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Evaluation of status quo and determinants of catastrophic health expenditure among empty-nest elderly in China: evidence from the China health and retirement longitudinal survey (CHARLS)

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Abstract. – OBJECTIVE: The aging society and the empty nest of the elderly have become issues that cannot be ignored by the Chinese government. Not only does the physical function of the empty-nest elderly (ENE) decline, and the incidence and prevalence of chronic diseases increase significantly, but they are also more likely to have loneliness, low life satisfaction, mental health problems, and even a much greater possibility of suffering from depression than the nonempty-nest elderly, besides the possibility of catastrophic health expenditure (CHE) which is also greatly increased. This paper aims to evaluate the status quo of dilemma and determinants of a vast sample of subjects based on the national level.

SUBJECTS AND METHODS: Data were obtained from the latest 2018's data of the China Health and Retirement Longitudinal Study (CHARLS). Under the guidance of Andersen's model of health services utilization, this study clarified the overall and different demographic characteristics and prevalence of CHE among ENE and further built the Logit and Tobit model to explore the determinants of CHE occurrence and its intensity.

RESULTS: A total of 7,602 ENE were included in the analysis, and the overall incidence of CHE among them was 21.20%. Poor self-reported health status (OR=2.03, 95% CI: 1.71-2.35), suffering from three or more chronic diseases simultaneously (OR=1.79, 95% CI: 1.42-2.15), low life satisfaction (OR=1.44, 95% CI: 1.20-1.68) and advanced age played the leading role in accounting for its high risk, and its intensity increased 0.0311 (SE=0.005), 0.0234 (SE=0.007), and 0.0178 (SE=0.005), respectively. In contrast, the leading drop in the probability of CHE among ENE was those whose monthly income was over 20,000 CNY (OR=0.46, 95% CI: 0.38-0.55), whose intensity declined 0.0399 (SE=0.005), whose monthly income was between 2,000 and 20,000 CNY (OR=0.78, 95% CI: 0.66-0.90) and whose intensity declined 0.021 (SE=0.005), and who were married during the survey period (OR=0.82, 95% CI: 0.70-0.94). Simultaneously, rural ENE showed more vulnerability and higher risk of CHE when confronted with these factors compared with the urban ones.

CONCLUSIONS: More attention should be paid for ENE in China. The priority, including the relevant health insurance or social security measurements, should be further strengthened.

Key Words:
Catastrophic health expenditure, Empty-nest elderly, Status quo, Determinants, China.

Abbreviations

ENE, the Empty-nest elderly; CHE, Catastrophic health expenditure; CHARLS, China Health and Retirement Longitudinal Study; CFPS, China Family Panel Studies; AM, Andersen's model of health services utilization; PF, predisposing factors; EF, enabling factors; NF, needing factors; NHCR: New Health Care Reform; UEBMI, the Urban Employee Basic Medical Insurance; MIUR, Medical Insurance for Urban Residents; NRCMI, the New Rural Cooperative Medical Insurance; OI, other insurance; NI, no any medical insurance.

Introduction

Empty-nest elderly (ENE) refers to people over the age of 60 who do not have children or whose children have moved out, in other words, they are single or live with only their siblings or spouses[1]. Currently, the number of elderly people in China is rapidly increasing and is nearing the threshold

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for a society with a profoundly aging population, indicating a severe aging society situation. On 11 May 2021, the most recent Seventh China Population Census was released, revealing that the population aged 60 and older was 264.02 million, or 18.70% of the total population, an increase of 10.14 million compared to the end of 2019[2]. Since the Reform and Opening-up, China's national family structure has changed significantly. Massive population mobility caused by urbanization and industrialization, as well as the reduction of the number of family children caused by family planning policy, has resulted in the continuous reduction of household size and the gradual core of the family structure, which has contributed significantly to the intensification of the "empty nest" phenomenon among the elderly[3,4]. Consequently, as a result of the population's aging and the rapid acceleration of urbanization, this phenomenon is becoming more prevalent, and the proportion of ENE is also rising at an alarming rate[1,3,5]. By the end of 2015, ENE accounted for more than 50% of the total elderly population, and in large and medium-sized cities, this proportion could reach 70%[5]. It is estimated that by 2050, the number of elderly childless Chinese at the end of their lives will reach 79 million, with ENE accounting for more than 54%[6]. Consequently, the aging society and the empty nests of the elderly have become issues that the Chinese government cannot ignore.

In contrast to their counterparts, ENE have fewer support resources and a higher prevalence of chronic illness. The physical function of the elderly declines as they age, and the incidence and prevalence of chronic diseases dramatically increase. A recent survey revealed that the prevalence of chronic diseases in the middle-aged and elderly population was 41% (95% CI: 35-46%), while this number could reach up to 57.4% in the elderly population[7]. Not only are ENE gradually separated from their original work and social environment due to aging and limited physical condition, but also they cannot receive spiritual consolation from their children, families, or even society[8,9]. Consequently, in addition to facing the same risk as the general elderly population, they are more likely to experience loneliness, low life satisfaction, mental health issues, and even a greater likelihood of suffering from depression than the elderly non-empty nest[8-11]. According to a meta-analysis, the detection rate of anxiety symptoms in ENE patients in China was 32.8%, which was significantly higher than that of the general elderly population[12]. This circumstance worsens the health status of ENE, and another survey revealed that the discomfort rate of ENE in two weeks reached 40.95% according to the cross-sectional data of China Family Panel Studies (CFPS) in 2018, with a medical treatment rate of 86.81%, which is significantly higher than that of the general elderly population[13].

