ORIGINAL ARTICLE

Catastrophic health expenditure among type 2 diabetes mellitus patients: A province-wide study in Shandong, China

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ABSTRACT

Aims/Introduction: Diabetes mellitus often causes high economic burden on the patients and their households. The present study aimed to assess the incidence and intensity of catastrophic health expenditure (CHE) relating to type 2 diabetes mellitus care, and to explore its determinants in China.

Materials and Methods: A total of 1,948 type 2 diabetes patients were included in the analysis. CHE for type 2 diabetes mellitus was defined as out-of-pocket payments for diabetes care that were ≥40% of the non-food expenditure of a household. The Chi-square-test was used to identify the factors associated with CHE. Multivariate logistic regression was used to assess the effects of explanatory analysis variables.

Results: The incidence of CHE for type 2 diabetes mellitus care was 13.8%. An association was observed between CHE incidence and household income level, and the poorest group was more likely to experience CHE as a result of diabetes mellitus care. The type 2 diabetes mellitus patients with complications were found to be more likely to experience CHE. Diabetes patients who experienced outpatient or inpatient services increased the likelihood of CHE, and those who experienced inpatient services were more likely to incur CHE.

Conclusions: Type 2 diabetes mellitus has a significantly catastrophic effect on patients and their households in China. Early screening for type 2 diabetes mellitus patients among the high-risk groups and effective management of the detected cases should be priorities to reduce the overall healthcare expenditure for type 2 diabetes mellitus.

INTRODUCTION

With rapid development, abrupt transition of lifestyles and social aging, the prevalence of diabetes is rapidly increasing worldwide[1,2]. Globally, the number of adults aged 20–79 years living with diabetes has risen from 108 million in 1980 to 415 million in 2015[3,4]. The number is predicted to reach 642 million by 2040[4]. The global prevalence of diabetes among adults aged >18 years has nearly doubled since 1980, rising from 4.7% in 1980 to 8.5% in 2014[3]. It has been found that diabetes prevalence is higher in low- and middle-income countries than in high-income countries[3]. In China, the prevalence rate of diabetes is 9.4%[5], which is the highest number of people (aged 20–79 years) with diabetes in the world, up to 109.6 million, and this number is predicted to reach 150.7 million by

2040[4]. The morbidity rate of type 2 diabetes mellitus accounted for 93.70% of all types of diabetes in China[6]. China alone had 1.3 million deaths as a result of diabetes in 2015, with 40.8% of those deaths occurring in people aged <60 years[4].

The International Diabetes Federation reported that the majority of countries spent between 5 and 20% of their total health expenditure on diabetes each year[4]. According to the purchasing power of the US dollar in 2015, global health spending to treat diabetes and prevent complications was estimated to range from $673 billion to $1,197 billion in 2015. By 2040, this number is projected to exceed $802 billion to $1,452 billion[4]. An estimated average of $1,622 to $2,886 per person with diabetes was spent globally on treating and managing the disease in 2015. In China, approximately $51 million was spent on diabetes-related care in 2015, second only to the USA[4]. Likewise, an estimated average annual cost per patient increased from $1,655 to $1,857 in China[6]. Out-of-

pocket (OOP) medical cost can still be considered a heavy burden for diabetes patients (approximately 20% of disposable income)[7].

Diabetes mellitus is considered to be one of the medical emergencies of the 21st century[4], as it not only seriously affects the physical and mental health of patients, but also pushes some patients and their households into poverty, and is a threat to social and economic development[8]. Diabetes patients need to receive good and high-quality treatment, which is usually available at costly hospitals when serious complications and acute symptoms occur, and, generally, it is an OOP payment. Some patients often borrow money or sell assets to pay for the treatment and related medications. This places many of the patients and their households at a higher finical risk, which can be measured in terms of catastrophic health expenditure (CHE).

Many studies have analyzed the patients and their households' expenditure on diabetes care in China, but few have assessed the associated incidence, intensity and determinants of CHE. The present study's overall goal was to describe the profile of CHE in type 2 diabetes mellitus patients. To do so, we had several specific objectives. First, we describe the extent of the incidence and intensity of CHE for type 2 diabetes mellitus care in China. Second, we explore the factors associated with CHE in type 2 diabetes mellitus patients.

