

# Trends and Determinants of Catastrophic Health Expenditure in China 2010-2018: A National Panel Data Analysis

**Cai Liu**

Tianjin University of Traditional Chinese Medicine

**Zhao min Liu**

Jining Medical University

**Stephen Nicholas**

Australian National Institute of Management and Commerce

**Jian Wang** (✉ [wangjian993@whu.edu.cn](mailto:wangjian993@whu.edu.cn))

Dong Fureng Institute of Economic and Social Development, Wuhan University, No.54 Dongsu Lishi Hutong, Dongcheng District, Beijing, 100010, China

---

## Research Article

**Keywords:** Catastrophic health expenditures, Household panel data, Medical poverty, China

**Posted Date:** January 4th, 2021

**DOI:** <https://doi.org/10.21203/rs.3.rs-125845/v1>

**License:**   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

# **Trends and Determinants of Catastrophic Health Expenditure in China 2010-2018: A national panel data analysis**

## **Cai Liu**

School of Management, Tianjin University of Traditional Chinese Medicine, Tianjin, 301617, China.

Email: [keidy0707@163.com](mailto:keidy0707@163.com)

## **Zhao-min Liu**

Jining Medical University, 669 Xueyuan Road, Donggang District, Rizhao City, Shandong Province, 276826, China.

Email: [Liu.zhaomin@163.com](mailto:Liu.zhaomin@163.com)

## **Stephen Nicholas**

Australian National Institute of Management and Commerce, 1 Central Avenue Australian Technology Park, Eveleigh Sydney NSW 2015, Australia;

Research Institute for International Strategies, Guangdong University of Foreign Studies, Baiyun Avenue North, Guangzhou, 510420, China;

School of Economics and School of Management, Tianjin Normal University, West Bin Shui Avenue, Tianjin, 300074, China;

Newcastle Business School, University of Newcastle, University Drive, Newcastle, NSW 2308, Australia.

Email: [stephen.nicholas@newcastle.edu.au](mailto:stephen.nicholas@newcastle.edu.au)

## **Jian Wang** (Corresponding author)

Dong Fureng Institute of Economic and Social Development, Wuhan University, No.54 Dongsu Lishi Hutong, Dongcheng District, Beijing, 100010, China;

Center for Health Economics and Management at School of Economics and Management, Wuhan University, 299 Bayi Road, Wuchang District, Wuhan, Hubei Province, 430072, China.

Email: [wangjian993@whu.edu.cn](mailto:wangjian993@whu.edu.cn)

Telephone: +86-010-63342936

## **Abstract:**

**Background:** Catastrophic health expenditures (CHE) push households into poverty in China. We analyze the trends in incidence and intensity, and explore the determinants of CHE, and propose policy recommendation to address CHE.

**Methods:** A unique 5-year national urban-rural panel database was constructed from China Family Panel Studies (CFPS) surveys. CHE incidence was measured by calculating headcount (percentage of households incurring CHE to the total household sample) and intensity was measured by overshoot (degree by which an average out of pocket health expenditure exceeds the threshold of the total sample). A linear probability model was employed to assess the trend in net effect of the determinants of CHE incidence and a random effect logit model was used to analyse the role of the characteristics of the household head, the household and household health utilization on CHE incidence.

**Results:** CHE determinants vary across time and geographical location. From 2010 to 2018, the total, urban and rural CHE incidence all showed a decreasing tendency, falling from 14.7% to 8.7% for total households, 12.5% to 6.6% in urban and 16.8% to 10.9% in rural areas. CHE intensity decreased in rural (24.50% to 20.51%) and urban (22.31% to 19.57%) areas and for all households (23.61% to 20.15%). Inpatient services were the most important determinant of the incidence of CHE. For urban households, the random effect logit model identified household head (age, education, self-rated health); household characteristics (members 65+ years, chronic diseases, family size and income status); and healthcare utilization (inpatient and outpatient usage) as determinants of CHE. For rural areas, the same variables were significant with the addition of household head's sex and health insurance.

**Conclusion:** The incidence and intensity of CHE in China displayed a downward trend, but was higher in rural than urban areas. Costs of inpatient service usage should be a key point on intervention strategies to address CHE. The policy implications include improving the economic level of poor households, reforming health insurance and reinforcing pre-payment hospital insurance methods.

**Keywords:** Catastrophic health expenditures, Household panel data, Medical poverty, China

## **1. Introduction**

Illness-caused poverty and poverty-caused illness challenge the well-being of whole societies. In China, medical costs, especially catastrophic health expenditures, can plunge families into long-term debt and medical poverty [1]. Catastrophic health expenditures (CHE) are out-of-pocket payments (OOP) for medical expenses, not covered by health insurance,  $\geq 40\%$  of total household expenditure minus food spending [1,2,3,4]. Like many other developing countries, the incidence of CHE in China reflects the limited health insurance coverage of OOP expenses [4]. In order to lower CHE and OOP expenses, China launched a series of healthcare reforms in 2009, including new national health insurance schemes. Currently, China's national basic medical insurance covers more than 1.35 billion people, with the insured rate reaching 95% of the population [5].

The determinants of CHE have been a topic of continued research interests in China [6] and other countries [7,8]. Empirical studies of the determinants of CHE broadly identify four main causes: first, characteristics of the household head,

including sex, age, education, marital status and self-rated health; second, features of the household [9], such as region, economic status and family size; third, attributes of the family members [10,11] including the number of old or young family members, family members with a doctor-diagnosed chronic and special diseases, such as cancer [12], diabetes [13] cardiovascular diseases [14] and hypertension [15]; and fourth, health care service utilization and policy related variables, including inpatient and outpatient hospital care services [6,7], access to health consultation services [16,17], the characteristics of the hospital [6,18], access to health services [6] including health insurance [4,14,19-22] and medical assistance and poverty alleviation policies [6,15].

These CHE determinants vary across time and geographical location. The time lag between the implementation of health policy and its outcomes requires panel, or longitudinal data [23]. Most CHE China studies utilized cross-sectional survey data [19-22] or limited 2 or 3 year longitudinal comparison studies [16]. Only two Chinese studies used panel data from the China Family Panel Studies (CFPS) to analyse the trends of CHE incidence and intensity in China [14,24]. Zhao et al focused on trends and socioeconomic disparities in CHE and health impoverishment in China using 4-year panel data (2010, 2012, 2014 and 2016) from the urban and rural perspective, but only applied the 2016 data, and not the panel model, to explore the determinants affecting CHE incidence [24]. Zhao et al reported that the proportion of households experiencing CHE decreased from 19.37% in 2010 to 15.11% in 2016 and the logistic regression model showed that chronic diseases, economic status, household size, residence location, age and education of the household head exert an influence on CHE. A study by Sun [14] applied a random effect model to 3 years (2012, 2014 and 2016) panel data to reveal the CHE trends from the perspective of different basic medical insurance schemes. Sun found that total CHE incidence and intensity exhibited overall rising trends from 2012 to 2016 and the random effect model showed that households covered by basic health insurance schemes did not decrease the odds of CHE occurrence.

We address these contradictory CHE outcomes. Only by assessing the changes across time, location, socioeconomic household characteristics and household health utilization can the trends of CHE, and their determinants, be analysed and health policy evaluated. First, we construct a unique CHE 5-year nationally representative panel database using CFPS to assess the trend in the incidence and intensity of CHE. Second, employing a linear probability and random effect model, we analyze the role of the characteristics of the household head, the household and household health utilization as determinants of CHE. Finally, the study offers new policy recommendations for the reduction the incidence of CHE in China, with implications for other developing countries.

