Research on the economic risk of diseases in middle-aged and elderly patients with diabetes—evidence from China

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Abstract
Objective To measure the economic risk of diseases in Chinese middle-aged and elderly patients with diabetes.

Methods The economic risk of diseases in Chinese middle-aged and elderly patients with diabetes was comprehensively analyzed using the family economic risk of diseases, catastrophic health expenditure, and relative risk of the disease.

Results The proportions of families with low, medium, and high family economic risk of diseases were 64.73%, 8.56%, and 26.71%, respectively. When the defining criteria are 15%, 25%, and 40%, the incidences of catastrophic health expenditure were 66.71%, 60.07%, and 54.59%, respectively. The health expenditure of diabetic patients was 1.80 times that of non-diabetic patients when the difference in patients’ income was eliminated.

Conclusion In general, Chinese middle-aged and elderly patients with diabetes face a large economic risk of diseases, which will seriously hinder the improvement of their family life quality. The sociodemographic characteristics related to diabetics will aggravate the patient’s economic risk, such as smoking, drinking, and low household income. Moreover, diabetes patients with different basic medical insurance have different economic risk of diseases.

Keywords Middle-aged and elderly · Diabetes patients · Diseases’ economic risk · China

Background
As one of the most important chronic non-communicable diseases in the world, diabetes is complicated and difficult to cure, which has caused serious harm to human health (Liu et al. 2018). Many studies have shown that the population of diabetics increased rapidly in developing countries, and China is a typical representative, especially in recent years (Nanditha et al. 2016). In 2015, the number of patients with diabetes in China was close to 110 million, which has accounted for a quarter of the global diabetes patients (International Diabetes Federation, IDF 2015).

Since diabetes is usually accompanied by many complications and its recurrence is common, diabetics usually spend a long period of time in treatment, which is a time- and money-consuming process (Leung et al. 2017). The total economic burden of Chinese middle-aged and elderly patients with diabetes was as high as 259.86 billion yuan in 2015, which accounted for 0.38% of the gross domestic product in the same period (Leng et al. 2018). In China, approximately $51 billion was spent on diabetes-related care in 2015, second only to the USA (Jing et al. 2019). The middle-aged and elderly people with diabetes are high-risk populations and consume large amounts of health resources. Moreover the middle-aged group is the main contributor to social and economic development and the elderly group is the main source of social burden. Therefore, it is very important to study the economic risk of middle-aged and elderly patients with diabetes.

Foreign studies on the economic risk of diseases are mainly the measurement of the catastrophic health expenditure rate (CHER) and analysis of its influencing factors. By analyzing the use of health services, Brinda et al. found that the CHER among the elderly in India was 7% and the CHER for older
Men and chronically ill patients was higher, while medical insurances could reduce this risk (Brinda et al. 2015). In Kenya, the proportion of households facing catastrophic health expenditure (CHE) was 1.52–28.38% and the number of working adults in the household was a favorable factor in reducing economic risk (Buigut et al. 2015). In Nepal, the cumulative incidence of CHE was 10.3% per month, and elderly people and residents living in remote areas were prone to CHE (Ghimire et al. 2018). There were 3.37% of families burdened with catastrophic costs and the brand of drug, income, and health insurance were significantly correlated with catastrophic expenditure in Iran (Juyani et al. 2016).

The research on the economic risk of diseases in China mainly focuses on three aspects: one was to measure CHE and its influencing factors, another was to analyze the protective effect of China’s basic medical insurance on CHE, and the third was to measure the family economic risk of diseases (FERD). For example, Si et al. measured the CHER for residents covered by different basic medical insurance and found that the CHER of residents with the urban employee basic medical insurance (UEBMI) and the new rural cooperative medical insurance (NRCMI) in different regions in China was 16.87–68.07% and 19.62–75.86%, respectively (Si et al. 2017). Yang et al. found that China’s basic medical insurance had a certain protective effect on residents’ CHE, but this protective effect varies between different types of insurance (Yang et al. 2016). Another study found that 13% of diabetes patients in China were at high FERD (Li and Wang 2017).

After analyzing the relevant literatures, we found that there are three main shortcomings in the study of diseases’ economic risk at home and abroad. First, most of the studies are regional, lacking national research. Second, evaluation indicators for analyzing the disease’s economic risk are not comprehensive; most studies are based on household expenditure rather than household income. Finally, the data quality was low, as most studies were based on regional and intermittent survey data. Through this paper, we aimed to achieve the following goals: (1) clarify the economic risk of diseases in Chinese middle-aged and elderly diabetics; (2) provide a health economic basis for the Chinese government and other governments around the world to formulate effective resistance strategies of diabetics’ economic risk, promote the rational allocation of health resources, and improve overall human health.

Materials and methods

Dataset

The data in this paper are based on the China Health and Retirement Longitudinal Study (CHARLS), which collects high-quality micro-data from Chinese people over the age of 45 years. This article selected the cross-sectional data from 2015 in the CHARLS database to measure the economic risk of diseases in Chinese middle-aged and elderly patients with diabetes. In 2015, the CHARLS project team conducted survey visits in 150 counties and 450 communities (villages) in 28 provinces (autonomous regions and municipalities) in China and a total of 20,967 people were surveyed, of which the urban population accounted for 31.6% and the rural population accounted for 68.4%. The CHARLS covers basic information, health status, medical insurance, household spending, and income of middle-aged and elderly residents in China.