METHODS

Study site
The present study was carried out in Shandong province, China. Shandong has the second largest total population in China (nearly 100 million in 2016), and its gross domestic product (GDP) ranks third in the country. The prevalence of diabetes mellitus in people aged ≥20 years was 9.9% in 2008, which was significantly higher than that in the whole country.

Study participants
A multistage stratified cluster sampling method was used to select participants. First, according to the proportion of urban to rural residents (1–2) and GDP per capita in Shandong in 2015, we selected two urban districts (one above the medium GDP level, Fushan; and the other below the medium GDP level, Weicheng) and four rural counties (one above the medium level, Rushan; two at the medium level, Yiyuan and Gaotang; and one below the medium level, Liangshan) as study sites. Second, according to per capita GDP, all of the subdistricts and townships in each selected urban district and rural county were divided into three levels. For each level, one subdistrict and one township were randomly selected. Third, we randomly selected two communities or villages with >1,000 permanent residents from each of the selected subdistricts and townships. All of the diabetes patients registered in the NCDs management system in the sampling communities or villages were recruited in the survey. A total of 2,183 diabetes patients were recruited, of which 1,948 type 2 diabetes mellitus patients with complete data were included in the analysis.

Data collection
A cross-sectional study was carried out from August to October, 2016. All the participants were interviewed face-to-face using a structured questionnaire by trained master's degree students from Shandong University School of Public Health. To ensure quality, all of the completed questionnaires were carefully checked by supervisors after the interview each day. The questionnaire included diabetes patients' demographic information (sex, age, education level, location, health insurance status, household income, household expenditure, food expenditure etc.), diabetes patients' health behaviors (smoking, drinking, exercise etc.), and diabetes patients' outpatient and inpatient health service utilization conditions (health service expenditure).

Variables and definitions
CHE is usually assessed by incidence and intensity indicators. Head count is used to measure incidence; mean gap and mean positive gap are used to reflect intensity. In the present study, CHE means the households whose OOP payments for diabetes care are ≥40% of their households' capacity to pay. The specific calculating methods of CHE incidence and intensity are described in detail by Wagstaff et al.[9–11] elsewhere.

Household income in the present study is defined as four categories: quartile 1, quartile 2, quartile 3 and quartile 4. Quartile 1 was the lowest quartile, quartile 2 was the mid-low quartile, quartile 3 was the mid-high quartile and quartile 4 was the highest quartile. Capacity to pay is the household expenditure minus food expenditure.

In the current study, if the patients engaged in physical exercise at least twice in the past week before the survey and for >30 min each time, 'physical exercise' was coded as 'yes.'

Diabetic complication was measured by using the question, 'Have you been diagnosed with diabetic complications?'. If the answer was 'yes', complication as coded as '1,' and if the answer was 'no,' complication was coded as '0.'

Outpatients' service was measured by using the question, 'Have you used an outpatient service in the past 6 months due to type 2 diabetes mellitus?'. If the answer was 'yes,' outpatient service was coded as '1,' and if the answer was 'no,' outpatient service was coded as '0.'

Inpatients' service was measured by using the question, 'Have you used an inpatient service in the past 12 months due to type 2 diabetes mellitus?'. If the answer was 'yes,' inpatient service was coded as '1,' and if the answer was 'no,' inpatient service was coded as '0.'

Physical examination was measured by using the question, 'Have you ever had a regular physical examination in the past 12 months?'. If the answer was 'yes,' physical examination was coded as '1,' and if the answer was 'no,' physical examination was coded as '0.'