Consequently, it is not difficult to comprehend that the probability of catastrophic health expenditures (CHE) for ENE is significantly higher than for the general elderly population, as measured by an official indicator of financial risk[14]. The World Health Organization (WHO) believed that catastrophic medical expenditure could effectively measure the economic burden of diseases on residents and suggested that CHE would be considered to have occurred when the proportion of self-funded medical expenditure in household non-survival expenditure exceeded the 40% definition standard[9,15]. Due to the lack of economic support, health care and so forth, the ENE face a greater risk of suffering from diseases. Also, low mental health level can greatly increase the likelihood that older adults will develop cardiovascular diseases and cancers[16,17]. Thus, ENE who frequently feel lonely and have low life satisfaction may be at a greater risk of developing CHE. A recent research[18] indicates that the incidence rate of CHE among Chinese seniors aged 60 and older is 17%, which is significantly higher than the incidence rate among urban and rural residents, which is 8.7%. In addition, a number of studies[19-22] have demonstrated that old adults aged 60 or older, patients with chronic diseases, a family with no children or even a small number of children are all significant risk factors for CHE. In 2009, the Chinese government launched the New Health Care Reform (NHCR) to reduce the financial burden of health expenditures on households to the greatest extent possible[23,24] and took targeted measures in poverty alleviation. Three main separate health insurance arrangements were expanded to cover both urban and rural residents; the Urban Employee Basic Medical Insurance (UEBMI) scheme, which was designed for people employed in (or retired from) the formal sectors; Medical Insurance for Urban Residents (MIUR), which is available to those urban residents without formal employment; the New Rural Cooperative Medical Insurance (NRCMI) for all rural residents[25]. However, as a result of the implementation of these health insurance plans, the demand for medical services has increased significantly, and the consequences of CHE have yet to be thor-

oughly examined, as there are still numerous out-of-pocket medical expenses[26]. Consequently, because the population of ENE is at a greater risk of falling into or returning to poverty in the future, they require more attention, and it remains to be seen whether the incidence of CHE has decreased among this group.

Due to a lack of a well-developed pension security system, the reality of 'aging before wealthy' appears to be more prominent and obvious in China's aging population than in other developed nations[27], combined with the precarious health of elderly individuals, the risk of CHE increases substantially. Likewise, if CHE occurs among ENE, its repercussions would be more severe because the majority of ENE lack external support and emotional solace[28,29]. However, previous research[3,6,10,11,30] on poverty in the ENE primarily focused on measuring ex-post poverty at a specific time or predicting it for a specific region. Few academics[5,10,30] evaluated systematically the current dilemma of this special group at the national level. Consequently, our team has undertaken this mission and attempted to bridge this gap by analyzing the results of a large national survey in order to answer the two questions listed below:

(i) What is the status quo of CHE among ENE in China?
(ii) What are the significant contributors that affect CHE occurrence risk and intensity in this special group?

Subjects and Methods

Data Source

Participants for this analysis were collected from the latest data in 2018 of the China Health and Retirement Longitudinal Survey (CHARLS), an ongoing public cross-sectional survey held by the National School of Development at Peking University to evaluate the aging problem of the Chinese elderly population and promote interdisciplinary research on that issue (http://charls.pku.edu.cn/). It took Chinese residents aged 45 years and older as the research object and adopted stratified multistage sampling. The sample covered 150 counties/districts in 28 provinces (including autonomous regions and municipalities directly under the Central Government) across the country, which was relatively representative[31]. The questionnaire included the sample's basic personal information, family structure and economic situation, health status, medical insurance and utilization, occupation, retirement and pension, income, assets, etc. The baseline data collection for CHARLS was conducted in 2011 and has collected panel data four times thus far. The second time was conducted in 2013, the third in 2015 and the fourth in 2018. All data were made public one year after the end of data collection.

Variables Selection

Participants

ENE were included in this study as the participants and the inclusion criteria of that population were: (i) The elderly aged 60 years or older. (ii) The respondents have no children or have children but are not around for a long period of time (one month or more)[3,11]. For the latest panel data in 2018 of CHARLS, the determination of participants should further answer the two items simultaneously, one was about the item "With whom is living together?" and "When your children is not living with you, how often do you contact with him/her on phone/by message/on WeChat/by mail/by email?". For the first question, we included respondents other without living with child. For the second question, we included respondents who had contact with their children less frequently than once every 1 month.

Dependent variables

Concerning the variable outcome of this study, namely the CHE, was assessed by the calculation standard of WHO. It is defined as out-of-pocket (OOP) medical expenses exceeding the threshold of the family's capacity to pay (CTP, 40% of the family's total ability to pay), in which case the family is forced to cut the rest of its expenses because of the OOP[32,33], this further worsens the financial situation of these families and the high cost of OOP makes it impossible for some families to pay for OOP and eventually they are forced to stop treatment leading to further deterioration[34]. Among them, CTP refers to the total household expenditure excluding food consumption, including rent, clothing, communication expenses, water and electricity expenses, fuel expenses, service expenses, entertainment expenses, daily necessities and medical expenses, etc. The calculation formula of CHE was as follows (1 stood for CHE occurred, while 0 was not):

Besides, to further measure the impact of OOP health expenses on household living standards, our study used the ratio of it to CTP of the household and the distance of threshold 40% to measure the average intensity of CHE[35]. The specific calculation formula was as follows:

This part required the participants to answer the following items concurrently in questionnaires of CHARLS: (i) "Generally, how much does your family spend per month? Including rent, food, clothing, communication expenses, water and electricity costs, fuel costs, service expenditures, entertainment expenditures, daily necessities, and medical expenses." (ii) "How much did your household spend on the direct and indirect medical expenses?" (iii) "How much did your household spend on food (excluding eating out expenditure, alcohol, cigarettes, cigars and tobacco expenditure)?"

Independent variables

Andersen's model (AM) of health services utilization – which was also the most common and widely used socio-behavioral model for health planning and service use factors – was used to evaluate any potential significant contributors of outcome variables in this study[36,37]. In this model, the variables that determine health service utilization were categorized into predisposing factors (PF), enabling factors (EF), and needing factors (NF).

PF refers to certain characteristics of individuals that may affect the use of medical services directly or indirectly and comprises demographic characteristics such as age, gender, ethnicity, marital status, and educational level[38]. Based on the 2018 CHARLS survey questionnaire, age, gender, marital status, educational level and living area were chosen as PF. Among them, the living area was categorized as the urban area and rural area, the former included ENE living in towns and urban neighborhoods in cities, while the latter included respondents living in suburban areas of cities and villages.

