A 25-Year Trend of Catastrophic Health Expenditure and Its Inequality in China: Evidence from Longitudinal Data

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Purpose: The Chinese government has carried out two major cycles of reform to improve the health system and reduce the disease burden on residents. This study aims to comprehensively track the trends in the occurrence of catastrophic health expenditure (CHE) and its inequality in the past 25 years, which may help better understand the influence of health system reforms on CHE and its inequality.

Methods: The study employed the subset of data from China Health and Nutrition Survey conducted from 1991 to 2015. Health payments and net household income were used to calculate CHE. Concentration index and decomposition analysis were used to measure the magnitude of income-related inequality in CHE and decompose it into determinants, respectively.

Results: The incidence of CHE in China increased from 3.10% in 1993 to 8.90% in 2004 and still maintained at a high level in the following years. The incidence gap of CHE between the richest and poorest became increasingly wider over year. Moreover, the values of adjusted concentration indexes were all negative in each year, decreasing from −0.202 in 1991 to −0.613 in 2015. Income was consistently the largest contributor to the inequality in CHE. The basic medical insurance did not decrease the incidence of CHE and showed the second largest contribution on its inequality before 2004. However, this contribution began to decline after 2006.

Conclusion: After the New Health Care Reform, despite many measures taken by the Chinese government, there was still a high incidence of CHE and an increasing inequality from 1991 to 2015. The basic medical insurance in China was not enough to protect households from CHE. The use of big data tools and techniques to effectively screen the poor households, and strengthening the social medical aid system would be helpful to decrease the inequality in CHE.

Keywords: catastrophic health expenditure, income-related inequality, concentration index, multilevel model

Introduction

In recent decades, many countries around the world have been optimizing their health-care systems to provide their citizens access to essential services to achieve universal health coverage.[1–3] Based on the basic national conditions and realities, China has also carried out important reforms in its health-care system.

With the implementation of the reform and "opening-up policy" to the outside world in 1978, China has gained unprecedented economic growth and marvelous success in many areas. To replicate the success of other areas, market-oriented health-care reform was introduced in the 1980s.[4] The government no longer had the central role in health-care delivery, encouraging the establishment of hospitals through multiple channels and allowing privatization of providers (such as barefoot doctors opened private village clinics).[5] Besides, the government allowed health facilities discretion in the employment of health workers, the use of health-care funds and other aspects. Health facilities shifted from being entirely dependent on government funding to being largely dependent on health-care services for income generation. Remarkable achievements have been made under the market-oriented health-care reform. The resource allocation in health care was more efficient, more innovative, and more responsive to consumer preferences. During this period,

however, China's traditional coverage plans collapsed, leaving the rural and urban residents exposed to potentially damaging health-care cost.[6–8] The Cooperative Medical Scheme for members of the agricultural commune covered only 10% of the rural residents in 1991, and the Labor Insurance Scheme and Government Insurance Scheme for state-owned enterprise workers and government officials covered 1.17% of the urban residents in 1994.[9] "Getting medical treatment is difficult and expensive" has become a social and economic problem in China. The total health expenditure in China mainly consists of three parts: government health expenditure, social health expenditure and out-of-pocket expenditure. Data from China Health Statistical Yearbook showed that, although the absolute value of government health expenditure rose from 3.544 billion yuan in 1978 to 155.253 billion yuan in 2005, the share of government investment on health expenditure showed a downward trend from 32.2% to 17.9%.[10] During this period, the proportion of out-of-pocket expenditure in total health expenditure showed a rapid increasing trend from 20.4% to 52.2%.[10] The health payment imposed heavy burden to the society and families. The problem of "Poverty caused by illness and return to poverty due to illness" has become one of the biggest challenges faced by Chinese people.[11–13]

After summarizing the reasons for the failures of the 1990s health-care reform, China officially launched a new round of health-care reform, which called New Health Care Reform (NHCR) in 2009. China adopted a government-led health system and highlighted the non-profit nature of health care. The NHCR reform is a comprehensive reform on every domain of the health-care system. The strategy includes establishing and improving the basic health system covering urban and rural residents, strengthening the public health-care system, improving the medical system, and completing a secured pharmaceutical supply system. One of the primary objectives of this reform is to provide people with affordable and equitable health-care services, and alleviate the problem of "Getting medical treatment is difficult and expensive". By 2019, over 95% of residents in China enrolled in one of three basic medical insurance schemes: New Rural Cooperative Medical Insurance for rural residents, Urban Employee Basic Medical Insurance for urban residents with formal work, and Urban Residents Basic Medical Insurance for urban residents without formal work.[14]