Statistical analysis
The data were double entered and checked using EPI Data 6.04 (Epidata Association, Odense, Denmark). SPSS 22.0 (IBM

Table 1 | Demographic, health service and health behavior characteristics of type 2 diabetes mellitus patients in Shandong, China (2016)

Variable	Survey frequency	Weight (%)
Observation	1,948	100.0
Sex		
Male	652	33.7
Female	1,296	66.3
Age groups (years)		
20–39	9	4.4
40–49	101	6.3
50–59	398	22.7
60–69	878	44.5
70–79	472	21.8
≥80	90	4.3
Residence		
Urban	457	12.4
Rural	1,491	87.6
Marital status		
Never married	23	1.3
Married	1,660	85.2
Divorced/widowed	265	13.5
Educational attainment		
Illiterate	718	42.2
Primary education	653	31.4
Junior education	414	18.9
Senior education	141	6.7
University or higher	22	0.8
Health insurance		
Self-pay	23	1.2
MIUE	246	6.7
MIUR	204	5.6
NCMS	1,475	86.5
Household income[†]		
Q1	476	28.1
Q2	485	25.5
Q3	495	25.3
Q4	502	21.1
Household size		
1–2	1,504	75.4
3–4	284	15.3
≥5	160	9.3
Sites		
Fushan	316	10.3
Gaotang	340	17.4
Rushan	305	16.7
Liangshan	323	23.8
Weicheng	341	8.8
Yiyuan	323	23.0
Diabetic complications		
Yes	354	17.6
No	1,594	82.4
Outpatient service		
Yes	279	14.8
No	1,669	85.2

Table 1 (Continued)

Variable	Survey frequency	Weight (%)
Inpatient service		
Yes	222	11.0
No	1,726	89.0
Smoking		
Never smoking	1,535	78.5
Always smoking	231	11.9
Quit smoking	182	9.6
Drinking		
Yes	270	13.5
No	1,678	86.5
Physical exercise		
Yes	1,224	62.0
No	724	38.0
Self-reported health status		
Good	469	22.5
Normal	839	44.0
Bad	640	33.5
Physical examination		
Yes	1,716	89.3
No	232	10.7

[†]Quartile 1 (Q1) is the poorest and quartile 4 (Q4) is the richest. MIUE, Medical Insurance for Urban Employees Scheme; MIUR, Medical Insurance for Urban Residents Scheme; NCMS, New Cooperative Medical Scheme.

Corporation, Armonk, NY, USA) was used to analyze the data. Household income, household expenditure, OOP and capacity to pay were presented as means (standard deviation) and medians to allow for the expected positive distribution. Sensitivity analysis of the incidence and intensity of CHE for diabetes mellitus was applied using different thresholds across different household income groups. The chi-square-test was used to identify factors associated with CHE. Multivariate logistic regression was used to assess the effects of explanatory analysis variables. Survey procedures were used to analyze survey data by taking into account the sample design.

Ethical considerations
The Ethics Committee of Shandong CDC reviewed and approved the study protocols and instruments. Written informed consent was obtained from all of the participants before the interview.

RESULTS
Characteristics of the study participants
Table 1 showed the characteristics of the study patients. The majority of the 1,948 type 2 diabetes patients were women (66.3%), aged ≥60 years (70.6%), from rural areas (87.6%), married (85.2%) and illiterate (42.2%). Approximately 86.5% of the patients were covered by the New Cooperative Medical Scheme, and 75.4% of the households had at most two

members. As for the health behaviors, 78.5% were never-smokers, 86.5% did not drink in the past 1 month, 62.0% did exercises in the past week and 89.3% had at least one physical examination in the past 12 months. With regard to health status, 17.6% had diabetic complications, 14.8% had experienced outpatient services in the past 6 months, and 11.0% had experienced inpatient services as a result of type 2 diabetes mellitus and its complications in the past 12 months. Approximately 77.5% of the patients reported normal or good health status.

Household income/expenditure, capacity to pay and opp payments for type 2 diabetes mellitus care

The mean annual household income and expenditure were $3,196 (median $1,632) and $3,059 (median $3,090), respectively. The urban patients' mean annual household income and expenditure were almost threefold and twofold those of the rural patients', respectively. The average capacity to pay was $2,139, with a median of $2,961. The urban patients' mean capacity to pay was 1.5-fold that of the rural patients. The mean OOP payment for type 2 diabetes mellitus care was $339 (median $90), accounting for approximately 15.8% of the mean capacity to pay (Table 2).