Sample

According to the questionnaire in CHARLS, we use the following two questions to select diabetes patients: (1) “Have you been diagnosed with these chronic diseases by a doctor?” and (2) “Are you now taking any of the following treatments to treat or control your diabetes?” When a diabetic patient had other chronic comorbidities, it is difficult to distinguish specific medical expenses according to diseases. Therefore, our study measures the economic risk of all diseases of diabetic patients, not only the economic risk caused by diabetes. Details of the research data screening is shown in Fig. 1.

Some diabetes patients may not use health services due to inconvenient transportation and low income, and, therefore, they do not have any health expenses. The diseases’ economic risk of these people measured by the relevant evaluation indicators is 0; in other words, these patients’ disease economic risk is 0 from the evaluation indicator, which is obviously inconsistent with the actual situation. Therefore, our study eliminated those cases who do not use health services, as well as those with missing values. In particular, the health expenditure in this article refers to the out-of-pocket health payments.

According to other studies, our study selects relevant factors that may affect the diseases’ economic risk of diabetic patients to analyze the demographic characteristics of diseases’ economic risk in Chinese middle-aged and elderly diabetics (Xu et al. 2003). The first category is the sociological characteristics of the population, which includes age, gender, urban or rural residence, and marital status. The second category is the socioeconomic characteristics, which include basic medical insurance types and household income levels. The third category is the patient’s health status, which includes the number of diabetic chronic comorbidities and self-evaluation of health status.

The evaluation indicators of diseases’ economic risk are based on the household income and the household disposable income, and they will be re-adjusted to fit this article. According to the definition of household income and household disposable income in China, the household disposable income is the household annual income minus food...
expenditures and the household annual income includes wage income, operating net income, and property income (such as interest, dividends, rent income, etc.), transfer income (such as pensions, social relief income, government transfer income, etc.) (Xu and Zhai 2018). Other issues that need attention are as follows: first, the food expenditure does not include eating out and tobacco and alcohol consumption; second, the household income includes the annual income of all household members, which is classed as living together and sharing income and expenditure.

**Measures**

**Definitions**

The economic risk of diseases is defined as the possibility of economic loss caused by the residents’ health expenditures when the disease occurs (Xu et al. 2003). The economic risk of diseases is a series of relative indicators based on the utilization of residents’ health services, health expenditures, and household incomes. Also, it is more rational and credible than the economic burden of diseases that the economic risk of diseases is used to show the impact of residents’ health expenditures on their household (Luo et al. 2011). The measurement indicators of diseases’ economic risk mainly include the FERD, CHE, the poverty-related health expenditure (PHE), and the relative risk of diseases (RRD) (Flores and O’Donnell 2016).

The FERD is used to measure how the health expenditures affect the household total income (Li and Wang 2017). The CHE is used to measure how the health expenditures affect the household disposable income, which includes the CHER, the average gap of catastrophic health expenditure (AGCHE), the relative gap of catastrophic health expenditure (RGCHE), and the concentration index of CHE (Kawabata et al. 2002). The PHE indicates whether individuals are poor due to illness, including the incidence of poverty, the total poverty gap, the average poverty gap, the relative poverty gap, and the poverty standardization gap (Yip and Hsiao 2009). The RRD is derived from Chinese scholars’ reference to the relative risk index of epidemiology, which illustrates the economic risks that a disease poses to residents (Hao et al. 1997).

**Calculations**

Since both CHE and PHE reflect the situation of residents’ poverty caused by diseases, this study chose one of the two indicators. This article selects the FERD, CHE (including the CHER, AGCHE, and RGCHE), and RRD to measure the economic risk of diseases in Chinese middle-aged and elderly population.
patients with diabetes. The relevant evaluation indicators are calculated as follows:

The FERD:

\[
FERD_i = \frac{HE_i}{HAI_i}, \quad \text{FERD}_i = \begin{cases} 
0 \leq \text{FERD}_i \leq 0.5 & \text{Low-FERD} \\
0.5 < \text{FERD}_i \leq 1.0 & \text{Medium-FERD} \\
\text{FERD}_i > 1.0 \text{ or } \text{FERD}_i < 0 & \text{High-FERD}
\end{cases}
\]

FERD

The FED is the family economic risk of diseases, HE

is the health expenditure, and HAI

is the household annual income. The FERD is mainly used by Chinese scholars, and its classification criteria refer to relevant literature (Li and Wang 2017).

The CHE:

\[
CHE_i = \frac{HE_i}{HDI_i}; \quad E_i = \begin{cases} 
0 & \text{if } CHE_i < Z \\
1 & \text{if } CHE_i \geq Z
\end{cases}
\]

CHE

CHE

is the catastrophic health expenditure of residents and HDI

is the household disposable income. When E

is 0, it means that the resident has not experienced CHE, and when E

is 1, it means that the resident has experienced CHE. Z

is the defining criteria for whether the CHE occurs. The three internationally accepted defining standards are 15%, 25%, and 40% (Daher 2001).

The CHER:

\[
CHER = \frac{1}{N} \sum_{i=1}^{N} E_i
\]

CHER

CHER

is the catastrophic health expenditure rate of residents in the survey population, which represents the ratio of the number of households with CHE to the total number of households.