EF is related to the ability and accessibility to utilize current available medical services, which also means that EF may be a factor promoting or hindering the use of these services, including health insurance type or its number, income, income level, occupational type, and so on[36,38]. This study explores the relationship between insurance type, monthly income, life satisfaction, social support, and employment status as factors that promote or hinder CHE and intensity during the research period. Specifically, health insurance was divided into five types in this study. Although UEBMI, NRCMI and MIUR have covered almost all citizens, we included a category for other insurance (OI) to account for ENE without the three main categories but with commercial medical insurance and/or other types of health insurance. Simultaneously, we also included a category for ENE without any medical insurance (NI). In addition, the monthly income classification standard was classified according to the official standard and statistical results of the Chinese National Bureau of Statistics in 2018[39]. Life satisfaction and social support (namely whether home or community elderly care services are enjoyed) were the results of self-evaluation based on the survey questionnaire.

NF is a physiological and psychological factor that is related to the presence and level of an individual's disease and indicates that an individual possesses the potential possibility of CHE occurrence[36]. Many studies[14,20,32,40] have shown that individual health status directly affects the occurrence of CHE. In this study, chronic disease counts, disability status and health condition (self-reported) were classified as to investigate the factors that directly affect CHE of ENE.

Statistical Analysis

STATA 16.0 (SPSS Inc., Chicago, IL, USA) were used to perform all data analyses and the normality of data were checked firstly. The independent *t*-test and one-way analysis of variance (ANOVA) were conducted to explore the differences in CHE incidence according to the demographic characteristics under the application of AM. With regard to the significant contributors, owing to the outcome variable were whether catastrophic health expenditure occurs and its intensity, Logit model and Tobit model were built for the exploration of them respectively, as below:

- Where x_i was the set of independent variables; β and γ were the parameter vector corresponding to the independent variables; ε_i and μ_i were the residual item; $Intensity_i$ was CHE intensity and CHE_i was the unobservable variable (latent variable). When $CHE_i > 0$, it was recorded as 1; otherwise, it was recorded as 0.
  Given x_i,β,ε_i, Logit model was set as followed:
- Where $F(\bullet)$ is the cumulative distribution function of ε_i. Assuming it obeys the logistic distribution, it is the logit model:
- Given x_i,γ,μ_i, Tobit model was set as followed:
- Where $Intensity_i^*$ was the latent variable, and when it was less than or equal to 0, the explained variable $Intensity_i$ would become 0, when it was larger than 0, the explained variable would be equal to $Intensity_i^*$ itself, as shown in formula (8). Perturbation term μ_i followed the mean value of 0 and the variance of σ^2 normal distribution.

According to previous studies[41-43], the incidence or intensity of CHE and its influencing factors among the elderly in rural and urban China are quite different. Consequently, classification based on the living areas of ENE (rural/urban/total) was initially performed to explore the associations between each independent variable and CHE occurrence risk (odds ratio, OR) or CHE intensity, and then the optimal multivariable model was chosen based on stepwise selection of all PF, EF, and NF in AM (the one with the highest value of Pseudo R^2 was regarded as the best). When the *p*-value was less than 0.05, it was considered significant.

Results

Selection of Participants

A total of 19,816 records were identified from the 2018 CHARLS database in this study. The eligibility criteria included the following: (i) All participants included in the CHARLS 2018 database. (ii) Participants who were younger than 60 years old were excluded. (iii) Observations whose variable ENE was missing were excluded. (iv) Observation whose other key variable for analysis was incomplete or missing was excluded. After selection, 7,602 ENE and 3,363 non-ENE were included for analysis. See Figure 1 for the detailed process.