With the use of several waves of cross-sectional survey, numerous studies have been published to investigate the distribution and the determinants of catastrophic health expenditure (CHE) after household covered by health insurance. These studies found that, despite the continuous improvement in Chinese social security and the implementation of universal health insurance, the incidence of CHE was still higher in China.[15] Besides, previous studies consistently demonstrated that some household characteristics, such as income and geographic area, were associated with the incidence of CHE.[16] However, due to the heterogeneity of the study design, there is a controversy on whether basic medical insurance could effectively protect households from CHE. Some comparative studies using the one-wave of cross-sectional survey before and after reimbursement reported that the incidence of CHE after reimbursement was lower than that before reimbursement, while other studies using the repeated cross-sectional data or short-term longitudinal data showed that medical insurance failed to prevent households from CHE and impoverishment.[17–19] Longitudinal data could more accurately reflect the fluctuation of potential factors over time, and thus it virtually always gets more reliable and more accurate results than cross-sectional data. However, there was no report of studies that aimed at identifying the incidence trends and inequalities of CHE combined with the dynamic process of health system reform over a long period of time. The study aims to comprehensively track the trends in the occurrence of CHE and its inequality, in order to better understand the influence of health system reform on CHE and its inequality. Our study will provide readers an overall picture of how the CHE and its distribution changed under the background of health system reform of China. Our study contributes to existing studies in two ways. Firstly, providing a unique insight into how CHE changed at different time points during the process of health system reform and exploring reasons why these developmental shifts took place. Secondly, providing policy makers with evidence to examine the effectiveness of current policies, and inform new directions for future policy development.

Materials and Methods
Data
The study used the data from the China Health and Nutrition Survey (CHNS). CHNS is an ongoing open cohort survey conducted by the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute

for Nutrition and Health (NINH, former National Institute of Nutrition and Food Safety) at the Chinese Center for Disease Control and Prevention (CCDC). The first wave of the survey was conducted in 1989 and took place every 2 to 4 years. A multistage, random cluster process was adopted to draw participants in 15 Chinese provinces and municipal cities that vary substantially in geography, economic development, public resources, and health indicators. The objective of the survey was to examine the effects of the health policies and programs implemented by the governments and to investigate how the social and economic transformation of Chinese society affects the health and nutritional status of its population. The data underlying this article are available at https://www.cpc.unc.edu/projects/china. This study used nine waves of CHNS from 1991 to 2015. Households without key information (health expenditure/net household income) were excluded. Finally, our study sample consisted of 3513 households in 1991, 3259 households in 1993, 3355 households in 1997, 3677 households in 2000, 2617 households in 2004, 2286 households in 2006, 2353 households in 2009, 3461 households in 2011, and 3814 households in 2015.

Variables
Outcome Measures
The primary outcome in this study was CHE. Although economists and epidemiologists have the consensus that a household is in catastrophe if its out-of-pocket health payment exceeds a chosen threshold that results in financial distress, however, uniformly accepted threshold are not reported in previous studies.[20] In the literature, the chosen threshold at which health payments are catastrophic varied from 5% to 40% of the household income or consumption expenditure.[20–23] In this study, threshold value of 40% of total net household income was used to investigate the incidence of CHE. The out-of-pocket health payment includes all types of direct health-related expenditures made by households, primarily for the purchase of self-medication, payments for outpatient, and inpatient care. The total net household income was conceptualized as the sum of all sources of income minus expenditures. There were nine sources of income: business, farming, fishing, gardening, livestock, non-retirement wages, retirement income, subsidies, and other income. The expenditures included five sources that report expenses: business, farming, fishing, gardening, and livestock. Expenses are 0 for the other four sources.