CHE for type 2 diabetes mellitus care

Table 3 presents the incidence, intensity and concentration indicators of CHE for type 2 diabetes mellitus care. In the poorest quartile (quartile 1) and richest quartile (quartile 4), CHE incidences were all highest and lowest, respectively, across different thresholds. The mean gap and mean positive gap indicators are also presented in Table 3. On average, healthcare payments for type 2 diabetes mellitus were 8.5% higher when measured using a 40% threshold. For households that experienced CHE, the mean positive gap showed that this excess increased to 62.1%.

Determinants of CHEs

Univariate analyses showed that those diabetes patients who were women ($P < 0.01$), who were from the poorest group ($P < 0.01$), who were from small households ($P < 0.01$), who had diabetic complications ($P < 0.001$), who used outpatient services in the past 6 months ($P < 0.001$), who used inpatient services in the past 12 months ($P < 0.001$), who did not drink in the past month ($P < 0.01$) and who thought self-reported health status were below normal ($P < 0.01$) were more likely to experience CHE. Those who engaged in physical exercise at least three times (>30 min each time) in the past week ($P < 0.01$) and who had physical examinations in the past 12 months ($P < 0.05$) were found to be less likely to experience CHE. Multiple logistic regression analysis identified that factors including household income, diabetic complications, outpatient service, inpatient service and self-reported health status were determinants linked with CHE for type 2 diabetes mellitus care (Tables 4 and S1).

DISCUSSION

In the present study, we found that the incidence of CHE for type 2 diabetes mellitus care was 13.8%. A study using the data of the Social-Economic Survey of Urban and Rural Households in China found that OOP health expenditure pushed 5.2% of the households into catastrophe based on the same threshold of CHE as the present study[12]. Zhao *et al.*[13] found that the incidence of CHE in general households in rural Gansu and

Table 2 | Distribution of direct costs and the incidence of catastrophic health expenditure for type 2 diabetes mellitus care in Shandong, China (2016)

Indicators	Residence		All
	Urban	Rural	
Survey frequency	457	1,491	1,948
Average OOP costs of diabetes mellitus care ($US)[†]			
Mean (SD)	406 (761)	329 (883)	339 (869)
Median (p25, p75)	142 (26, 445)	89 (23, 297)	90 (22, 320)
Average annual household income ($US)			
Mean (SD)	7,451 (7,722)	2,591 (3,542)	3,196 (4,579)
Median (p25, p75)	6,647 (2,967, 10,326)	1,442 (653, 3,367)	1,632 (712, 4,184)
Average annual household expenditure ($US)			
Mean (SD)	4,915 (4,057)	2,795 (2,700)	3,059 (2,987)
Median (p25, p75)	4,136 (2,849, 5,816)	2,134 (1,276, 3,467)	2,315 (1,365, 3,834)
Average capacity to pay ($US)			
Mean (SD)	2,930 (3,586)	2,027 (2,433)	2,139 (2,621)
Median (p25, p75)	2,092 (1,387, 3,272)	1,409 (813, 2,395)	1,484 (846, 2,567)
OOP costs share of capacity to pay (%)	13.9	16.2	15.8
Households with catastrophic health expenditure (%)	13.1	13.8	13.8

[†]Based on an exchange rate of 6.74 RMB yuan to $US1.00 in the month the survey was carried out. OOP, out-of-pocket; SD, standard deviation.

Table 3 | Incidence and intensity of catastrophic health expenditure for type 2 diabetes mellitus care by household economic status in Shandong, China (2016)

Catastrophic health expenditure	Thresholds				
	20%	30%	40%	50%	60%
Head count (%)					
Q1	33.4	23.7	17.1	14.5	11.6
Q2	28.5	17.5	13.1	10.6	8.1
Q3	28.4	20.2	14.4	9.2	7.4
Q4	21.3	13.9	9.3	6.6	4.8
Total	28.3	19.2	13.8	10.5	8.2
P-value	0.000	0.000	0.000	0.000	0.000
Mean catastrophic payment gap (%)					
Q1	18.8	16.1	14.1	12.6	11.3
Q2	11.2	9.1	7.6	6.5	5.5
Q3	11.0	8.6	6.9	5.8	5.0
Q4	6.9	5.2	4.1	3.2	2.7
Total	12.4	10.1	8.5	7.4	6.4
Mean positive gap (%)					
Q1	56.3	68.0	82.9	86.8	98.3
Q2	39.6	51.7	58.2	61.3	67.9
Q3	38.8	42.7	47.9	63.0	67.7
Q4	32.6	37.5	44.3	50.1	56.2
Total	43.8	52.8	62.1	70.1	78.5

Q1, quartile 1; Q2, quartile 2; Q3, quartile 3; Q4, quartile 4.