The AGCHE:

\[
AGCHE = \frac{1}{N} \sum_{i=1}^{N} E_i \left( \frac{HE_i}{HDI_i} - Z \right); \quad E_i = \begin{cases} 
0 & \text{if } CHE_i < Z \\
1 & \text{if } CHE_i \geq Z
\end{cases}
\]

AGCHE

AGCHE

is the average gap between the CHE of residents who have experienced CHE and Z in the whole population. It illustrates the extent to which the economic gap in residents’ CHE affects all diabetics.

The RGCHE:

\[
RGCHE = \frac{AGCHE}{CHER}
\]

RGCHE

RGCHE

is the average gap between the CHE of residents who have experienced CHE and Z in the diabetes patients. RGCHE illustrates the extent to which the economic gap in residents’ CHE affects diabetics with CHE.

The RRD:

\[
RRD = \frac{PCHE_{Diabetics}}{PCHE_{Respondents}}; \quad \text{Corrected-RRD} = RRD \times \frac{PCAI_{Diabetics}}{PCAI_{Respondents}}
\]

RRD

RRD

is the relative risk of diseases, which illustrates the economic risk of diseases caused by diabetes. PCHE

refers to the per capita health expenditure of diabetes patients and PCHE

is the per capita health expenditure of respondents. In order to prevent the influence of respondents’ incomes on the indicators, the corrected RRD values are generally adopted. PCAI

is the per capita household annual income of diabetes patients and PCAI

is the per capita household annual income of respondents.

Statistical analysis

First, this paper selects the FERD to analyze the impact of diabetes’ health expenditures on the household total income, and the CHER, AGCHE, and RGCHE are selected to analyze the impact that diabetes’ health expenditures have on the household disposable income. By combining the calculation results of the FERD and CHER, it is possible to analyze the potential risk of whether reducing the household’s basic living expenses is able to meet the medical needs of household members. Finally, the RRD is selected to measure the economic risk caused by diabetes. This article used these evaluation indicators to comprehensively analyze the economic risk of diseases in Chinese middle-aged and elderly patients with diabetes.

The data extraction and collation in this paper is done in Stata 14.0 and Excel 2010, and the statistical description of the data is analyzed using SPSS19.0.

Results

Characteristics of diabetes patients

The total sample size in the 2015 CHARLS database is 20,967, and 1919 diabetic patients were screened, so the prevalence of diabetes in the middle-aged and elderly population was 9.15%. After deleting the respondents with missing information, 19,830 samples and 1908 diabetic patients were included in this article. Compared with non-diabetic patients, Chinese middle-aged and elderly patients were older and had more chronic comorbidities, higher household income, higher utilization of health services, almost doubled health expenditures, and poorer self-evaluation health status. The rate of smoking and drinking was lower for diabetes patients,
and the prevalence of diabetes in women and urban populations was higher (Table 1).

Among the 1908 diabetic patients, 28.51% had taken outpatient treatment, 27.52% had been hospitalized, 66.82% had taken self-treatment, and 19.34% had not taken any form of health service. The health expenditures generated by the three forms of health service utilization are 14,208.22 yuan/year, 8670.74 yuan/year, and 4727.08 yuan/year, respectively (Table 2).

The family economic risk of diseases

The rates of low FERD, medium FERD, and high FERD were 64.73%, 8.56%, and 26.71%, respectively. The FERD of urban diabetic patients was smaller than that of the rural patients. Diabetic patients who were married and living with their spouses had lower FERD. The basic medical insurance type was negatively correlated with the FERD of diabetics. Moreover, the rate of low FERD in diabetic patients with UEBMI was lower than that of patients without basic medical insurance. As household income increases, the FERD of diabetic patients decreased. In particular, the better the diabetics’ health status, the smaller the FERD. Also, the rate of low FERD in smoking and drinking patients was higher than that in patients with who did not smoke or drink (Table 3).

The catastrophic health expenditure rate

When the defining criteria of the CHER are 15%, 25%, and 40%, the CHERs of diabetic patients were 66.71%, 60.07%, and 54.59%, respectively. The CHER in rural diabetes patients, diabetics with a low level of household income, diabetes patients with poor health, and diabetic patients who did not drink were higher than that in the control group. The differences in the CHERs of diabetes patients in regards to age, gender, and marital status were not significant at the 5% statistical level. When the defining criteria is 15%, the CHER of smoking diabetics was lower than that of the control group. Of note, the ascending ranking of CHER for patients with different basic medical insurance was: UEBMI, without basic medical insurance, urban resident basic medical insurance (URBMI), and NRCMI (Table 4).