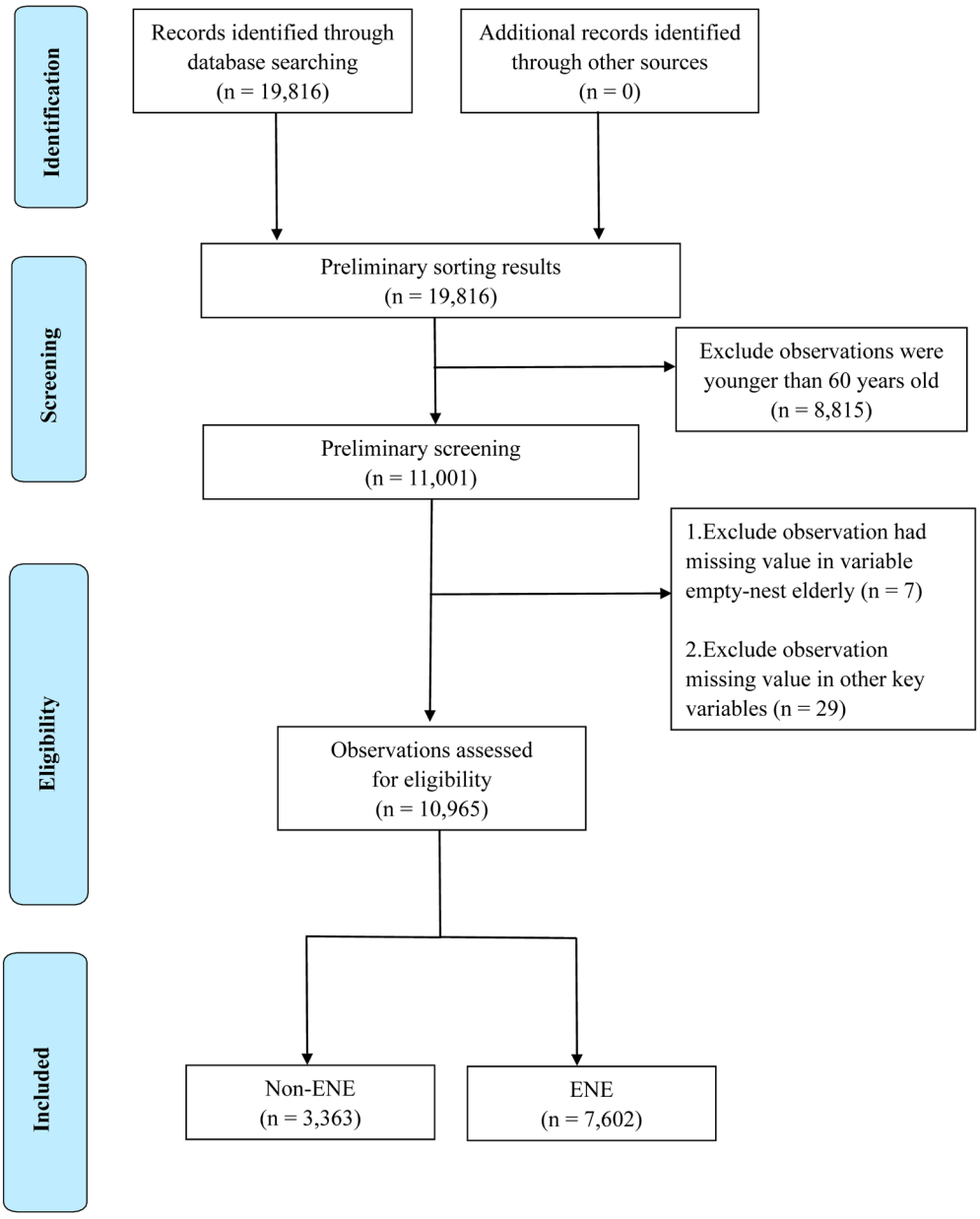

Figure 1. Procedure for participants selection.

Descriptive Statistics and Incidence of Catastrophic Health Expenditure

The descriptive statistics of the included ENE are presented in Table I. Among PF, female (53.17%), age between 60 and 69 years (54.39%), no schooling (54.47%) and currently married possessed the maximum number compared with other classification criteria in the same variable. More than half the number of ENE (58.25%) were in rural areas. Of these participants, 31.11%, 31.36% and 37.53% lived in the western, central, and eastern zones, respectively. With regard to EF, 2.93% of ENE had no insurance, with UEBMI, MIUR and NRCMI accounting for 15.13%, 4.26% and 62.52% of those respondents, respectively. In addition, at least 30% of ENE were unemployed, and over half (51.51%) of ENE had a monthly income lower than 2,000 CNY (namely, only approximately 276.4$). Similarly, only 35.15% of the respondents reported that they were satisfied with their current living, while the majority (79.18%) received no social support. Regarding their health status and NF, almost half of these respondents (48.71%) suffered from one or more chronic diseases, and less than 30% of them reported having a good health condition. More seriously, 36.61% of these ENE were in a state of disability (Table I).

Table I also summarizes the incidence of CHE for the study period. The overall incidence of CHE of ENE was 21.20% based on our study. The different groups of the variables of gender, education, residence areas, monthly income, life satisfaction, employment status, disease counts, disability and self-reported health condition presented a significant difference for CHE incidence. Meanwhile, the CHE incidence of female ENE (22.09%), ENE whose age was equal to or over 70 years old (24.67%, 24.32% for the age group 70-79, 80~, respectively), no schooling ENE (23.09%), ENE not married (21.28%), rural ENE (23.98%) and ENE who lived in eastern (21.28%) and central regions (22.19%) were all higher than the overall level (21.20%). Similarly, ENE whose insurance type was NRCMI (24.01%), monthly income was lower than 276.4$ (26.3%), life satisfaction was dissatisfied (27.32%), and those receiving no social support and being in a jobless state (22.63%) possessed a higher CHE incidence. Last but not least, ENE who reported a poor health condition (31.35%), had a disability (24.65%) or suffered from one or more chronic diseases tended to have a higher CHE incidence compared with the overall level.

Determinants of CHE According to Living Areas of ENE

Table II summarizes the CHE risk and intensity among different potential contributors based on the living areas (rural/urban) of ENE for the study period. From the overall perspective, age, monthly income, life satisfaction, disease counts, and health condition were all significantly associated with CHE incidence and intensity. Among them, the probability of CHE among ENE whose self-reported health condition was poor increased the most significantly, with 103.12% (OR=2.0312, SE=0.164), and its intensity increased 0.0311 (SE=0.005). The second was ENE suffering from 3 or more chronic diseases simultaneously, with 78.86% (OR=1.7886, SE=0.186), and its intensity increased 0.0234 (SE=0.007), and ENE who was dissatisfied with their current living, with 44.13% (OR=1.4413, SE=0.121). In contrast, the largest drop in the probability of CHE among ENE was those whose monthly income was over 20,000 CNY, with 53.76% (OR=0.4624, SE=0.044), and its intensity declined 0.0399 (SE=0.005), and the other was ENE, whose monthly income was between 2,000 and 20,000 CNY, with a drop of 22.09% (OR=0.7791, SE=0.061) and intensity declined 0.021 (SE=0.005). The probability of CHE among ENE who were married or possessed agricultural jobs also decreased significantly by 18.56% and 19.87%, respectively, although it seems that CHE intensity was not associated with these two factors. Interestingly, the risk of CHE increased among ENE who possessed NRCMI, although the intensity did not present a significant difference (Table II).

With regard to different residence areas, the older ENE, or those who reported a poor health condition and the chronic disease counts was equal to or over than three always possessed a higher risk or intensity of CHE no matter in rural or urban households. However, it seems that when the age of ENE was larger than 80, rural ones would face a higher probability and intensity of CHE than the urban (51.32% *vs.* 32.83%, 0.0314 *vs.* 0.0175), similarly for the ENE whose health condition was poor (107.8% *vs.* 79.69%, 0.0372 *vs.* 0.0175). Similarly, rural ENE tended to be more sensitive about the dissatisfied living status and this population faced a higher risk of CHE than the urban ones (52.97% *vs.* 28.17%). On the contrary, the higher monthly income status could decrease the probability and intensity of CHE significantly both in rural and urban areas.

Table I. Empty-nest elderly descriptive statistics and their catastrophic health expenditure incidence according to the Anderson model.