Heilongjiang province were 6.3 and 5.4%, respectively. A study by Yan *et al.*[14] showed that 5.4% of the rural households in Shaanxi province experienced CHE in 2011. Another study by Gong *et al.*[15] found that 4.5 and 4.3% of the rural households experienced CHE in 2006 and 2008, respectively, in the same province as the present study. The mean gap and mean positive gap of the type 2 diabetes mellitus care were 8.5 and 62.1%, respectively. Both were higher than those in general households in rural Gansu (0.95, 15.03%) and rural Heilongjiang (0.82, 14.65%)[13]. They were also higher than those in rural Shaanxi in 2009 (4.14, 21.40%) and 2011 (2.45, 19.64%)[14]. The CHE incidence and intensity from OOP for type 2 diabetes mellitus care in the present study were much higher than those of the aforementioned studies, which showed that type 2 diabetes mellitus had a significant catastrophe-incurring effect on the patients and their households in China.

The risk of CHE was found to be closely associated with economic status. Those households with type 2 diabetes mellitus patients in poorer quartiles were at higher risk of suffering CHE, which was similar to previous studies in China and some other countries[16–18]. CHE incidence and intensity indicators, using different thresholds (20, 30, 40, 50, 60%), were all highest in the poorest households (quartile 1). When adjusting for potential confounders, the economic status was still linked with CHE.

Clearly, the present finding should be an impetus to take more comprehensive measures in poverty alleviation targeting those poor households with type 2 diabetes mellitus patients.

We found that the diabetes patients with complications were more likely to experience CHE. Some previous studies have shown that complication-induced healthcare expenditure caused a high economic burden in diabetes patients[7,19,20]. A study by Williams *et al.*[19] showed that the presence of microvascular complications of type 2 diabetes mellitus resulted in an increased cost of 70% compared with those with no complications, and the cost would even increase up to 3.5-fold in those with both microvascular and macrovascular complications compared with those with no evidence of complications. The presence of complications exerted a substantial impact on the costs for patients with type 2 diabetes mellitus. This finding showed an urgent need for the prevention and control of type 2 diabetes mellitus-related complications to reduce the healthcare expenditures and potential CHE for diabetes patients and their households. Diabetic case management should be a priority, including optimal management of blood glucose to prevent and delay the presence of diabetic complications, and early detection and management of existing complications to prevent further progression.

Diabetes patients who experienced outpatient services and inpatient services as a result of diabetes mellitus and its complications increased the probability of CHE. Compared with outpatients' services, the diabetes patients who experienced inpatient services were more likely to incur CHE. A national survey on the economic burden of type 2 diabetes mellitus from 2007 to 2008 showed that the average outpatient cost per person at a visit was $46.22 and $54.73 in urban and rural China, respectively. At the same time, the average inpatient cost per person at a visit was $2,222.77 and $499.73 in urban and rural China[21]. Hospitalization cost plays a decisive role in direct medical costs of type 2 diabetes mellitus, which was also shown by some other studies[20]. In addition to the direct healthcare costs, the indirect expenses, including transportation expenses, accommodation expenses and some other expenses, incurred by diabetes patients and their families during the process of seeking healthcare services would inevitably increase the likelihood of CHE. The latest version of the Guideline for the Basic Public Health Service in China (2017) recommends early screening for type 2 diabetes mellitus among high-risk groups, and targeted interventions for different types of detected cases so as to provide timely treatment. This reduces the overall diabetes mellitus-related healthcare costs.