## **2. Materials and Method**

### **2.1 Data**

From five waves of the 2010-2018 China Family Panel Studies, we constructed a nationally representative longitudinal database on the health and socio-economic

status of households and individuals aged 16 and above across 25 provinces in China. Using a multistage probability sampling approach with implicit stratification, the 2010 CFPS baseline survey yielded a representative national sample at county level, village level, and household level [25]. In order to analyze the trends, incidence, and determinants of CHE, we built an unbalanced panel database by matching the household ID in the current CFPS survey with the same household in the previous CFPS survey. After managing missing and abnormal values, we obtained a sample consisting of 11700 households in 2010, 9290 in 2012, 11309 in 2014, 13092 in 2016 and 11520 in 2018. We constructed the panel structure by tracking 7386 or 63.12% of the 2010 households in the 2012 sample, which provided data on the trends in the same household's circumstances during the preceding two-year period. In the third wave survey in 2014, 64.67% (7313/11309) households from 2012 were tracked; in the fourth wave survey in 2016, 72.62% (9507/13092) households were tracked from 2014 survey and in the fifth wave survey in 2018, 82.14% (9462/11520) of the 2016 households were tracked. The surveys of CFPS were approved by the Ethical Committee of Peking University and informed consent was obtained from all individual participants.

## 2.2 Variables

### 2.2.1 Measurement of CHE, CHE incidence and intensity

When a household's out-of-pocket health payments, including outpatient and inpatient services, preventative care, maternal and child health services and medication expenses, exceed 40 percent of its capacity to pay for non-food expenditure, the household faces CHE. CHE was coded 1 when OOP health expenditures as a proportion of household income, or capacity to pay (CTP), was equal or exceeds 0.4 and 0 otherwise. CHE incidence was measured by headcount, which refers to the percentage of households incurring CHE to the total household sample:

$$Headcount = \frac{1}{N} \sum_{i=1}^N CHE_i \quad (1)$$

where N represents the sample size,  $CHE_i$  is 1 when the  $i$ th household incurred CHE, and 0 otherwise.

CHE intensity was measured by overshoot which is the degree by which an average OOP health expenditure exceeds the threshold of the total sample [6]:

$$Overshoot = \frac{1}{N} \sum_{i=1}^N CHE_i \left( \frac{OOP_i}{CTP_i} - z \right) \quad (2)$$

where N is the sample size,  $OOP_i$  and  $CTP_i$  refer to OOP health expenditure and capacity to pay of the  $i$ th household and z is the threshold value, which is 40%.

### 2.2.2 Independent variables

Based on the previous studies, three categories of factors influence the household's risk of CHE was collected. First, demographic characteristics of the household head, including sex, age (16-34 years, 35-54 years, 55-64 years and 65+ years), marital status (unmarried, married and divorced or widow), education (illiteracy and elementary, middle school, high school and college and above) and self-rated health (poor, medium and good). Second, household characteristics comprising whether there were household members aged 65 years and older; household members had a doctor-diagnosed chronic disease(s) in the past 6 months; family size (1-3, 4-5 and  $\geq 6$  members); and household economic status, measured by the quartile of annual per capita household income. The last category of factors refers to the healthcare utilization of the household, consisting of whether any family member used inpatient service in the past year; outpatient usage measured by whether any household member had used outpatient services in the past two weeks; and the type of health insurance, comprising the new rural cooperative medical scheme (NRCMS), urban employee basic medical insurance (UEBMI), urban resident basic medical insurance (URBMI), supplementary medical insurance (SMI) and no health insurance. SMI referred to all kinds of relatively high profit packages of the insurance programme, for instance, free medical service scheme for special sectors, commercial health insurance and enterprise supplementary medical insurance.

### 2.3 Linear Probability Model

We are interested not only in the trend in the urban-rural CHE incidence, but also the reasons and the size of their effect on the trend pattern. First, we regressed the CHE incidence by urban-rural location in each year and compared the coefficients to estimate the net effect of each determinant. There are several biases when applying the coefficient from binary logit models to compare the net effect of independent variables, which could cause model misspecification and estimation errors [26]. Linear probability modelling (LPM) is a robust method to compare the coefficients in a binary outcome regression for the same model, but different samples [27-30]. To estimate the net effects of the determinants to CHE incidence by urban-rural location from 2010 to 2018, we applied LPM to conduct regressions for the sub-sample by region in each year and compare the absolute value of coefficient in the models.

### 2.4 Random effect model

Given the dependent variable, CHE incidence, is a dummy variable, the binary logit model was used to estimate the determinants of CHE. Improving on the use of cross-sectional data, we built a panel dataset to better explore the determinants for the occurrence of CHE. Since there were several unchanged variables for all or most respondents, such as sex, marriage, education, a random effect panel logit model was employed to analyze the determinants of CHE based on the CFPS 2010-2018 panel data by urban-rural location:

$$\text{Log}(P_{it}) = \ln\left(\frac{p_{it}}{1-p_{it}}\right) = \beta_0 + \beta_1 * \text{Householdhead}_{it} + \beta_2 * \text{Household}_{it} + \beta_3 * \text{Healthservice}_{it} + e_{it} \quad (3)$$

where  $P_{it}$  is the likelihood of CHE occurrence for  $i$ th household in the urban-rural location in the year  $t$  ( $t=2010, 2012, 2014, 2016, 2018$ ), and  $P_{it}/(1-P_{it})$  is the odds ratio (OR) of CHE occurrence.

### **3.Results**

#### **3.1 Description of rural, urban and total households**

Supplementary Table 1 displays the basic characteristics of urban, rural and total sample households by year. In 2010 and 2012 males accounted for more than 70% of the household heads, falling to broadly male-female equity from 2014 to 2018. For rural households, although the percentage of male household heads was larger than female, the disparity became smaller. For urban households, female heads exceeded males, except for 2010, for the whole sample period. Averaging roughly 50%, the 35-54 years age group was always the largest age group. More than 80% of household heads were married. Household head's education level were relatively low. From 2012 to 2018, more than 60% household heads perceived their health as good and broadly the same for urban and rural households.

Looking at household characteristics, about 30% of households had family member(s) aged  $\geq 65$  years old, which confirms that the population aging problem was more serious in rural areas. Similarly, around 30% of households contained members with doctor-diagnosed chronic disease(s), roughly equal in urban and rural areas. About 50% of households had 1-3 members and 15% of households had 6 or more family members, but 60% of urban households had 1-3 family members, while 20% of rural households had 6 or more members. The economic status of households was improving, but urban households were economically better off than rural households.

Finally, for the health service utilization, inpatient service usage gradually increased from 16.7% in 2010 to 25.3% in 2018, rising from 15.9% in 2010 to 23.6% in 2018 for urban households and from 17.4% in 2010 to 27.6% in 2018 for rural households. Outpatient service also rose from 34.3% in 2010 to 60% in 2016, before falling to 41.9% in 2018. In urban households, outpatient services rose from 29.8% in 2010 to 36.8% in 2018 and from 38.3% in 2010 to 47.2% in 2018 in rural households. Between 55%-65% of households were covered by NRCMS, which covered rural residents; urban households covered by UEBMI gradually rose over 2010-2018; and the coverage rate of SMI and no health insurance fell.