The relative economic risk of disease

In 2015, the per capita health expenditure of diabetes patients was 9595.62 yuan/year and the per capita health expenditure of respondents was 4712.11 yuan/year, so the RRD was 2.04. The per capita household annual income of respondents was 28,664.79 yuan/year and the per capita household annual income of diabetic patients was 32,604.88 yuan/year. Therefore,

| Characteristics | Diabetes (n = 1908) | Non-diabetes (n = 17,922) | p-value (T/X²) | Total (n = 19,830) |
|-----------------|---------------------|---------------------------|---------------|-------------------|
| x ± s | | | | |
| Age (years) | 62.45 ± 9.840 | 58.97 ± 10.435 | < 0.001 (T = 14.587) | 59.30 ± 10.43 |
| Number of chronic comorbidities | 2.59 ± 1.993 | 1.14 ± 1.336 | < 0.001 (T = 30.897) | 1.28 ± 1.48 |
| Household income (yuan) | 34,034.68 ± 96,289.83 | 29,440.54 ± 71,824.63 | 0.016 (T = 2.400) | 30,550.01 ± 76,107.37 |
| Outpatient health expenditure (yuan) | 14,208.22 ± 48,235.63 | 9484.49 ± 32,214.07 | 0.028 (T = 2.206) | 10,143.55 ± 34,924.35 |
| Hospitalization health expenditure (yuan) | 8670.74 ± 18,423.34 | 7194.52 ± 15,629.69 | 0.091 (T = 1.692) | 7487.20 ± 16,228.79 |
| Self-treatment health expenditure (yuan) | 4727.08 ± 11,807.47 | 2969.22 ± 9398.72 | < 0.001 (T = 5.102) | 3178.33 ± 9732.62 |
| Annual health expenditure (yuan) | 11,896.32 ± 35,829.1 | 6642.45 ± 22,896.74 | < 0.001 (T = 5.599) | 7271.68 ± 24,860.33 |
| No. (%) | | | | |
| Female | 57.34 (n = 1094) | 51.97 (n = 9314) | < 0.001 (X² = 19.92) | 52.49 (n = 10,408) |
| Urban | 39.94 (n = 762) | 28.40 (n = 5089) | < 0.001 (X² = 110.44) | 29.51 (n = 5851) |
| Married and living together | 81.13 (n = 1548) | 81.77 (n = 14,654) | 0.496 (X² = 0.46) | 81.70 (n = 16,202) |
| Utilizing health services | 80.66 (n = 1539) | 63.11 (n = 11,311) | < 0.001 (X² = 232.8) | 64.80 (n = 12,850) |
| Self-evaluation of health status is good | 12.74 (n = 243) | 26.43 (n = 4736) | < 0.001 (X² = 523.2) | 25.12 (n = 4981) |
| Smoking | 20.96 (n = 400) | 28.69 (n = 5142) | < 0.001 (X² = 63.0) | 27.95 (n = 5542) |
| Drinking | 27.73 (n = 529) | 36.35 (n = 6515) | < 0.001 (X² = 60.64) | 35.52 (n = 7044) |

The average health expenditure is calculated based on the patients who used health services.
the corrected RRD of diabetic patients was 1.80. This shows that the health expenditure of diabetics was 1.80 times that of non-diabetics, which also clearly shows that diabetes will obviously increase the financial burden and economic risk of residents.

### Discussion

This study aims to explore the economic risk of Chinese middle-aged and elderly diabetics at the individual level. We use the FERD and CHER to measure the economic risk caused by health expenditures of Chinese middle-aged and elderly diabetics, and the RRD to analyze the economic risk brought about by diabetes. According to our analysis, we had a general understanding on it and further discuss some impressive findings in the following paragraphs.

The result of the diseases’ economic risk in this article more accurately illustrate the actual situation in China. In previous studies, most scholars used residents’ consumption expenditures instead of their household incomes to measure evaluation indicators of diseases’ economic risk (Huang and Yin 2018). With the development of China’s economy, residents’ incomes have been much higher than their consumption expenditures, so if we still use the consumption expenditures to calculate the relevant evaluation indicators, it will overestimate the diseases’ economic risk. In the CHARLS database, the household annual income of residents is 28,664.79 yuan, and it is higher than the annual consumption expenditure of residents, which is 21,972.15 yuan. The CHER of diabetic patients measured by consumption expenditures were 79.79%, 75.07%, and 68.90%, which are significantly higher than the results measured by household incomes. So, our results are clearly in line with China’s actual situation.

Low household incomes inhibit the release of health service demands of diabetics and aggravate the economic risk of patients. From the result of Tables 3, 4, and 5, the FERD and CHER of diabetics patients with a low level of household income were higher than those of patients with a medium level of household income, but the RGCHs is less than that of patients with a medium level of household income. These results show that diabetic patients with a low level of household income are more likely to face high economic risk, but the economic gap of health expenditures is less than that of patients with a medium level of household income. For patients with low income, even a small amount of health expenditures will increase their poverty by a large amount and expose them to high economic risks of diseases, so they hesitate to use health services. But if they do not treat the disease in time, it will aggravate the disease and lead to more serious economic burden of diseases (Xu and Zhai 2018). For example, the proportion of patients with a low level of household income suffering from three or more other chronic diseases was 37.7%, which was higher than that of patients with a medium level of household income (29.71%). More serious illnesses put patients at a higher economic risk of the disease.

Smoking and drinking will increase the diseases’ economic risk of diabetes patients. When CHE occurred, the economic gap of smoking and drinking diabetics was far greater than that of non-smoking and non-drinking diabetics. For example, when the defining criteria is 40%, the RGCHs of smoking and drinking diabetics were 52.10 and 57.19, respectively, and it was much higher than that of non-smoking and non-drinking diabetics, for which the RGCHs were 11.43 and 16.73, respectively. Smoking and drinking are non-independent variables, as well as potential risk factors for diabetes. Moreover, there is a significant multiplicative interaction with age, exercise, and family history, which significantly increases the risk of these factors (Chinese Medical Association Diabetes Branch 2018). Therefore, if diabetics do not follow the doctor’s advice to quit smoking and drinking, it may cause irreversible major illnesses, resulting in high economic risk.