The present study had some limitations. First, data about income, expenditure and health service utilization relied on self-reported information, which would probably result in recall basis. Second, the data showed here were derived from a cross-sectional study, and the relationship between identified factors and CHE could not be interpreted as cause and effect.

The present study found that type 2 diabetes mellitus had a significantly catastrophic effect on the patients and their households in China. The poorest diabetic households were more likely to incur CHE. Factors including household income,

Table 4 | Relationship between patients' characteristics and rate of catastrophic health expenditure for type 2 diabetes mellitus in Shandong, China (2016)

Variables	Univariate model				Multivariate model		
	CHE (weight %)	*P*-value	OR	OR 95% CI	*P*-value	OR	OR 95% CI
Sex							
Male	70 (10.7)		1.0			1.0	
Female	200 (15.3)	0.003	1.51	1.18–1.94	0.49	1.08	0.85–1.39
Household income[†]							
Q1 (poorest)	84 (17.1)		1.0			1.0	
Q2	68 (13.1)	0.015	0.73	0.57–0.93	0.158	0.72	0.44–1.15
Q3	70 (14.5)	0.227	0.82	0.58–1.14	0.248	0.70	0.37–1.31
Q4 (richest)	48 (9.3)	0.007	0.49	0.30–0.81	0.008*	0.35	0.17–0.73
Household size							
1–2	226 (15.0)		1.0			1.0	
3–4	33 (11.1)	0.078	0.71	0.48–1.04	0.949	0.98	0.57–1.71
≥5	11 (8.0)	0.044	0.49	0.24–0.97	0.783	0.84	0.22–3.17
Sites							
Yiyuan	32 (10.3)		1.0			1.0	
Fushan	54 (16.9)	0.000	1.77	1.46–2.14	0.002	1.89	1.32–2.71
Gaotang	27 (7.5)	0.077	0.70	0.47–1.04	0.845	1.05	0.61–1.80
Rushan	86 (28.7)	0.000	3.48	2.33–5.21	0.000	4.35	2.36–8.02
Liangshan	36 (10.4)	0.975	1.00	0.68–1.48	0.097	1.44	0.93–2.23
Weicheng	35 (11.9)	0.395	1.17	0.79–1.74	0.006	2.77	1.39–5.52
Diabetic complications							
No	167 (10.4)		1.0			1.0	
Yes	103 (29.5)	0.000	3.61	2.72–4.77	0.045*	1.56	1.01–2.40
Outpatient service							
No	177 (10.4)		1.0			1.0	
Yes	93 (32.8)	0.000	4.19	2.48–7.09	0.001*	3.45	1.75–6.79
Inpatient service							
No	129 (8.2)		1.0			1.0	
Yes	141 (58.6)	0.000	15.82	10.17–24.61	0.000*	15.24	10.32–22.52
Drinking							
No	251 (14.8)		1.0			1.0	
Yes	19 (7.0)	0.004	0.43	0.25–0.74	0.057	0.68	0.40–1.17
Physical exercise							
No	124 (17.2)		1.0			1.0	
Yes	146 (11.6)	0.001	0.66	0.51–0.85	0.288	0.76	0.44–1.29
Self-reported health status							
Good	36 (7.7)		1.0			1.0	
Normal	109 (12.6)	0.004	1.79	1.21–2.67	0.000*	1.89	1.49–2.39
Bad	125 (19.4)	0.000	2.92	1.97–4.32	0.095	1.69	0.90–3.15
Physical examination							
No	44 (21.4)		1.0			1.0	
Yes	226 (12.8)	0.019	0.54	0.33–0.89	0.288	0.75	0.44–1.29

P-values with statistical significance. [†]Quartile 1 (Q1) is the poorest and quartile 4 (Q4) is the richest. CI, confidence interval; OR, odds ratio.

diabetic complications, outpatient service, inpatient service and self-reported health status were determinants linked with CHE for type 2 diabetes mellitus care. Early screening for type 2 diabetes mellitus patients among the high-risk groups and effective management of the detected cases should be prioritized to reduce the overall healthcare expenditure for type 2 diabetes mellitus.

DISCLOSURE

The authors declare no conflict of interest.