#### **3.2 CHE incidence and intensity 2010-2018**

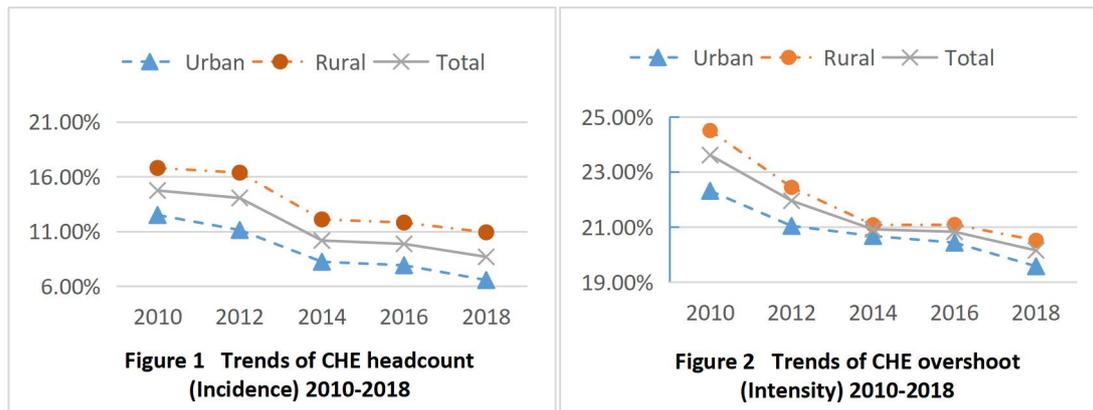


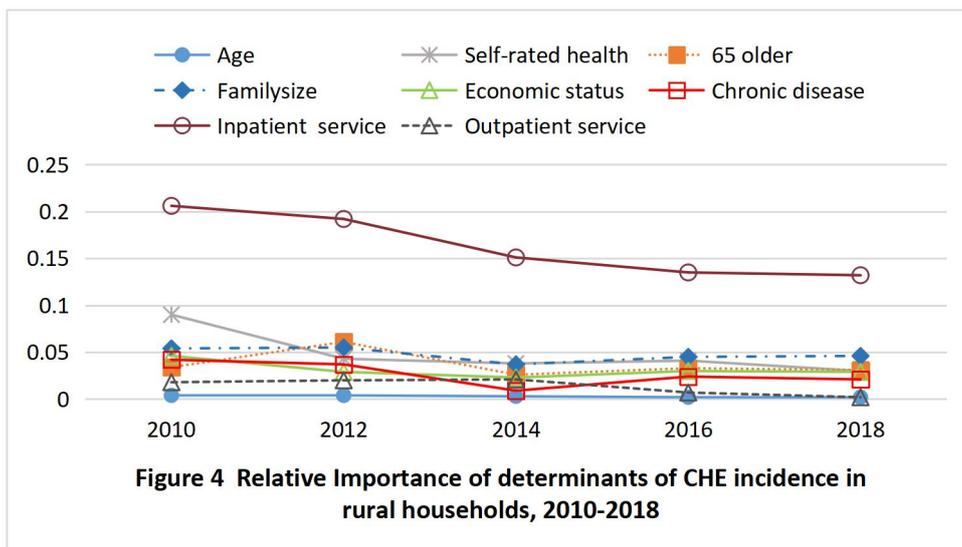
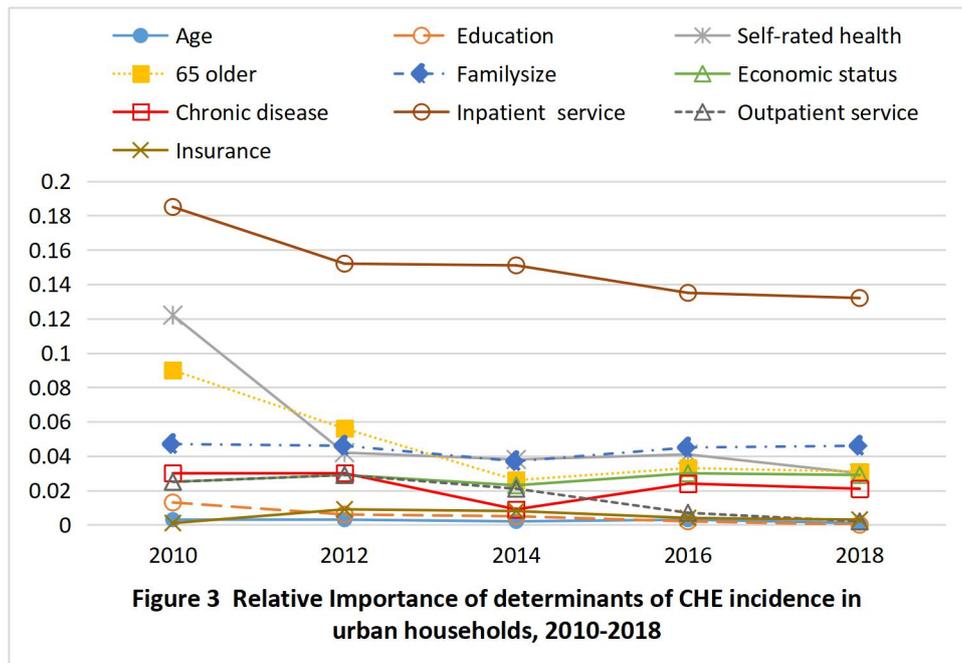
Figure 1 displays the trends of CHE incidence measured by the headcount of households from 2010 to 2018. Total, urban and rural CHE incidence all showed a decreasing tendency, falling from 14.7% in 2010 to 8.7% in 2018 for total households, 12.5% in 2010 to 6.6% in 2018 for urban households and 16.8% in 2010 to 10.9% in 2018 for rural households. The decreasing amplitude for the 2012 to 2014 years was relatively larger than for other years.

Figure 2 shows the trends of CHE overshoot, or intensity. Overall, CHE intensity decreased in rural (24.5% to 20.5%) and urban (22.3% to 19.6%) areas and for all households (23.6% to 20.2%), with the most rapid decline from 2010 to 2014.

### 3.3 Determinants of CHE incidence and intensity

Supplementary Table 2 and supplementary Table 3 analyse the determinants of CHE incidence in urban and rural households in each year. The linear probability model in Supplement Table 2 shows household head's characteristics (age, education level, self-rated health), household characteristics (member(s) 65+ years old, family size, economic status, doctor-diagnosed chronic diseases) and healthcare utilization (use of inpatient services in the past year and outpatient service use in the last two weeks and health insurance) were significant determinants of urban household CHE incidence. For rural households in Supplementary Table 3, the same variables were significant, except education and health insurance.

For variables significant for at least two of the year periods, Figure 3 and Figure 4 show the trends in the relative importance of the determinants of urban and rural CHE incidence. For both rural and urban households, inpatient services were the most important determinant of the incidence of CHE, while household head's age was the weakest determinant. Most determinants displayed a downward trend from 2010 to 2018, including inpatient services, self-rated health, 65+ year old household members, outpatient services, education and insurance. The relative importance of family size, economic status and chronic disease was stable in Figure 3 and Figure 4.