Factors	Variables	Participants (n, %)	Case (n, %)	*t*/F	*p*-value
PF	**Gender**				
	Female	4,042 (53.17%)	893 (22.09%)	2.019	0.044
	Male	3,560 (46.83%)	719 (20.2%)		
	Age				
	60-69	4,135 (54.39%)	760 (18.38%)	21.80	0.000
	70-79	2,509 (33%)	619 (24.67%)		
	80~	958 (12.6%)	233 (24.32%)		
	Education				
	No schooling	4,141 (54.47%)	956 (23.09%)	4.394	0.000
	Primary school or more	3,461 (45.53%)	656 (18.95%)		
	Marital status				
	Currently married	5,896 (77.56%)	1,249 (21.18%)	0.084	0.933
	Others	1,706 (22.44%)	363 (21.28%)		
	Residence areas				
	Rural	4,428 (58.25%)	1,062 (23.98%)	7.023	0.000
	Urban	3,174 (41.75%)	550 (17.33%)		
	Region				
	East	2,853 (37.53%)	607 (21.28%)	1.52	0.219
	Central	2,384 (31.36%)	529 (22.19%)		
	West	2,365 (31.11%)	476 (20.13%)		
EF	**Insurance type**				
	NI	223 (2.93%)	37 (16.59%)	1.05	0.349
	UEBMI	1,150 (15.13%)	168 (14.61%)		
	MIUR	324 (4.26%)	46 (14.2%)		
	NRCMI	4,753 (62.52%)	1,141 (24.01%)		
	OI	1,314 (17.28%)	247 (18.8%)		
	Monthly Income				
	<2,000 CNY	3,916 (51.51%)	1,030 (26.3%)	78.79	0.000
	2,000-20,000 CNY	1,492 (19.63%)	301 (20.17%)		
	>20,000 CNY	2,194 (28.86%)	281 (12.81%)		
	Life satisfaction				
	Satisfied	2,672 (35.15%)	498 (18.64%)	21.89	0.000
	Medium	3,484 (45.83%)	719 (20.64%)		
	Dissatisfied	1,446 (19.02%)	395 (27.32%)		
	Social support				
	None	6,019 (79.18%)	1,300 (21.6%)	1.69	0.184
	Low support	1,266 (16.65%)	255 (20.14%)		
	High support	317 (4.17%)	57 (17.98%)		
	Employment status				
	Agricultural jobs	2,590 (34.07%)	535 (20.66%)	3.19	0.041
	Non-agricultural jobs	2,033 (26.74%)	403 (19.82%)		
	Jobless	2,979 (39.19%)	674 (22.63%)		
NF	**Disease counts**				
	0	3,899 (51.29%)	703 (18.03%)	23.31	0.000
	1	2,211 (29.08%)	508 (22.98%)		
	2	914 (12.02%)	218 (23.85%)		
	3-	578 (7.6%)	183 (31.66%)		
	Disability				
	Yes	2,783 (36.61%)	686 (24.65%)	5.594	0.000
	No	4,819 (63.39%)	926 (19.22%)		
	Health condition (self-reported)				
	Good	2,157 (28.37%)	363 (16.83%)	95.69	0.000
	Moderate	3,279 (43.13%)	570 (17.38%)		
	Poor	2,166 (28.49%)	679 (31.35%)		
Total	–	7,602 (100%)	1,612 (21.20%)	–	–

UEBMI, the Urban Employee Basic Medical Insurance; MIUR, Medical Insurance for Urban Residents; NRCMI, the New Rural Cooperative Medical Insurance; OI, other insurance; NI, no medical insurance, the same below.

Table II. Determinants of the prevalence and intensity of catastrophic health expenditure among empty-nest elderly based on the living areas.

		Rural household		Urban household		Total	
		CHE	Intensity	CHE	Intensity	CHE	Intensity
	PF						
Age	60-69 (Ref)	1.00	0	1.00	0	1.00	0
	70-79	1.3686*** (0.113)	0.0144*** (0.005)	1.4876*** (0.163)	0.0177*** (0.005)	1.4124*** (0.092)	0.0162*** (0.004)
	>80	1.5132*** (0.193)	0.0314*** (0.009)	1.3583* (0.220)	0.0175** (0.008)	1.4588*** (0.145)	0.0259*** (0.006)
Gender	Female (Ref)	1.00	0	1.00	0	1.00	0
	Male	0.9676 (0.079)	-0.0046 (0.005)	1.060 (0.114)	-0.0001 (0.005)	1.0134 (0.065)	-0.0018 (0.004)
Education	No schooling (Ref)	1.00	0	1.00	0	1.00	0
	Primary school or more	1.0817 (0.091)	0.0045 (0.005)	0.861 (0.096)	-0.0050 (0.005)	0.9903 (0.066)	-0.0001 (0.004)
Marital status	Unmarried (Ref)	1.00	0	1.00	0	1.00	0
	Married	0.7057*** (0.069)	-0.0069 (0.006)	1.031 (0.127)	0.0011 (0.006)	0.8144*** (0.062)	-0.0034 (0.004)
	EF						
Insurance type	NI (Ref)	1.00	0	1.00	0	1.00	0
	UEBMI	2.0473*** (0.564)	0.0299* (0.017)	0.768 (0.197)	-0.0146 (0.011)	1.1412 (0.193)	0.0009 (0.009)
	MIUR	0.5775 (0.375)	-0.0161 (0.032)	0.6148* (0.174)	-0.0256** (0.013)	0.8361 (0.1763)	-0.0153 (0.011)
	NRCMI	1.6327*** (0.282)	0.0123 (0.011)	0.850 (0.203)	-0.0125 (0.011)	1.3081** (0.178)	0.0030 (0.008)
	OI	1.3769* (0.246)	0.0142 (0.011)	0.773 (0.183)	-0.0178* (0.011)	1.0989 (0.153)	-0.0002 (0.008)
Monthly Income	< 2,000 CNY (Ref)	1.00	0	1.00	0	1.00	0
	2,000-20,000 CNY	0.7922** (0.078)	-0.0176*** (0.006)	0.7969* (0.105)	-0.0206*** (0.006)	0.7791*** (0.061)	-0.0210*** (0.005)
	>20,000 CNY	0.4516*** (0.060)	-0.0426*** (0.007)	0.4798*** (0.068)	-0.0337*** (0.006)	0.4624*** (0.044)	-0.0399*** (0.005)
Life satisfaction	Satisfied (Ref)	1.00	0	1.00	0	1.00	0
	Medium	1.0632 (0.091)	-0.0021 (0.005)	1.172 (0.132)	0.0029 (0.005)	1.1101 (0.075)	0.0003 (0.004)
	Dissatisfied	1.5297*** (0.159)	0.0219*** (0.007)	1.2817* (0.184)	0.0104 (0.007)	1.4413*** (0.121)	0.0178*** (0.005)
Social support	None (Ref)	1.00	0	1.00	0	1.00	0
	Low support	1.0520 (0.105)	-0.0019 (0.007)	0.7551** (0.101)	-0.0148*** (0.006)	0.9204 (0.073)	-0.0081* (0.005)
	High support	0.8404 (0.179)	-0.0131 (0.013)	0.804 (0.184)	-0.0064 (0.010)	0.8072 (0.125)	-0.0107 (0.008)
Employment status	Jobless (Ref)	1.00	0	1.00	0	1.00	0
	Agricultural jobs	0.8096** (0.077)	-0.0065 (0.006)	0.6471*** (0.095)	-0.0117* (0.007)	0.8013*** (0.061)	-0.0046 (0.004)
	Non-agricultural jobs	0.8779 (0.091)	0.0015 (0.007)	0.909 (0.117)	0.0044 (0.006)	0.9077 (0.072)	0.0051 (0.005)