### Table 2 Health service utilization of middle-aged and elderly patients with diabetes in China

| Health service utilization | No. | Utilization rate (%) | Per capita health expenditure (yuan/year) |
|---------------------------|-----|----------------------|------------------------------------------|
| Outpatient                | 544 | 28.51                | 14,208.22                                |
| Hospitalization           | 525 | 27.52                | 8670.74                                  |
| Self-treatment            | 1275| 66.82                | 4727.08                                  |
| Did not take any health services | 369 | 19.34                | 0                                        |
| Health expenditure for diabetics (yuan/year) | 11,896.32 | |

(1) The per capita health expenditure in the form of three types of health services is based on the patient’s use of the health service, and there is a coincidence between the three forms. For example, some patients who had taken outpatient treatment and were also hospitalized. (2) Health expenditures generated by different forms of health services do not have homogeneity of variance, so the non-parametric rank sum test is used. The rank sum test Chi-squared = 93.136, *p* = 0.0001, which indicates that the difference in the average health expenditures generated by different forms of health service is significant at the 5% statistical level.
Health expenditures of diabetes patients will seriously hamper the improvement of the household life quality. When the defining criteria are 15%, 25%, and 40%, respectively, the CHERs of Chinese middle-aged and elderly patients with diabetes were 66.71%, 60.07%, and 54.59%, respectively, while only 26.71% of diabetics were in high FERD. This shows that, when deducting the necessary food expenditures of households, the number of households facing high economic risk of diseases will increase by 30% (438 households). If the health expenditure is large relative to the

Table 3: Distribution of the family economic risk of diseases (FERD) of Chinese middle-aged and elderly people with diabetes

| Group                          | 0 ≤ FERD ≤ 0.5 | 0.5 < FERD ≤ 1.0 | FERD > 1.0 or FERD < 0 | Statistics | p-Value |
|-------------------------------|----------------|------------------|------------------------|------------|--------|
| Urban and rural               |                |                  |                        |            |        |
| Urban                         | 74.62<sup>a</sup> | 7.28<sup>b</sup> | 18.10<sup>b</sup>     | $\chi^2 = 44.47$ | < 0.001 |
| Rural                         | 58.00<sup>a</sup> | 9.44<sup>b</sup> | 32.57<sup>b</sup>     |            |        |
| Age (years)                   |                |                  |                        |            |        |
| ≤ 59 years old                | 67.40          | 7.69             | 24.91                  |            |        |
| ≥ 60 and ≤ 74 years           | 63.61          | 9.43             | 26.95                  |            |        |
| ≥ 75 years old                | 61.05          | 7.56             | 31.40                  |            |        |
| Gender                        |                |                  |                        |            |        |
| Male                          | 67.10<sup>a</sup> | 7.78<sup>a</sup> | 25.12<sup>a</sup>     | $\chi^2 = 2.705$ | 0.259  |
| Female                        | 62.99<sup>a</sup> | 9.13<sup>a</sup> | 27.88<sup>a</sup>     |            |        |
| Marital status                |                |                  |                        |            |        |
| Married and living together   | 67.01<sup>a</sup> | 7.78<sup>a</sup> | 25.21<sup>b</sup>     | $\chi^2 = 13.92$ | < 0.001 |
| Other (unmarried, separated, divorced, etc.) | 55.52<sup>a</sup> | 11.72<sup>b</sup> | 32.76<sup>b</sup> |            |        |
| Type of basic medical insurance |                |                  |                        |            |        |
| Without basic medical insurance | 79.38        | 6.53             | 14.09                  | $G = 0.165$ | < 0.001 |
| NRCMI                         | 65.41          | 9.77             | 24.81                  |            |        |
| URBMI                         | 58.19          | 9.42             | 32.39                  |            |        |
| UEBMI                         | 71.12          | 6.95             | 21.93                  |            |        |
| Household income              |                |                  |                        |            |        |
| Low level of household income | 27.40          | 7.96             | 64.64                  | $G = 0.759$ | < 0.001 |
| Medium level of household income | 68.95       | 13.06            | 17.99                  |            |        |
| High level of household income | 89.40         | 5.30             | 5.30                   |            |        |
| Number of comorbidities       |                |                  |                        |            |        |
| ≤ 3 comorbidities             | 68.75<sup>a</sup> | 7.86<sup>a, b</sup> | 23.39<sup>b</sup>     | $\chi^2 = 22.32$ | < 0.001 |
| > 3 comorbidities             | 56.20<sup>a</sup> | 10.04<sup>b</sup> | 33.76<sup>b</sup>     |            |        |
| Self-evaluation of health status |                |                  |                        |            |        |
| Health self-evaluation is poor | 53.69        | 9.29             | 37.02                  | $G = 0.364$ | < 0.001 |
| Health self-evaluation is fair | 74.16         | 8.29             | 17.54                  |            |        |
| Health self-evaluation is good | 74.84         | 6.45             | 18.71                  |            |        |
| Whether smoking               |                |                  |                        |            |        |
| Smoking                       | 70.63          | 6.27             | 23.10                  | $\chi^2 = 6.266$ | 0.044  |
| Non-smoking                   | 63.18          | 9.16             | 27.66                  |            |        |
| Whether drinking              |                |                  |                        |            |        |
| Drinking                      | 74.12<sup>a</sup> | 6.53<sup>a, b</sup> | 19.35<sup>b</sup>     | $\chi^2 = 21.20$ | < 0.001 |
| Non-drinking                  | 61.21<sup>a</sup> | 9.32<sup>a, b</sup> | 29.47<sup>b</sup> |            |        |
| Family economic risk of disease of diabetics | 64.73         | 8.56             | 26.71                  |            |        |