### 3.4 Random effect model of CHE incidence

Table 1 presents the estimated odds ratio (OR), p value and corresponding 95% confidence interval (CI) in the logit random effect model for the determinants of urban and rural CHE incidence. For urban locations, household head characteristics (age, education, self-rated health), household characteristics (members 65 years or older, chronic diseases, family size, economic status), and healthcare utilization (inpatient and outpatient usage) were significant determinants of urban households' CHE incidence. From Table 1, the same variables were significant variables for rural households, with the addition of household head's sex and health insurance.

For the urban households, household head aged 55-64 increased the odds of incurring CHE 1.706 times and aged 65+ 2.615 times the 16-34 age group. High school and above education level of household head decreased the risk of CHE from 1 to 0.735. Compared with self-rated good health group, the poor health group increased the odds of incurring CHE 2.437 times and the medium health group, 1.135 times. Households with family members 65+ years old increased the CHE risk 1.389

times and households with doctor-diagnosed chronic disease 1.314 times. More family members reduced the risk of CHE, with 4-5 member households decreasing the odds of suffering CHE from 1 to 0.608 and 6+ members households 0.509. Households in lowest quartile income group (2.655 times), quartile 2 group (1.763 times) and quartile 3 group (1.519 times) were more likely to incur CHE than the highest quartile income household group. Inpatient (3.710 times) and outpatient (1.236 times) health service utilization increased the odds of suffering CHE compared to household not utilizing healthcare. Finally, the health insurance variable was not significant.

For the rural households, Table 1 shows that household head aged 55-64 (1.613 times) and aged 65+ (2.087 times) increased the odds of incurring CHE compared to the 16-34 age group. A high level of household head's education effectively decreased the risk of CHE, with the risk of CHE 0.852 lower for the middle school group and 0.789 lower for the high school and above than the illiterate and elementary educated group. CHE in the self-rated poor health (1.933 times) and medium health(1.292 times) groups increased CHE incidence compared to the good health group. Households with family members 65 years+ (1.214 times) and with doctor-diagnosed chronic diseases (1.301 times) were more likely to incur CHE. More family members reduced the risk of CHE, with 4-5 member households decreasing the odds of suffering CHE to 0.608 and 6+ member households to 0.468. Rural household in the poorest income quartile (2.253 times), income quartile 2 (1.572 times) and income quartile 3 (1.218 times) were more likely to incur CHE than the highest income quartile. Inpatient (3.395 times) and outpatient (1.145 times) health service utilization increased the odds of suffering CHE. Sex was an especially important determinant of rural CHE, where male household heads increased CHE 1.092 times compared to urban female head households. Compared with households covered by no insurance, those covered by NRCMS increased the likelihood of incurring CHE from 1 to 1.164. Other insurance groups showed no effect in the CHE occurrence.

**Table 1 Random effect regression of CHE incidence in urban and rural households, 2010-2018**

Variables	Urban=27496			Rural=28880		
	OR	95%CI	P	OR	95%CI	P
Sex (Reference Female)						
Male	0.996	0.905-1.097	0.941	1.092	1.003-1.188	<b>0.042</b>
Age (Reference 16-34)						
35-54	0.944	0.780-1.143	0.556	0.919	0.791-1.068	0.272
55-64	1.706	1.398-2.083	<b>0.000</b>	1.613	1.377-1.890	<b>0.000</b>
≥65	2.615	2.034-3.360	<b>0.000</b>	2.087	1.712-2.535	<b>0.000</b>
Marital status (Reference Unmarried)						
Married	1.037	0.764-1.407	0.818	0.963	0.786-1.182	0.721
Divorced or widow	1.235	0.890-1.713	0.206	0.999	0.793-1.257	0.991
Education (Reference Illiterate and elementary)						
Middle school	0.904	0.806-1.014	0.086	0.852	0.785-0.924	<b>0.000</b>
High school and above	0.735	0.632-0.855	<b>0.000</b>	0.789	0.678-0.918	<b>0.002</b>
Self-rated health (Reference good)						
Poor	2.437	2.154-2.758	<b>0.000</b>	1.933	1.754-2.130	<b>0.000</b>
Medium	1.135	1.187-1.525	<b>0.000</b>	1.292	1.166-1.431	<b>0.000</b>
65 and older (Reference No)						
Yes	1.389	1.181-1.634	<b>0.003</b>	1.214	1.076-1.369	<b>0.002</b>
Chronic disease (Reference No)						
Yes	1.314	1.190-1.451	<b>0.000</b>	1.301	1.200-1.410	<b>0.000</b>
Family size (Reference 1-3)						
4-5	0.608	0.543-0.680	<b>0.000</b>	0.608	0.556-0.665	<b>0.000</b>
≥6	0.509	0.431-0.600	<b>0.000</b>	0.468	0.420-0.521	<b>0.000</b>
Economic status (Reference Quartile 4 (Highest))						
Quintile 1 (Lowest)	2.655	2.296-3.070	<b>0.000</b>	2.253	1.948-2.605	<b>0.000</b>
Quintile 2	1.763	1.528-2.035	<b>0.000</b>	1.572	1.354-1.825	<b>0.000</b>
Quintile 3	1.519	1.334-1.729	<b>0.000</b>	1.218	1.043-1.421	<b>0.013</b>
Inpatient service (Reference No)						
Yes	3.710	3.367-4.087	<b>0.000</b>	3.395	3.134-3.677	<b>0.000</b>
Outpatient service (Reference No)						
Yes	1.236	1.121-1.363	<b>0.000</b>	1.145	1.057-1.240	<b>0.001</b>

Health insurance (Reference No insurance)						
NRCMS	1.084	0.926-1.270	0.315	1.164	1.005-1.349	<b>0.043</b>
UEBMI	0.932	0.782-1.111	0.434	0.865	0.654-1.144	0.308
URBMI	1.181	0.985-1.416	0.073	1.139	0.833-1.558	0.414
SMI	0.929	0.756-1.142	0.485	0.898	0.677-1.190	0.453
cons	0.011	0.007-0.018	0.000	0.043	0.028-0.065	0.000
lnsig2u	-2.028	-3.298--0.758	—	-2.128	-3.390--0.866	—
sigma_u	0.363	0.192-0.685	—	0.345	0.184-0.649	—
rho	0.038	0.011-0.125	—	0.035	0.010-0.113	—
Prob > chi2	0.000			0.000		
Chi-square	186.94			263.36		
AIC	13611.27			19462.716		

#### 4. Discussion

Our study applied a 5-year nationally representative Chinese household panel dataset to analyze the trend, incidence, intensity and determinants of CHE for urban and rural areas in China. Measured by headcount, CHE incidence decreased from 14.73% in 2010 to 8.67% in 2018, with CHE in rural areas about 4% higher than for urban households. CHE intensity, measured by overshoot, also fell from 23.61% in 2010 to 20.15% in 2018, with rural areas about 1% higher than urban households. Our results are broadly consistent with some previous studies [31,32], which found the overall incidence of CHE was around 13%, displayed a downward trend and was higher in rural than urban areas. But our estimates were lower than Sun's CHE estimates, who also used CFPS panel data [14]. The difference with Sun's CFPS results might be due to Sun's balanced panel data dropping almost half the observations in his samples each year.

Compared with other countries, China had a higher CHE incidence. In a study carried out across 59 countries, the rate of CHE ranged from 0.01 in Czech Republic and Slovakia to 10.5% in Vietnam [2]. Possible reasons for the differences between China and other countries may be China's rapid increase of health expenditure due to the current fee-for-service payment system and low level of benefit packages from the fragmented social health insurance schemes [24]. Our higher CHE in rural areas than urban areas was consistent with other studies [17,24,33], with some international studies reporting that rural households' incidence of CHE over 1.5 times higher than the national average [24, 34].