Continued

But its reducing effect became more striking among rural ENE whose income were higher than 20,000 CNY (namely about 2,757.44$) than the urban ones (54.84% *vs.* 52.02%, 0.0426 *vs.* 0.0337). It is noteworthy that when ENE possessed the agricultural jobs in urban areas, their CHE risk and in-

Table II *(continued)*. Determinants of the prevalence and intensity of catastrophic health expenditure among empty-nest elderly based on the living areas.

		Rural household		Urban household		Total	
		CHE	Intensity	CHE	Intensity	CHE	Intensity
Disease counts	**NF**						
	0 (Ref)	1.00	0	1.00	0	1.00	0
	1	1.3255*** (0.112)	0.0138** (0.006)	1.047 (0.121)	0.0030 (0.005)	1.2088*** (0.082)	0.0089** (0.004)
	2	1.2132* (0.142)	0.0107 (0.008)	1.159 (0.174)	-0.0058 (0.007)	1.1900* (0.109)	0.0029 (0.005)
	3-	1.7259*** (0.233)	0.0222** (0.010)	1.8455*** (0.302)	0.0242*** (0.008)	1.7886*** (0.186)	0.0234*** (0.007)
Disability	Yes (Ref)	1.00	0	1.00	0	1.00	0
	No	1.0188 (0.078)	0.0009 (0.005)	0.8910 (0.093)	0.0004 (0.005)	0.9727 (0.060)	0.0004 (0.004)
Health condition	Good (Ref)	1.00	0	1.00	0	1.00	0
	Moderate	1.1835 (0.123)	0.0057 (0.006)	1.0960 (0.142)	-0.0009 (0.005)	1.1656* (0.094)	0.0032 (0.004)
	Poor	2.0780*** (0.210)	0.0372*** (0.007)	1.7969*** (0.244)	0.0175*** (0.006)	2.0312*** (0.164)	0.0311*** (0.005)
	Observations	4,428	4,428	3,174	3,174	7,602	7,602
	Constant	0.1283*** (0.028)	0.0378*** (0.014)	0.2740*** (0.080)	0.0674*** (0.013)	0.1622*** (0.028)	0.0484*** (0.010)
	LR Chi^2	255.92	162.84	162.34	124.31	428.26	306.98
	Prob	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Pseudo R^2	0.0525	-0.0445	0.0555	-0.0293	0.0545	-0.0403

Standard errors in parentheses, ***p<0.01, **p<0.05, *p<0.1; Ref, reference group.

tensity became lower than the rural ones (35.29% *vs.* 19.04%, -0.0117 *vs.* -0.0065). In addition, the rural ENE who possessed health insurance of UEBMI, NRCMI, or any insurance, and those whose chronic diseases counts were one or two were significantly associated with CHE while the urban ones were not.

Determinants of CHE Based on Anderson Model

Table III presents the results of the logistic regression analysis of the cross-sectional data of ENE from the 2018 CHARLS wave based on the Anderson Model, indicating the determinants of the prevalence of CHE. Three types of models passed the significance test, and the degree of fit was the strongest when all three kinds of factors were added, which was consistent with the interpretation of AM[36]. In PF, age, marital status, and living area were all significantly associated with CHE occurrence among ENE in Model III, while in Model I, educational level also had a potential effect. In EF, both monthly income and life satisfaction were significant contributors to CHE among ENE in Model III, although employment status was also significantly associated in Model II. For NF, chronic disease counts and self-reported health conditions were significant contributors to CHE. Overall, married status, living in urban areas, higher monthly income, higher life satisfaction and good self-reported health conditions were all protective factors of CHE, and good health conditions (OR=0.6909), higher monthly income (OR=0.6996) and married status (OR=0.8229) were the most significant ones among them. Conversely, higher age (OR=1.2826) and more disease counts (OR=1.1877) were significant risk factors for CHE in ENE (Table III).

Table IV presents the results of the Tobit regression analysis according to the Anderson Model, indicating the determinants of the intensity of CHE among ENE. Similarly, all models were significant, and the degree of fit in Model III was the best. Compared with the significant contributors in the logit model, only marital status in PF was not associated with CHE intensity. Among all protective factors of CHE intensity, good health conditions (-0.0141) and higher monthly income (-0.0181) were still the most significant. Among the risk factors, higher age (0.0149) and more disease counts (0.0068) were the most significant (Table IV).