NRCMI = new rural cooperative medical insurance; UEBMI = urban employee basic medical insurance; URBMI = urban resident basic medical insurance

(1) This article refers to the percentile method to rank all the respondents’ household income into three equal parts, including low level of household income (household income ≤ 4110 yuan/year), medium level of household income (household income > 4110 yuan/year and ≤ 26,014 yuan/year), and high level of household income (household income > 26,014 yuan/year). (2) The age grouping is based on the WHO’s age grouping, which defines 45–59 years old as the middle-aged, 60–74 years old as the younger elderly, 75–89 years old as the elderly, and ≥ 90 years old as the longevity elderly). Because of the small number of longevity elderly in the database, this article combined the longevity elderly and the elderly groups. (3) The Chi-squared test was used for the single-order classification data and the gamma coefficient was used to analyze the correlation of the data for the classification data that are bidirectionally ordered and with different attributes. (4) The Chi-squared test contains comparisons between different groups. The different superscript letters of each group indicate that the difference between the two groups is statistically significant.
Table 4  Situation of the catastrophic health expenditure rate (CHER) in Chinese middle-aged and elderly patients with diabetes

| Group                        | The defining criteria is 15% |             | The defining criteria is 25% |             | The defining criteria is 40% |             |
|------------------------------|-----------------------------|-------------|-----------------------------|-------------|-----------------------------|-------------|
|                              | Rate | \( \chi^2 \) | \( p \)-Value | Rate | \( \chi^2 \) | \( p \)-Value | Rate | \( \chi^2 \) | \( p \)-Value |
| Urban and rural              |      |              |               |      |              |               |      |              |               |
| Urban                        | 58.38 | 49.75 |               | 43.65 |               |               | 47.888 | < 0.001 |               |
| Rural                        | 72.38 | 67.09 |               | 62.03 |               |               | 62.03 |               |               |
| Age (years)                  |      |              |               |      |              |               |      |              |               |
| ≤ 59                         | 65.20a | 57.51a | 0.337 0.118   | 52.38a | 0.095         |               | 4.699 | 0.095         |               |
| ≥ 60 and ≤ 74               | 68.46a | 62.67a |               | 57.28a |               |               |      |              |               |
| ≥ 75                         | 63.95a | 56.98a |               | 50.00a |               |               |      |              |               |
| Gender                       |      |              |               |      |              |               |      |              |               |
| Male                         | 63.37 | 57.21 |               | 52.19 |               |               | 52.19 |               |               |
| Female                       | 69.16 | 62.16 |               | 56.35 |               |               | 56.35 |               |               |
| Marital status               |      |              |               |      |              |               |      |              |               |
| Married and living together  | 66.75 | 59.74 |               | 54.19 |               |               | 54.19 |               |               |
| Other (unmarried, separated, divorced, etc.) | 66.55 | 61.38 |               | 56.21 |               |               | 56.21 |               |               |
| Type of basic medical insurance | 48.439 | 58.882 | < 0.001 | 40.888 | < 0.001 |               | 78.632 | < 0.001 |               |
| Without basic medical insurance | 58.82a | 52.94a |               | 47.06a |               |               |      |              |               |
| NRCMI                        | 73.38b | 67.96b |               | 63.02b |               |               |      |              |               |
| URBMI                        | 66.17b | 54.89b |               | 51.13b |               |               |      |              |               |
| UEBMI                        | 52.58b | 43.99b |               | 34.02c |               |               |      |              |               |
| Household income             |      |              |               |      |              |               |      |              |               |
| Low level of household income | 93.91a | 93.44a | 0.022 0.001   | 91.33a | < 0.001       |               |      |              |               |
| Medium level of household income | 73.88b | 66.17b |               | 59.74b |               |               |      |              |               |
| High level of household income | 40.28c | 29.86c |               | 22.61c |               |               |      |              |               |
| Number of comorbidities      |      |              |               |      |              |               |      |              |               |
| ≤ 3 comorbidities           | 64.11 | 56.45 |               | 51.21 |               |               |      |              |               |
| > 3 comorbidities           | 72.22 | 67.74 |               | 61.75 |               |               |      |              |               |
| Self-evaluation of health status | 74.325 | 54.170 | < 0.001 | 51.963 | < 0.001       |               |      |              |               |
| Health self-evaluation is poor | 78.02a | 70.06a |               | 64.45a |               |               |      |              |               |
| Health self-evaluation is fair | 57.89b | 52.47b |               | 47.37b |               |               |      |              |               |
| Health self-evaluation is good | 52.90b | 47.10b |               | 40.65b |               |               |      |              |               |
| Whether smoking              |      |              |               |      |              |               |      |              |               |
| Smoking                      | 63.60 | 57.48 |               | 52.61 |               |               |      |              |               |
| Non-smoking                  | 68.62 | 61.66 |               | 55.80 |               |               |      |              |               |
| Whether drinking             |      |              |               |      |              |               |      |              |               |
| Drinking                     | 59.30 | 52.51 |               | 47.49 |               |               |      |              |               |
| Non-drinking                 | 69.49 | 62.90 |               | 57.25 |               |               |      |              |               |
| Catastrophic health expenditure rate (%) | 66.71 | 60.07 | 0.048 0.113 0.141 | 54.59 | 0.148 0.235 0.113 | 0.001 0.001 0.001 |