Our linear probability model and random effects model provided new insights into CHE in China. The relative importance of household head's characteristics (age, education level, self-rated health), household characteristics (member(s) 65+ years old, family size, economic status, doctor-diagnosed chronic diseases) and healthcare utilization (use of inpatient services in the past year and outpatient service use in the

last two weeks and health insurance) as determinants of CHE incidence declined over the 2010-2018 period, with the decline about the same in urban and rural areas. Inpatient service usage accounted for 10-20% of all determinants of CHE, and addressing the costs of inpatient service usage would attenuate CHE in China.

The random effect model revealed that urban household head characteristics (age, education, self-rated health), urban household characteristics (members 65 years or older, chronic diseases, family size, economic status), and urban healthcare utilization (inpatient and outpatient usage) were significant determinants of urban households' CHE incidence. The same variables were significant variables for rural households, with the addition of household head's sex and health insurance. Previous studies also showed age and chronic diseases of family member increase the probability of CHE [16,17,18,24,35,36]. China's rapid population aging, and the elderly suffering comorbidities, warns that the incidence of CHE will increase in the future. These trends highlight the urgency in developing long-term care insurance, extending insurance coverage, improving the medical health assistance system, prioritizing outpatient services, supporting the costs of essential medications and expanding to rehabilitation services [24].

We found that large household size protects against CHE, which was also reported in some other studies [6,37]. Although all households were covered by the same insurance benefit package, larger households shared the CHE risk among a larger number of people that meant greater family-based medical cost affordability [6]. We also found that the risk of CHE was closely linked with households' economic status, with households in poor income quartiles more likely to suffer CHE, which is consistent with other Chinese and international studies [24,38]. These results emphasize that addressing CHE is not only a matter of health policy, but also economic policy. Income improvement policies, including poverty reduction, will limit the number of poor households that are susceptible to CHE. Reform to China's social security system and income equality policies should provide a safety net for poor households, the rural elderly, those with chronic diseases and single member households.

A key finding was that health service utilization was the single most important variable associated with CHE both in urban and rural areas. While some Chinese studies argued that health utilization variables, including inpatient service and outpatient service usage, influenced the occurrence of CHE [6], most studies only included inpatient services [37] and the two studies using CFPS panel data did not include health service utilization [14,18,24]. In China, consultation visits to medical institutions grew sharply from 5838 million visits in 2010 to 8308 million visits in 2018, and the annual hospitalization rate jumped from 10.5% in 2010 to 18.2% in 2018 [39]. Much of this growth in health demand, and greater CHE risk, can be traced to China's distorted health care incentive mechanisms that encouraged overuse and

over-servicing. Restricting unnecessary and inflated health expenditures by health service providers requires a change in the payment method by insurers to hospitals. For example, capitation payment methods deliver lower OOP expenses, a major contributor to CHE, than fee-for-service and case payment methods [40].

We identified significant differences in CHE risk between rural and urban households, including household head sex and health insurance. Previous studies took mainly a nationwide view of health insurance and CHE, with contradictory results [2,4,6,19,22,32]. In contrast to the purpose of health insurance, NRCMS increased the CHE risk for rural households. All other insurance groups had no effect on decreasing the risk of CHE both in urban and rural areas. The NRCMS reimbursement ratio was very low, and outpatient coverage limited, which offered rural residents inadequate protection from hospitalization expenses, especially in high-level hospitals. Our study showed that the health insurance schemes require further reform, especially improving the benefits and coverage of NRCMS, URBMI and UEBMI. Rural and urban households headed by the least-educated significantly contributed to increasing CHE, which is consistent with other studies [18,41]. However, we found differences between urban and rural households, with both middle school and high school and above rural households decreased the risk of CHE, but middle school education did not affect the CHE occurrence in urban area. These differences require further research.

## **5. Limitations**

There are several limitations. The standard CHE calculation used here excluded extremely poor households that cannot afford health services. Future research should identify families so poor they did not access a doctor. Second, OOP health expenditure in CFPS survey did not cover the indirect cost for medical services, such as transportation expense, accommodation costs and income loss, which may underestimate our estimates of the incidence and intensity of CHE. Third, the absence of data on the characteristics of hospitals, such as hospital level, should be addressed in future studies. Finally, CFPS health service utilization, health expenditure and household income were self-reported, which may be less accurate than data from medical records.

## **6. Conclusion**

CHE incidence decreased from 2010 to 2018 both in urban and rural areas, but CHE was higher in rural than urban households. For both urban and rural households, inpatient service usage remained the most important determinant of CHE incidence, while age was the weakest factor. Almost all the included variables influenced CHE incidence in urban households (except gender and marriage) and rural household (except marriage). Both in urban and rural areas, the older household head's age, poor and medium self-rated health, family members 65+ years, members with

doctor-diagnosed chronic diseases, low household income status, inpatient and outpatient service utilization significantly increased the risk of suffering CHE. There were differences in association with CHE risk between rural and urban households, including household head sex, education level and health insurance. These findings have important policy implications for healthcare delivery and financing in China and other developing countries. To address CHE, the policy implications include improving the economic level of poor households; further reforming national health insurance schemes, especially improving the benefit package of public basic insurance, and improving commercial insurance and specific insurance schemes for vulnerable populations; and reinforcing pre-payment hospital insurance methods to control OOP hospital expenses.

### **List of abbreviations**

CHE: Catastrophic health expenditures; OOP: Out-of-pocket payments; CFPS: China Family Panel Studies; CTP: Capacity to pay; NRCMS: New rural cooperative medical scheme; UEBMI: Urban employee basic medical insurance; URBMI: Urban resident basic medical insurance; SMI: Supplement medical insurance; LPM: Linear probability modelling; OR: Odds ratio; CI: Confidence interval.

### **Declarations**

- **Ethics approval and consent to participate**

The China Family Panel Studies, from which our data come, were approved by the Ethical Committee of Peking University and were performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki. Informed consent was obtained from all individual participants included in China Family Panel Studies.

- **Consent for publication**

Not applicable

- **Availability of data and code**

The datasets used in this study were derived from China Family Panel Studies in the years of 2010,2012,2014,2016 and 2018. Available at: <http://www.iss.pku.edu.cn/cfps/>. Accessed 19 Aug 2019. The code used in this study is available from the corresponding author on reasonable request.

- **Competing interests**

The authors declare that they have no competing interests as defined by BMC, or other interests that might be perceived to influence the results and/or discussion reported in this paper.

- **Funding**

The research was supported by the Project from NHC Key Laboratory of Health Economics and Policy Research in Shandong University(NHC-NEPR2019005). The grant provided funding for the interpretation of the data.

#### ● **Authors' contributions**

**Liu Cai:** Funding acquisition, Data analysis, Writing-Original draft preparation.

**Liu Zhao Min:** Software, Data analysis, Interpreted the results

**Nicholas Stephen:** Writing-Reviewing and Editing

**Wang Jian:** Conceptualization, Supervision

#### ● **Acknowledgments**

We gratefully acknowledge the China Family Panel Studies for providing data and training in using the database. The authors also acknowledge the helpful comments by the editor and reviewers.