Table III. Determinants of the prevalence of catastrophic health expenditure using logistic regression according to the Anderson model.

		Model I			Model II			Model III		
Factors	**Variables**	**OR**	**SE**	***p***	**OR**	**SE**	***p***	**OR**	**SE**	***p***
PF	Age	1.2998	0.054	0.000	1.2362	0.055	0.000	1.2826	0.057	0.000
	Male	0.8929	0.055	0.066	0.9739	0.062	0.676	1.0003	0.064	0.996
	Education	0.8810	0.055	0.043	1.0070	0.065	0.914	0.9948	0.065	0.936
	Married	0.8185	0.061	0.007	0.8259	0.062	0.011	0.8229	0.062	0.010
	Urban	0.6752	0.041	0.000	0.8214	0.054	0.003	0.8399	0.055	0.008
EF	Insurance				0.8863	0.191	0.575	0.7981	0.174	0.301
	Monthly income				0.6781	0.026	0.000	0.6996	0.028	0.000
	Life satisfaction				0.8114	0.032	0.000	0.8178	0.033	0.000
	Social support				0.9371	0.053	0.255	0.9180	0.053	0.138
	Employment status				0.9247	0.037	0.047	0.9461	0.038	0.163
NF	Disease counts							1.1877	0.036	0.000
	Disability							1.0513	0.064	0.411
	Health condition							0.6909	0.027	0.000
Constant	–	0.2392	0.019	0.000	0.8002	0.207	0.389	1.3198	0.366	0.317
LR chi²	–		99.80			240.09			390.19	
Prob	–		0.000			0.000			0.000	
Pseudo R²	–		0.013			0.031			0.050	

SE, Standard errors.

Table IV. Determinants of the intensity of catastrophic health expenditure using *Tobit* regression according to the Anderson model.

		Model I			Model II			Model III		
Factors	**Variables**	**OR**	**SE**	***p***	**OR**	**SE**	***p***	**OR**	**SE**	***p***
PF	Age	0.0154	0.003	0.000	0.0140	0.003	0.000	0.0149	0.003	0.000
	Male	-0.0073	0.004	0.043	-0.0038	0.004	0.303	-0.0027	0.004	0.460
	Education	-0.0070	0.004	0.056	0.0005	0.004	0.897	-0.0001	0.004	0.987
	Married	-0.0039	0.004	0.365	-0.0026	0.004	0.556	-0.0027	0.004	0.533
	Urban	-0.0253	0.004	0.000	-0.0134	0.004	0.000	-0.0125	0.004	0.001
EF	Insurance				-0.0138	0.012	0.228	-0.0172	0.011	0.131
	Monthly income				-0.0196	0.002	0.000	-0.0181	0.002	0.000
	Life satisfaction				-0.0094	0.002	0.000	-0.0087	0.002	0.000
	Social support				-0.0056	0.003	0.082	-0.0063	0.003	0.051
	Employment status				-0.0001	0.002	0.976	0.0010	0.002	0.662
NF	Disease counts							0.0068	0.002	0.000
	Disability							0.0010	0.004	0.790
	Health condition							-0.0141	0.002	0.000
Constant	–	0.0515	0.005	0.000	0.1138	0.014	0.000	0.1332	0.015	0.000
LR Chi²	–		111.90			217.76			282.70	
Prob	–		0.000			0.000			0.000	
Pseudo R²	–		-0.015			-0.029			-0.037	

SE, Standard errors.

Discussion

To the best of our knowledge, this is the first study to estimate the CHE incidence and intensity of Chinese ENE according to different factors of AM, and the study also clarifies the determining factors. According to our findings, the incidence of CHE was as high as 21.2%, indicating that on average, more than one in every five ENE had CHE. Among non-ENE in China, this percentage could drop to 12.95%[18]. Concurrently, the high incidence of this unique but enormous population in China was nearly two to four times that of the elderly in other countries, particularly those with high incomes. Brinda et al[44] examined 2,414 individuals aged 65 and older from a nationally representative, multistage data sample and discovered that the prevalence of CHE among the elderly in India was only 7% (95% CI: 6%-8%). Even with a lower evaluation standard (compared to the threshold of 40% in our study), namely 10% and 25% of the household income, the prevalence of CHE among 8,347 Brazilians aged 50 or older was only 17.9% and 7.5%, respectively[45]. Surprisingly, the percentage of adults 65 and older with CHE was only 5.8% in the United States and 3.0% in South Korea, despite the threshold of 25%[46].

In light of the overall high prevalence of CHE among Chinese ENE, its causes or significant contributors merit investigation. The results of our study indicated that poorer health status and lower life satisfaction may represent a significant difference, whether compared to other older adults in the United States or internationally[18,47]. Almost 30% of ENE in China reported poor health status compared with only 19.7% among non-ENE[47], which was also the factor leading to the greatest increase in CHE probability at 103.12%. Although less than 10% of ENE suffered from three or more kinds of chronic diseases, it was still the second leading factor causing CHE, with 78.86%. A recent study[19] of 51,661 elderly patients with chronic diseases in 15 European countries revealed that, even in these relatively wealthy developed countries with disease risk-sharing mechanisms, the risk of CHE for the elderly with chronic diseases was still significantly higher than that of other populations, varying by disease type. Brinda et al[44] also found that old Indian individuals with chronic diseases were at higher risk of CHE (OR: 1.4-1.8, varying based on the type), although its overall risk seemed still lower than ENE in China. One of the additional leading factors was life satisfaction, which was associated with a 44.13 percent increase in CHE risk. It was more related to psychological factors and mental health conditions. Due to a lack of mental care, social contact, and emotional support, a study[48] of Korean seniors living alone found that the ENE had poor mental health, and their risk of suffering from anxiety, depression, and other problems significantly increased, which could even lead to CHE. Similarly, Hacihasanoğlu et al[49] indicated that the loneliness of ENE was significantly higher than that of non-ENE, and their health level was relatively poor and suffered from a higher risk of CHE through a survey of the mental health status of the elderly in five family health centers in Turkey. Another study in Portugal revealed that elderly individuals living alone and those with chronic diseases are "vulnerable groups" for CHE and that their risk is significantly higher than that of the general population[22].