NRCMI = new rural cooperative medical insurance; UEBMI = urban employee basic medical insurance; URBMI = urban resident basic medical insurance

This table describes whether there is a difference in the CHER between different groups, so the Pearson Chi-squared test is used. The Chi-squared test included comparisons between different groups, with the different superscript letters of each group indicating a statistically significant difference between the two groups.

The household’s available resources or it is catastrophic for the household, such health expenditures will hinder the improvement of household life quality (Zhao et al. 2019). The huge health expenditures of middle-aged and elderly people with diabetes in China may cause the household to reduce other expenses, such as education, entertainment, and may even reduce the expenditure on food and other necessities. This may lead to diabetes patients entering a low life quality and may become a vicious circle. This circle can be explained in the following two steps. First of all, many complications of
Table 5  The average gap of catastrophic health expenditure (AGCHE) and relative gap of catastrophic health expenditure (RGCHE) in Chinese middle-aged and elderly patients with diabetes

| Group                                | The defining criteria is 15% | The defining criteria is 25% | The defining criteria is 40% |
|--------------------------------------|------------------------------|------------------------------|------------------------------|
|                                      | AGCHE | RGCHE | AGCHE | RGCHE | AGCHE | RGCHE | AGCHE | RGCHE |
| Urban and rural                      |       |       |       |       |       |       |       |       |
| Urban                                | 7.87  | 13.48 | 7.85  | 15.78 | 7.83  | 17.94 |
| Rural                                | 18.79 | 25.96 | 18.80 | 28.02 | 18.82 | 30.34 |
| Age (years)                          |       |       |       |       |       |       |       |       |
| ≤ 59 years old                       | 29.14 | 44.69 | 29.14 | 50.66 | 29.14 | 55.63 |
| ≥ 60 years old and ≤ 74              | 5.07  | 7.40  | 5.07  | 8.09  | 5.08  | 8.87  |
| ≥ 75 years old                       | 7.61  | 11.89 | 7.60  | 13.33 | 7.59  | 15.18 |
| Gender                               |       |       |       |       |       |       |       |       |
| Male                                 | 24.42 | 38.53 | 24.42 | 42.68 | 24.42 | 46.80 |
| Female                               | 7.01  | 10.14 | 7.01  | 11.28 | 7.01  | 12.45 |
| Marital status                       |       |       |       |       |       |       |       |       |
| Married and living together          | 16.64 | 24.93 | 16.64 | 27.85 | 16.64 | 30.72 |
| Other (unmarried, separated, divorced, etc.) | 5.20  | 7.82  | 5.20  | 8.47  | 5.21  | 9.26  |
| Type of basic medical insurance      |       |       |       |       |       |       |       |       |
| Without basic medical insurance      | 19.49 | 33.14 | 19.48 | 36.79 | 19.46 | 41.36 |
| NRCMI                                | 16.58 | 22.59 | 16.59 | 24.41 | 16.61 | 26.37 |
| URBMI                                | 14.17 | 21.41 | 14.15 | 25.78 | 14.13 | 27.65 |
| UEBMI                                | 4.72  | 8.97  | 4.69  | 10.67 | 4.67  | 12.82 |
| Household income                     |       |       |       |       |       |       |       |       |
| Low level of household income        | 13.04 | 13.89 | 13.09 | 14.01 | 13.17 | 14.42 |
| Medium level of household income     | 31.88 | 43.15 | 31.86 | 48.15 | 31.84 | 53.29 |
| High level of household income       | 0.92  | 2.29  | 0.89  | 2.99  | 0.87  | 3.83  |
| Number of comorbidities              |       |       |       |       |       |       |       |       |
| ≤ 3 comorbidities                   | 15.88 | 24.77 | 15.88 | 28.13 | 15.89 | 31.02 |
| > 3 comorbidities                   | 11.16 | 15.45 | 11.16 | 16.47 | 11.16 | 18.08 |
| Self-evaluation of health status     |       |       |       |       |       |       |       |       |
| Health self-evaluation is poor       | 1.73  | 3.27  | 1.73  | 3.68  | 1.74  | 4.29  |
| Health self-evaluation is fair       | 9.74  | 16.82 | 9.73  | 18.55 | 9.73  | 20.55 |
| Health self-evaluation is good       | 21.54 | 27.61 | 21.54 | 30.75 | 21.55 | 33.43 |
| Whether smoking                      |       |       |       |       |       |       |       |       |
| Smoking                              | 27.41 | 43.09 | 27.40 | 47.68 | 27.41 | 52.10 |
| Non-smoking                          | 6.37  | 9.29  | 6.37  | 10.33 | 6.38  | 11.43 |
| Whether drinking                     |       |       |       |       |       |       |       |       |
| Drinking                             | 27.14 | 45.76 | 27.14 | 51.69 | 27.16 | 57.19 |
| Non-drinking                         | 9.58  | 13.79 | 9.58  | 15.23 | 9.58  | 16.73 |
| The economic gap of diabetics        | 14.37 | 21.54 | 14.37 | 23.92 | 14.37 | 26.33 |