#### **References**

- [1] Zhu W, Xia YQ. An analysis on household consumption-fueled borrowing in China. *Journal of Finance and Economics* 2018; 44(10):67-81. Doi: <https://doi.org/10.16538/j.cnki.jfe.2018.10.005>
- [2] Xu K, Evans DB, Kawabata K, et al. Household catastrophic health expenditure: a multicountry analysis. *The Lancet* 2003; 362:111–7. Doi: [https://doi.org/10.1016/S0140-6736\(03\)13861-5](https://doi.org/10.1016/S0140-6736(03)13861-5)
- [3] Wagstaff A, Van Doorslaer E. Catastrophic and impoverishment in paying for health care: with application to Vietnam 1993-98. *Health Economics* 2003;12:921-34. Doi: <https://doi.org/10.1002/hec.776>
- [4] Wagstaff A, Lindelow M. Can insurance increase financial risk? The curious case of health insurance in China. *Journal of Health Economics* 2008;27 (4):990-1005. Doi: <https://doi.org/10.1016/j.jhealeco.2008.02.002>
- [5] Yu H. Universal health insurance coverage for 13 billion people: what accounts for China's success? *Health Policy* 2015;119(9):1145–52. Doi: <https://doi.org/10.1016/j.healthpol.2015.07.008>
- [6] Wang ZH, Li XJ, Chen SM. Catastrophic health expenditures and its inequality in elderly households with chronic disease patients in China. *International Journal for Equity in Health* 2015;14:8. Doi: <https://doi.org/10.1186/s12939-015-0134-6>
- [7] Dorjdagva J, Batbaatar E, Svensson M, Dorjsuren B, Kauhanen J. Catastrophic health expenditure and impoverishment in Mongolia. *International Journal for Equity in Health* 2016;15:105. Doi: <https://doi.org/10.1186/s12939-016-0395-8>
- [8] Chuma J, Maina T. Catastrophic health care spending and impoverishment in Kenya. *BMC Health Services Research* 2012;12:413. Doi: <https://doi.org/10.1186/1472-6963-12-413>
- [9] Kien VD, Minh HV, Giang KB, et al. Socioeconomic inequalities in catastrophic health expenditure and impoverishment associated with non-communicable diseases

in urban Hanoi, Vietnam. *International Journal for Equity in Health* 2016;15:169. Doi: <https://doi.org/10.1186/s12939-016-0460-3>

[10] Alkhatib AA, Hilden K, Adler DG. Impact of the policy of expanding benefit coverage for cancer patients on catastrophic health expenditure across different income groups in South Korea. *Social Science & Medicine* 2015;138:241–7. Doi: <https://doi.org/10.1016/j.socscimed.2015.06.012>

[11] Rahman M, Gilmour S, Saito E, Sultana P, Shibuya K. Health-related financial catastrophe, inequality and chronic illness in Bangladesh. *PLoS One* 2013;8:e56873. Doi: <https://doi.org/10.1371/journal.pone.0056873>

[12] Leng AL, Jing J, Nicholas S, Wang J. Catastrophic health expenditure of cancer patients at the end-of-life: a retrospective observational study in China. *BMC Palliative Care* 2019;18(1):43. Doi: <https://doi.org/10.1186/s12904-019-0426-5>

[13] Guan XD, Li H, Xin XX, Guo ZG, Ma LL, Han S, Shi LW. Research on equity and influential factors of medicine expenditure affordability for diabetes patients in China. *Chinese Pharmaceutical Affairs* 2015; 29:1047–54. in Chinese. Doi: [10.16153/j.1002-7777.2015.10.010](https://doi.org/10.16153/j.1002-7777.2015.10.010)

[14] Sun J, Lyu SJ. The effect of medical insurance on catastrophic health expenditure: evidence from China. *Cost Effectiveness Resource Allocation* 2020;18(10):1-11. Doi: <https://doi.org/10.1186/s12962-020-00206-y>

[15] Zhang XY, Xu QQ, XL, Jing ZHY, Sun L, Li JJ, Zhou CC. Catastrophic health expenditure: a comparative study between hypertensive patients with and without complication in rural Shandong, China. *BMC Public Health*. 2020;20(1):545. Doi: <https://doi.org/10.1186/s12889-020-08662-0>

[16] Quintal C. Evolution of catastrophic health expenditure in a high income country: incidence versus inequalities. *International Journal for Equity in Health* 2019(18):145-56. Doi: <https://doi.org/10.1186/s12939-019-1044-9>

[17] Yazdi-Feyzabadi V, Bahrapour M, Rashidian A, Haghdoost AA, Javar MA, Mohammad Hossein Mehrolohasani. Prevalence and intensity of catastrophic health care expenditures in Iran from 2008 to 2015: a study on Iranian household income and expenditure survey. *International Journal for Equity in Health* 2018;17(1):44. Doi: <https://doi.org/10.1186/s12939-018-0743-y>

[18] Liu H, Zhu H, Wang JH, Qi XY, Zhao MM, Shan LH, et, al. Catastrophic health expenditure incidence and its equity in China: a study on the Initial implementation of the medical insurance integration system. *BMC Public Health* 2019;19(1):1761. Doi: <https://doi.org/10.1186/s12889-019-8121-2>

[19] Jue Y, Yong LY, Nina H. Empirical study on the relief effect of catastrophic Health expenditure under three basic medical schemes. *Chinese Health Economics* 2012;31(1):26–8. in Chinese Doi: [10.3969/j.issn.1003-0743.2012.01.008](https://doi.org/10.3969/j.issn.1003-0743.2012.01.008)

[20] Zhao SW, Zhang XY, Dai W, Ding YX, Chen JY, Fang, PQ. Effect of the catastrophic medical insurance on household catastrophic health expenditure: evidence from China. *Gaceta Sanitaria* 2020;34(4):370-76. Doi: <https://doi.org/10.1016/j.gaceta.2018.10.005>

[21] Wang Y, Xu D. Can basic medical insurance reduce catastrophic health spending for residents? Evidence from data of CHARLS. *Financial Theory & Practice* 2019;41(2):87-94. in Chinese Doi: [10.3969/j.issn.1003-4625.2019.02.012](https://doi.org/10.3969/j.issn.1003-4625.2019.02.012)

[22] Guo N, Iversen T, Lu M, Wang J, Shi L. Does the new cooperative medical scheme reduce inequality in catastrophic health expenditure in rural China? *BMC*

Health Services Research 2016;16(1):653. Doi:  
<https://doi.org/10.1186/s12913-016-1883-7>

[23] Cheng HG, Augustin D, Glass EH, Anthony JC. Nation-scale primary prevention to reduce newly incident adolescent drug use: the issue of lag time. *Peer Journal* 2019;7(11):e6356. Doi: <https://doi.org/10.7717/peerj.6356>

[24] Zhao Y, Oldenburg B, Mahal A, et al. Trends and socio-economic disparities in catastrophic health expenditure and health impoverishment in China: 2010 to 2016. *Tropical Medicine & International Health* 2019;25(2):236-47. Doi: [10.1111/tmi.13344](https://doi.org/10.1111/tmi.13344)

[25] Yu Xie, Ping Lu. The sampling design of the China Family Panel Studies (CFPS). *Chinese Journal of Sociology* 2015; 1(4): 471–84. Doi: [10.1177/2057150X15614535](https://doi.org/10.1177/2057150X15614535)

