderly medical expenditure, which also proves the direct impact of health on medical expenditure. The self-rated health status of the elderly will significantly influence the medical expenditure of the elderly in China. The more negative the self-rated health status is, the higher the medical expenditure is. Maybe when the elderly self-rated health status is poor, outpatient treatment is frequent²⁶. In addition, disease is the most direct influencing factor. The prevalence of chronic diseases in the elderly in China is relatively high, with an average of 1.68 chronic diseases, of which 73.21% suffer from one or more chronic diseases. Elderly patients with chronic diseases have a long and large demand for medical care. In addition, once the chronic diseases recur, the treatment cost is very expensive²³. It also further shows that the average annual medical expenditure of the elderly patients with chronic diseases is higher than that of the healthy elderly. Whether suffering from disabilities has no significant impact on the medical expenditure of the elderly, which is the same as Ma Aixia's analysis. The reason may be that most disabilities, such as physical disability, deafness and blindness, do not need continuous medication or hospitalization, so the impact on medical expenditure is limited⁶.

The study also finds that the higher the education level is, the higher the medical expenditure is. The medical expenditure of the elderly with diploma of primary school, middle school, high school and above are 1.01, 1.34 and 1.77 times of that of illiterate people respectively and higher education level increases the ability of the elderly to use medical services²⁷, which is the same with Liu Guoen et al.'s study result that income has a significant impact on medical expenditure, and the medical expenditure of high-income population is significantly higher than that of the low-income population¹⁰. The higher the income level of the elderly is, the more attention they pay to their health status, so the medical expenditure is more²³.

According to the results of one-way ANOVA of physical activity of the elderly with different characteristics, the medical expenditure and physical activity of the elderly who meet the amount of physical activity show a negative correlation. At the same time, Tobit model 1 shows that physical activity has a significant impact on medical expenditure. The medical expenditure of elderly people who participate in high-intensity or moderate intensity exercise and walking exercise is far lower than those who only participate in walking exercise and who walk for 210 minutes or more a week, that is there is a

difference medical expenditure between the elderly people who participate in walking only and those who participate in middle and high intensity of physical exercise. By reviewing the literature in sports about the impact of physical activity on medical expenditure in China, it is found that the research in this field is still in its infancy. Yang Guang³ and Yang Wenchuan⁴ et al. found that physical activity played an important role in restraining the growth of medical expenditure. And the related foreign research also confirmed this result. On one hand, insufficient physical activity will influence medical expenditure. Ding et al.²⁸ estimated that the global lack of physical activity in 2013 had led to an increase of about 53.8 billion US dollars in global health care expenditure. On the other hand, regular physical activity is helpful to relieve the pressure of medical expenditure. Ackerman et al.²⁹ used a retrospective cohort study and found that the average annual medical expenditure of the elderly over 65 years old who participated in community exercise programs in the past three years was far lower than that of those who did not regularly participate in physical exercise. However, there is a lack of research on the difference of medical expenditure between walking and middle or high-intensity exercise.

In addition, because predisposing characteristics will not directly influence personal medical expenditure, but indirectly play a role through influencing enabling resources and need factors⁸, as the basis in building model, the predisposing characteristics are analyzed firstly and included the direct influencing factors—need factors in this paper. In this study, because the occurrence of diseases or the decline in health status are the prerequisites and direct influencing factors for individuals to use medical services⁸, therefore, with the addition of need factors in model 4, the impact of physical activity changes is significant to insignificant. To a certain extent, physical activity will not directly influence medical expenditure, but may influence that by chronic diseases and self-rated health status, which confirms the exploration of the dynamic relationship between health behavior and demographic characteristics by BMHSU model from the side¹⁴. Through many quantitative empirical studies, scholars at home and abroad have shown that there is a certain correlation between physical activity and medical expenditure of the elderly, but they have not explained the influencing path at the same time. At present, some studies take health-related variables as mediation factors for path analysis. A public health survey in Sweden studied the mediation role of self-rated health between physical activity and medical service utilization through path analysis³⁰. The influence of physical activity on medical expenditure is a long-term effect, so it is suggested that the elderly should be encouraged to improve their need factors through physical activity, thus affecting medical expenditure. However, for its mechanism, it is suggested to use path analysis to explore, which can be further demonstrated in future research.

Declarations

Data availability

The data that support the findings of this study are available from National School of Development, Peking University. Restrictions apply to the availability of these data, which were used under license for

this study. Data are available at <http://charls.pku.edu.cn/pages/data/111/zh-cn.html> with the permission of Peking University.

Competing interests

The authors declare no competing interests.

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Author contributions

C. Hong conceived the design and performed statistical analysis and F. Wu performed the figure generation. All authors reviewed the manuscript.

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Figures

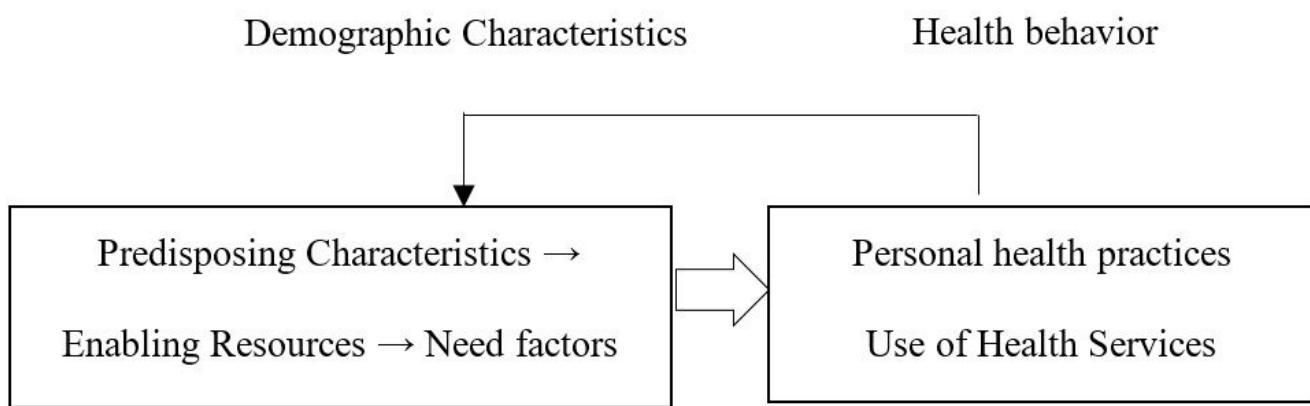


Figure 1

Phase 4 of Behavioral Model of Health Services Use 14. The model of health service's use such as the use of medical care is a function of the elderly with perceived need and predisposition to use services while some factors enable or impede the use. And it also recognizes personal health practices such as physical activities as interacting with the need factors and the use of health services. Among the predisposing characteristics, demographic factors such as age and gender represent biological factors suggesting the likelihood that the elderly will need health service. Social structure is measured by factors include education, marriage and hukou (living in rural or urban) that determine the status of the elderly in the community; Among enabling resources, personal resources and community resources are both included.

Health resources should be available where the elderly live and work and the elderly must have the ability and means to get to those services include income, medical insurance and pension; Among need factors, the elderly will get to health service like medical care with the perceived need including self-rated health and chronic diseases.