In contrast, our findings have also uncovered "protective factors" that reduce the risk of CHE. As anticipated, a higher income level significantly reduced the incidence and severity of CHE. If the monthly income was greater than 2,000 CNY, the CHE risk could be substantially reduced. However, based on our findings, less than half of ENE reached this income level. Another similar study, also based on three waves of panel data (2011-2015) from CHARLS, demonstrated that economic conditions played a striking role in CHE, specifically that it had a "pro-poor" effect, meaning that the poorer the households were, the more likely they were to have CHE[50]. Kyriopoulos et al[51] through investigations among middle-aged and elderly individuals in Greek, also pointed out that households of low socioeconomic status were more likely to incur CHE, which revealed substantial inequalities in the risk of CHE. In addition, ENE who were married during the survey period had a lower risk of CHE, suggesting that for ENE who lacked childcare and companionship, finding a suitable partner to live with appeared to be an effective means of preventing CHE. Consistent with another study from China[3], which found that the depression of ENE was significantly more severe than that of non-ENE and that actively seeking a partner was conducive to alleviating this condition and reducing the likelihood of CHE, it was found that actively seeking a partner was conducive to improving this situation and decreasing the likelihood of CHE. In addition, the increased risk of CHE among ENE who possessed NRCMI may have been due to the fact that although this insurance covered a wide range, the actual effect was not so obvious, and the majori-

ty of ENE who owned this insurance were rural, leading to false positive results[52,53]. Notably, even though NRCMI and MIUR were merged in 2020, signifying the establishment of a unified medical insurance system for urban and rural residents, rural ENE should still receive more attention[40]. The Chinese government and policymakers should promote the reform of payment methods to enhance the financing level of medical insurance for urban and rural residents, the financing mechanism, and the efficiency of fund use[54,55]. When exposed to the same risk factors, such as old age or poor health, ENE from rural areas tended to be more susceptible to CHE. In contrast, it appeared that ENE from urban areas had a lower risk of contracting CHE[56]. However, if any potential favorable conditions were present, such as a higher income level, it was the rural ENE that decreased the CHE the most. Even though the gap in medical insurance coverage between urban and rural areas in China has narrowed in recent years, the more vulnerable rural households require a higher level of security, and more social support should be provided for rural households[14,57].

AM's analytic framework illuminated these potential determinants, and specific factors in PF, EF, and NF exerted a substantial influence on CHE and its intensity[58]. Even though the residence area was included as a separate variable in the analysis, the effect of other variables did not change significantly. The model had the greatest explanatory power, however, when all PF, EF, and NF were included simultaneously. NF was the primary determinant of CHE, and some fundamental characteristics of ENE, such as a low general education level, lack of economic resources, lack of daily care and emotional support, and low social participation, indicated that ENE were socially vulnerable groups[59]. Therefore, when formulating national poverty alleviation policies, health policymakers should prioritize basic medical insurance and medical care for these vulnerable groups[3,57,60]. Through redistribution of social security, the gap between the wealthy and the poor should be reduced, and the affordability of medical care for vulnerable groups could be further enhanced[61]. In addition, governments should clarify their responsibilities, increase investment in health education, promote the cooperation and participation of medical institutions, elderly care institutions, schools, communities and other sectors of society through classified guidance, and formulate health publicity and education programs for different groups, such as ENE with multiple diseases[62,63]. Last but not least, basic medical institutions should play the role of health gatekeepers to the fullest, take the initiative to provide family doctors with contracted services, establish health records for elderly individuals, explore the integration of primary care and public health, and promote prevention and health care, diagnosis and treatment of common diseases and common disease conditions[64-67].

Limitations

Several limitations of this study should be clarified. First, recall bias, the mode of data collection, and the structure of the questionnaire may all have an impact on the accuracy of the final results. Second, we did not account for different CHE thresholds, such as 10% or 25%, which are also common evaluation standards[44,46]. Nevertheless, we were certain that the CHE incidence would rise if we adopted these lower thresholds. In this study, only incurred health costs were evaluated; the potential population whose members did not seek treatment because they could not afford it was not included. Taking into account these omissions, the CHE incidence may also be higher. However, the aforementioned limitations do not invalidate this study because, due to the nature of the large samples, it can reduce estimation bias to a certain extent. ENE should still receive more attention in future research.

Conclusions

More attention should be paid for the Chinese empty-nest elders with a high incidence of catastrophic health expenditures. Under the guidance of Andersen's model of health services utilization, the prevalence and intensity of catastrophic health expenditures might be affected by the collective effect of predisposing factors, enabling factors and needing factors. Among them, the poor self-reported health status, suffering from multiple chronic diseases simultaneously, low life satisfaction and advanced age played the leading role in accounting for its high risk, while the higher income level and married status could decrease this hazard significantly. In addition, rural empty-nest elders showed more vulnerability and a higher risk of catastrophic health expenditures, and relevant health insurance or social security measures should be further strengthened. A sound social medical security system should be established, and priority should be undoubtedly given to these vulnerable groups.

Conflict of Interests

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Ethics Approval

The study protocol was approved by the Institutional Review Board at Peking University. The IRB approval number for the main household survey, including anthropometrics, is IRB00001052-11015, and the IRB approval number for biomarker collection is IRB00001052-11014.

Authors' Contributions

Conceptualization, Yuquan Chen; Methodology, Yuquan Chen and Xiaoli Zhu; Material search, Yanwei You, Xiaoli Zhu, Qi Zhang; Data extraction, Yanwei You, Xiaoli Zhu, Qi Zhang and Yuquan Chen; Data analysis, Yuquan Chen and Yanwei You; Writing-original draft preparation, Yuquan Chen; Writing-review and editing, Yuquan Chen, Xiaoli Zhu, Yanwei You, Qi Zhang and Tao Dai; Supervision, Tao Dai; Project administration, Tao Dai; Funding acquisition, Tao Dai. All authors have read and agreed to the published version of the manuscript.

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