[26] Hoetker, Glenn P. Confounded coefficients: Extending recent advances in the accurate comparison of logit and probit coefficients across groups. Working paper. Oct. 22, 2004. University of Illinois at Urbana-Champaign. [www. Public. Asu.edu/.../research/Hoetker-confounded.wp.pdf](http://www.Public.Asu.edu/.../research/Hoetker-confounded.wp.pdf). Doi: [10.2139/ssrn.609104](https://doi.org/10.2139/ssrn.609104)

[27] Wooldridge, Jeffery M. *Econometric analysis of cross sectional and panel data*. Cambridge: MIT press 2002. Doi: [10.1108/02635570710822822](https://doi.org/10.1108/02635570710822822)

[28] Mood Carina. Logistic regression: why we cannot do what we think we can do, and what can do about it. *European Sociological Review* 2010; 26(1): 67-82. Doi: [10.2307/40602478](https://doi.org/10.2307/40602478)

[29] Karlson, Kristian B, Anders H, Richard B. Comparing regression coefficients between same-samples nested models using logit and probit: a new method. *Sociological Methodology* 2013;42(1): 286-313. Doi: [10.1177/0081175012444861](https://doi.org/10.1177/0081175012444861)

[30] Hong Y B. On the coefficients comparison between logistic regression and the solutions: a brief review. *Chinese Journal of Sociology* 2015;35(04):227-48. In Chinese. Doi: [10.15992/j.cnki.31-1123/c.2015.04.009](https://doi.org/10.15992/j.cnki.31-1123/c.2015.04.009)

[31] Wu D, Yu F. Improvement of the reduction in catastrophic health expenditure in China's public health insurance. *PLoS ONE* 2018;13:e0194915. Doi: [10.1371/journal.pone.0213243](https://doi.org/10.1371/journal.pone.0213243)

[32] Meng Q, Xu L, Zhang Y, Qian J, Cai M, Xin Y, Gao J, Xu K, Boerma JT, Barber SL. Trends in access to health services and financial protection in China between 2003 and 2011: a cross-sectional study. *The Lancet* 2012; 379(9818): 805-14. Doi: [10.1016/S0140-6736\(12\)60278-5](https://doi.org/10.1016/S0140-6736(12)60278-5)

[33] Abu-Zaineh M, Romdhane HB, Ventelou B, Moatti JP, Chokri A. Appraising financial protection in health: the case of Tunisia. *International Journal of Health Care Finance & Economics* 2013;13(1):73-93. Doi: [10.1007/s10754-013-9123-8](https://doi.org/10.1007/s10754-013-9123-8)

[34] O'Donnell O, Doorslaer E, Rannan-Eliya A, Somanathan C, Doorslaer E, Rannan-Eliya S. Explaining the incidence of catastrophic payments for health care: comparative evidence from Asia. *EQUITAP Working Paper No. 5*. 2005.

[35] Arsenijevic J, Pavlova M, Rechel B, Groot W. Catastrophic health care expenditure among older people with chronic diseases in 15 European countries. *PLoS One* 2016;11(7): e0157765. Doi: [10.1371/journal.pone.0157765](https://doi.org/10.1371/journal.pone.0157765)

[36] Wang J, Chen L, Ye T, Zhang Z, Ma J. Financial protection effects of modification of China's New Cooperative Medical Scheme on rural households with chronic diseases. *BMC Health Services Research* 2014; 14(1): 305. Doi: [10.1186/1472-6963-14-305](https://doi.org/10.1186/1472-6963-14-305)

- [37] Wang JH, Zhu H, Liu H, Wu K, Zhang X, Zhao MM, et al. Can the reform of integrating health insurance reduce inequity in catastrophic health expenditure? Evidence from China. *International Journal for Equity in Health* 2020;19(1):49. Doi: <https://doi.org/10.1186/s12939-020-1145-5>
- [38] Su TT, Kouyaté B, Flessa S. Catastrophic household expenditure for health care in a low income society: a study from Nouna district, Burkina Faso. *Bull World Health Organ* 2006;84: 21-7. Doi: /S0042-96862006000100010
- [39] National Health Commission of the People's Republic of China. Bulletin of national health commission of the People's Republic of China. <http://www.nhc.gov.cn/wjw/gongb/list.shtml>. Accessed 22 May 2019.
- [40] Yang Y, Yu Z, Nicholas S, Maitland E, Huang ZW, Ma Y, Man XW, Shi XF. Managing Urban Stroke Health Expenditures in China: Role of Payment Method and Hospital Level. Unpublished paper, 2020.
- [41] Boing AC, Bertoldi AD, AJDd B, Posenato LG, Peres KG. Socioeconomic inequality in catastrophic health expenditure in Brazil. *Rev Saude Publica* 2014;48(4):632–41. Doi: [doi/10.1590/S0034-8910.201404800511](https://doi.org/10.1590/S0034-8910.201404800511)