REFERENCES

1. Alberti K. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: Diagnosis and classification of diabetes mellitus. Provisional report of a WHO Consultation. *Diabet Med* 1998; 15: 539–553.
2. Whiting DR, Guariguata L, Weil C, *et al.* IDF diabetes atlas: global estimates of the prevalence of diabetes for 2011 and 2030. *Diabetes Res Clin Pract* 2011; 94: 311–321.
3. World Health Organization. Global Report on Diabetes, 2016. Available from: http://www.who.int/diabetes/global-report/en/ Accessed March 13, 2018.
4. International Diabetes Federation. Key message Diabetes Atlas, 7th edn. 2015 Update. Brussels: International Diabetes Federation, 2016.
5. World Health Organization. Diabetes country profiles 2016: China. Available from: http://www.who.int/diabetes/country-profiles/chn_en.pdf?ua=1 Accessed March 13, 2018.
6. Pan XR, Yang WY, Li GW, *et al.* Prevalence of diabetes and its risk factors in China, 1994. National Diabetes Prevention and Control Cooperative Group. *Diabetes Care* 1997; 20: 1664–1669.
7. Huang Y, Pepijn V, Zhu J, *et al.* Economic burden in Chinese patients with diabetes mellitus using electronic insurance claims data. *PLoS ONE* 2016; 11: e0159297.
8. Beaglehole R, Bonita R, Alleyne G, *et al.* UN high-level meeting on non-communicable diseases: addressing four questions. *Lancet* 2011; 378: 449–455.
9. Xu K, Evans DB, Carrin G, *et al.* Protecting households from catastrophic health spending. *Health Aff* 2007; 26: 972–983.
10. O'Donnell O, van Doorslaer E, Wagstaff A, *et al.* Analyzing Health Equity Using Household Survey Data: A Guide to Techniques and Their Implementation. Washington, DC: The World Bank, 2008.
11. Wagstaff A, van Doorslaer E. Catastrophe and impoverishment in paying for health care: with applications to Vietnam 1993–1998. *Health Econ* 2003; 12: 921–934.
12. Fang H, Zhao Y, Wang J, *et al.* A study on financial equity: analysis on household health expenditure on catastrophic diseases. *Chin Health Econ* 2003; 22: 5–7 (Chinese).
13. Zhao Y, Tao S, Wan Q, *et al.* Case study on catastrophic health expenditure in rural China. *Chin Health Econ* 2004; 23: 5–8 (Chinese).
14. Yan J, Hao N, Liao S, *et al.* The changes and influencing factors on catastrophic health expenditures before and after new health care reform: a study in Mei County. *Shaanxi province. Chin J Health Policy* 2013; 6: 30–33 (Chinese).
15. Gong X, Yu R, Meng Q, *et al.* Study on the effect of New Rural Cooperative Medical System on catastrophic health care payment. *Res Health Econ* 2009; 9: 27–29 (Chinese).
16. Zhou C, Long Q, Chen J, *et al.* Factors determine catastrophic expenditure for tuberculosis care: a patient survey in China. *Infect Dis Poverty* 2016; 5: 6.
17. Li Y, Wu Q, Xu L, *et al.* Factors affecting catastrophic health expenditure and impoverishment from medical expenses in China: policy implications of universal health insurance. *Bull World Health Organ* 2012; 90: 664–671.
18. Adhikari SR, Maskay NM, Sharma BP. Paying for hospital-based care of Kala-azar in Nepal: assessing catastrophic, impoverishment and economic consequences. *Health Policy Plan* 2009; 24: 129–139.
19. Williams R, Van Gaal L, Lucioni C. Assessing the impact of complications on the costs of Type II diabetes. *Diabetologia* 2002; 45: S13–S17.
20. Hu H, Sawhney M, Shi L, *et al.* A systematic review of the direct economic burden of type 2 diabetes in China. *Diabetes Ther* 2015; 6: 7–16.
21. Zhao WH. The Study on Direct Economic Burden of Diabetes in China. Beijing: Peking Union Medical College, 2012 (Chinese).

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1 | Relationship between patients' characteristics and rate of catastrophic health expenditure for type 2 diabetes mellitus patients in Shandong, China (2016)