NRCMI = new rural cooperative medical insurance; UEBMI = urban employee basic medical insurance; URBMI = urban resident basic medical insurance

diabetes patients seriously affect their health, which will directly lead to a decline in their working hours and work ability. Then, such a decline in labor force will indirectly lead to a decrease in their income (Zhang et al. 2017). Second, the high health expenditure of diabetic patients will affect the spending on education or culture; this will directly affect the opportunity of household members to acquire knowledge and indirectly affect their ability to create wealth. Therefore, if diabetic patients are not well protected against the economic risk of diseases, increasing health expenditures will seriously hinder the improvement of the household life quality. Diabetes will increase the diseases’ economic risk of residents, and improving the diagnosis rate of diabetic patients is conducive to reducing the economic risk of
patients’ diseases. The CHER of diabetic patients is 3.31 times that of residents, which is also calculated based on the CHARLS database (Xu and Zhai 2018). This indicates that the economic risk of diseases faced by diabetic patients is much higher than that of residents. The complications of diabetes are many and serious, especially the serious harm to the cardiovascular and cerebrovascular diseases, which will increase the economic burden of diabetic patients (Seidell and Halberstadt 2015). The corrected RRD in this article is 1.80, which means that the health expenditure of diabetic patients is 1.80 times that of non-diabetic patients when the difference in patients’ income is eliminated. The higher corrected RRD also indicates that diabetes increases the economic burden and the economic risk of the diseases. Diabetes is a chronic disease and early treatment and control of blood glucose are able to reduce the incidence of complications (Liu et al. 2018). Moreover, the proportion of undiagnosed diabetes in China is as high as 63%, and these undiagnosed patients are unable to take measures to control their blood glucose in time, which will increase the probability of the occurrence of complications and make diabetics face a higher economic risk of diseases (Chinese Medical Association Diabetes Branch 2018). Therefore, if the diagnosis rate of diabetes is increased, the economic risk of diseases will be reduced.

Diabetes patients with different basic medical insurance have different economic risks of disease. The rate of diabetics with UEBMI at a low FERD was higher than that of diabetics with URBMI and NRCMI, and their CHER was smaller than that of patients with URBMI and NRCMI. This shows that the diseases’ economic risk of diabetics with UEBMI is lower than that of patients purchasing the other two types of insurance, which may be because the protection level of different basic medical insurance in China is unequal. Taking the reimbursement policy for diabetic patients in Beijing as an example, the starting line and reimbursement ratio of diabetics’ hospitalization expenses for the NRCMI and URBMI are 300 yuan (80%), 800 yuan (78%), and 1300 yuan (73%) in the first-, second-, and third-level hospitals, and the ceiling line is 250,000 yuan. For diabetics with UEBMI, after the accumulative hospitalization expenses reached 30,000 yuan, the reimbursement rates in the first-, second-, and third-level hospitals are 90%, 87%, and 85%, respectively. As the cumulative costs increased, the maximum reimbursement rate could reach 97%, and its ceiling is 500,000 yuan. The unfairness of the reimbursement policy between different basic medical insurances may be the main reason that diabetes patients with different basic medical insurance have different economic risks of disease.

Conclusion

Chinese middle-aged and elderly patients with diabetes face higher economic risk of diseases, and unhealthy lifestyles will increase the economic risk. China’s basic medical insurance system has a certain resistance to the diseases’ economic risk of diabetes patients, but it cannot meet the actual needs of patients. If diabetics are not sufficiently resistant to the economic risk of diseases, their household life quality will decline and may fall into a vicious circle. We also found that increasing the diagnosis rate of diabetic patients will help reduce the threat of the economic risk of diseases and adjusting the difference in the protection level between different basic medical insurance may become the key to effectively resisting the diseases’ economic risk of diabetes patients.

Limitations

In this article, the data are derived from an authoritative database and it use multiple indicators to comprehensively measure the economic risk of diseases in Chinese middle-aged and elderly patients with diabetes, so it is more in line with China’s actual situation than other studies. But there are still some shortcomings. (1) The CHARLS program has been in operation for 10 years, and there are some respondents who have withdrawn from the project due to death and respondents with resistance, which will result in the loss of a valid sample. (2) Much of the data in the CHARLS database comes from respondents’ self-reports, such as consumer expenditures, health expenditures, etc., which can lead to some bias in the data. (3) The subject of this article is those who know they have diabetes, so it misses the estimation of diseases’ economic risk of diabetes patients who are not aware of their diabetes. In the follow-up study, a comparative analysis of the diseases’ economic risk of patients will be conducted on whether the patient is aware of their diabetes. On this basis, the evaluation indicator of poverty-related health expenditures will be added to in order to more accurately measure the diseases’ economic risk of diabetes patients.

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Compliance with ethical standards

Conflict of interest The content of this study was independently completed by the authors listed. There is no fund project support and no other scholars are involved. Therefore, there are no other relevant interest institutions and individuals and all authors agree with the author order in the article.
Ethical approval  This article does not address any moral and ethical issues.

Informed consent  All authors are informed.

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