# Figures

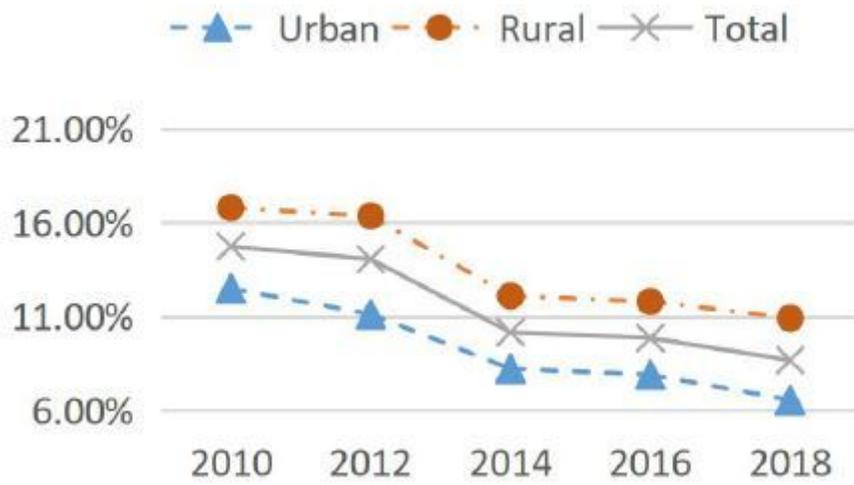


Figure 1

Trends of CHE headcount (Incidence) 2010-2018

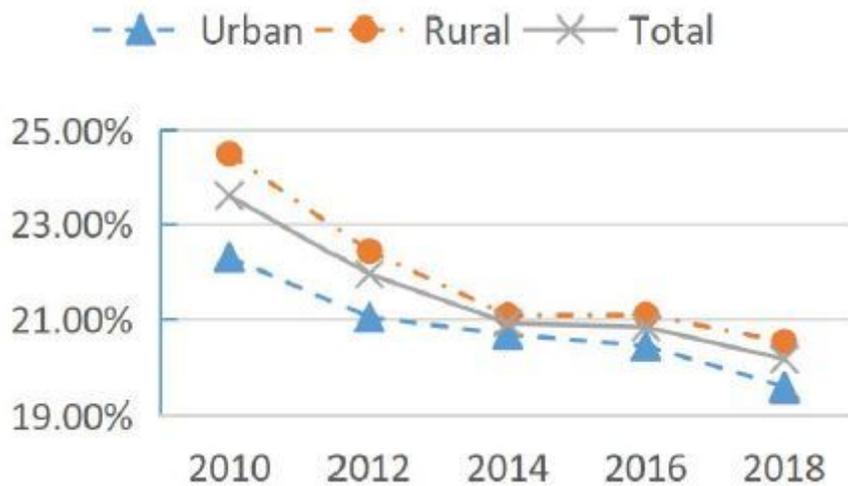


Figure 2

Trends of CHE overshoot (intensity) 2010-2018

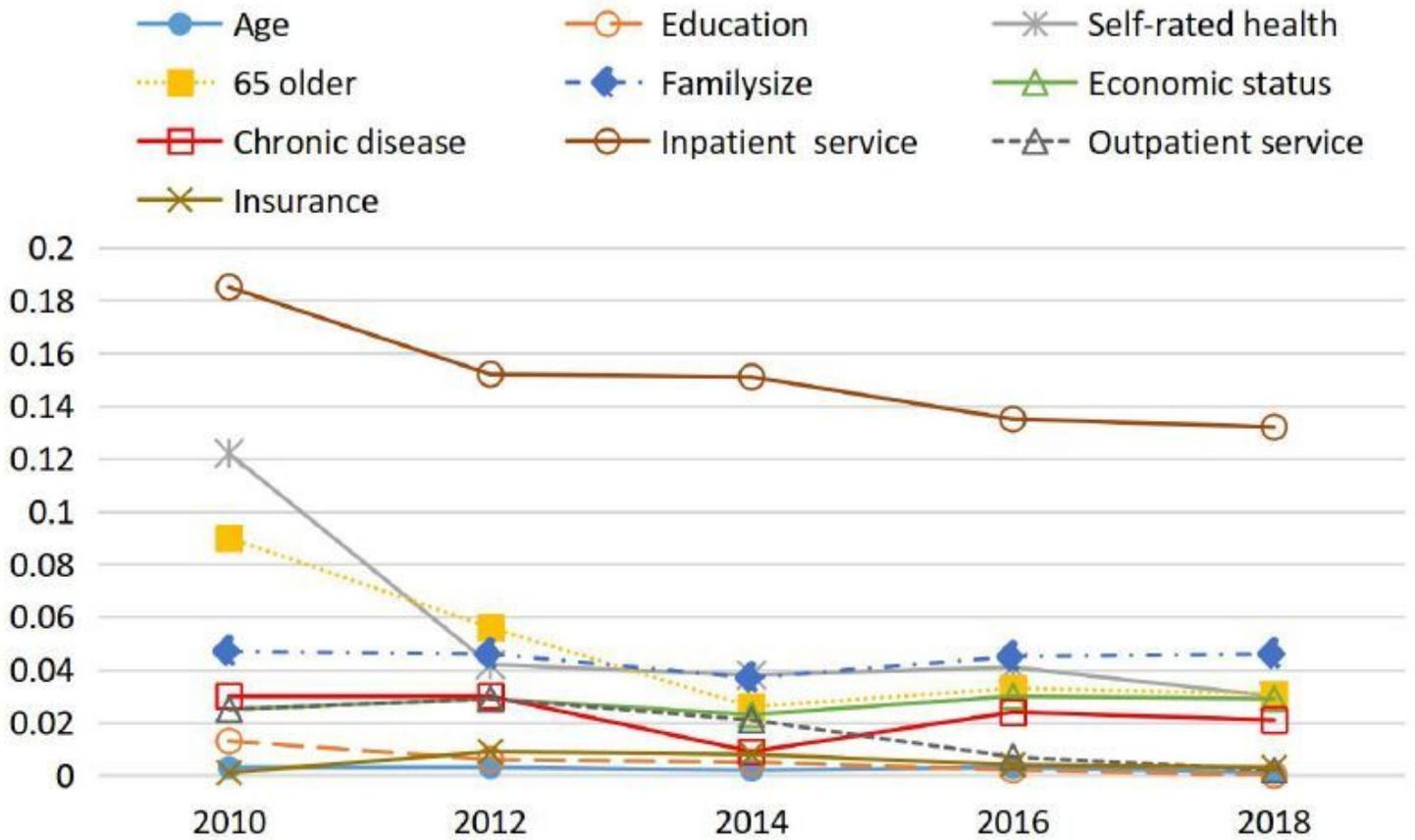


Figure 3

Relative Importance of determinants of CHE incidence in urban households, 2010-2018

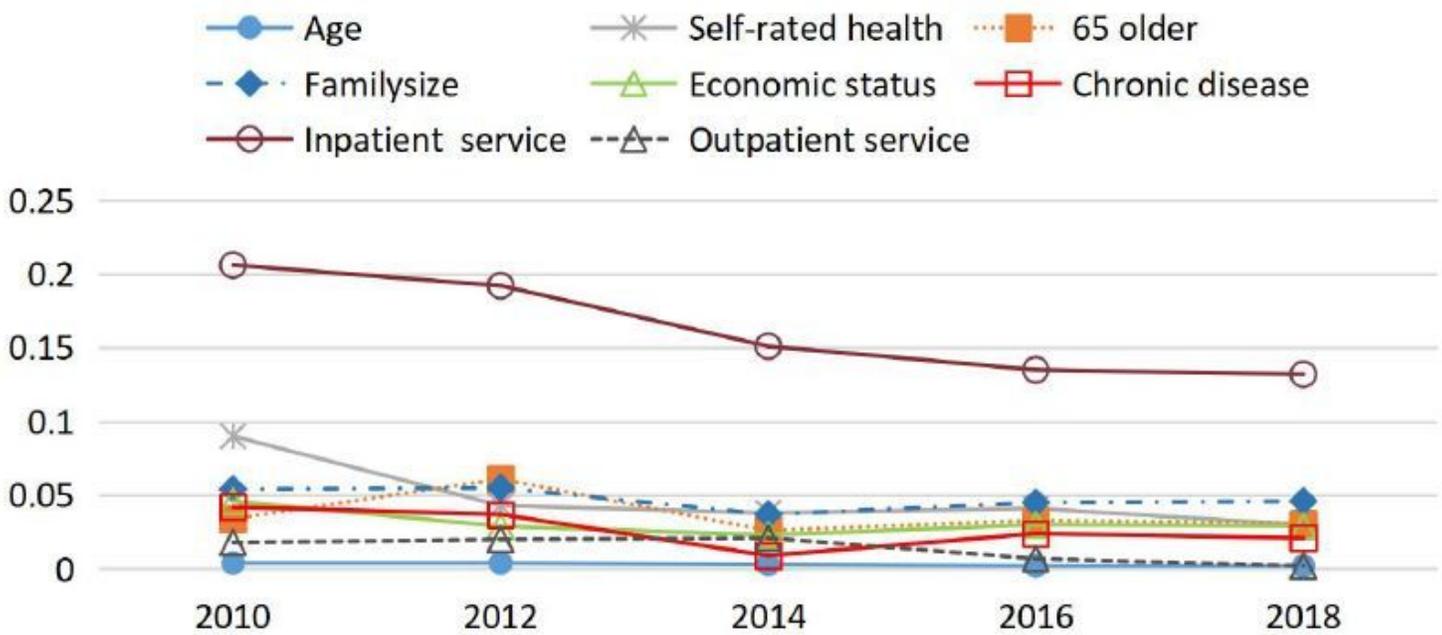


Figure 4

## Supplementary Files

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

- [Supplementaryfile.pdf](#)