Independent Variables
With reference to previous studies, a set of independent variables that may be associated with incidence of CHE were included in the study. Household characteristics included were household size (1, 2–5, ≥6), basic medical insurance, living areas, geographic regions (Eastern China, Central China, and Western China) and per capita net household income. Basic medical insurance is a binary variable taking on the value of one if all household members were covered by basic medical insurance, and vice versa. Living areas is a binary variable taking on the value of one if investigated household located in urban areas, and vice versa. Per capita net household income was calculated by dividing the total net household income by the household size. Households were grouped into five quintiles by per capita net household income, namely the poorest, poorer, middle, richer and richest. Household head characteristics were age, gender, educational attainment (illiteracy, elementary, middle school, high school, and university) and marital status (unmarried, married, others) of household head.

Statistical Analysis
Descriptive statistics were used to describe the basic feature of the samples in the study.

Longitudinal data are often conceptualized as multilevel data where the repeated observations are nested within individuals. With the sharp increasing in longitudinal research designs, multilevel models have recently received more attention in a variety of different disciplines. Compared to models applied in cross-sectional studies, multilevel analysis enables the control of individual heterogeneity to avoid bias in the resulting estimates. In multilevel models for longitudinal data, the lowest level of data is the measurement at a specific time point and individual constitutes the second level of nesting.[24] The two-level null model could be written as follows:

Level-1 (repeated-measures level) model:

$$y_{ti} = \beta_{oi} + e_{ti}$$

where t represents the investigation in years and i represents the i-th individual. β_{oi} is the estimated average y for the i-th individual. e_{ti} is the within-individual random error which captures the difference between the observed y at time t and the predicted y of the i-th individual. e_{ti} is assumed to be normally distributed which captures the within-individual variation.

Level-2 (individual level) models can be presented as follows:

$$\beta_{oi} = \gamma_{00} + U_{0i}$$

where γ_{00} is the grand mean of the dependent variable, U_{0i} is the difference between the i-th average dependent variable and the grand mean, U is assumed to be normally distributed with the expected value of 0 and the variance σ_u^2.

The multi-level random intercept model with independent variables can be written as follows:

$$y_{ti} = \beta_{oi} + \beta_{1i}x_{1ti} + e_{ti}$$

where β_{1i} is unknown coefficients to be estimated.

Concentration index is a widely used approach to measure socioeconomic-related inequality in health. It is defined as twice the area between the concentration curve and the equality line, running from the bottom-left corner to the top-right.[23] The value of concentration index lies between the −1 and 1. A negative value indicates the interested health variable concentrated on the poor, and vice versa. In the case where there is no income-related inequality, the concentration index would be zero. The concentration index can be written as follows:

$$C = \frac{2}{\mu}cov(y_i, R_i)$$

Where μ is the mean of dependent variable, R_i is relative rank of individual i in the distribution of incomes. When our interested variable is binary, the bounds of the concentration index for this variable are not −1 and 1 but depend on the mean of the variable, which confounds comparison of inequality across time with different incidence of CHE. To avoid these limitations, the Wagstaff's adjusted concentration index, which is simply the concentration index divided by the difference of 1 minus the mean incidence of CHE, was employed in our study.[25]

Based on the regression model, concentration index can be decomposed into the contributions of a set of determinants.[23] For any regression model, such as

$$y_i = \alpha + \sum_k \beta_k x_{k_i} + \varepsilon_i$$

The concentration index for y, C can be written as

$$C = \sum_k (\beta_k \bar{x}_k / \mu) C_k + GC_\varepsilon / \mu$$

where β_k, C_k, and $\bar{x}_k$ are the estimated coefficient, concentration index, and mean of kth independent variable, respectively. $(\beta_k \bar{x}_k / \mu) C_k$ and $(\beta_k \bar{x}_k / \mu)(C_k / C)$ represents the contribution and the percentage contribution of kth independent variable on the concentration index of CHE, respectively. As shown in the equation, the concentration index consists of two parts: an explained component which is the sum of contributions from the regressors in the model, and an unexplained component which is also called residual.

Data management and statistical analysis were performed using SAS and Stata software.

Results

Table 1 shows the characteristics of households and heads of household over time. Great changes have taken place in the demographic characteristics of household heads. The mean age of household heads increased from 45.64 years old in 1991 to 57.87 years old in 2015, whereas the proportion of male household heads dropped from 84.2% to 77.69% at the same period. The characteristics of households also have undergone huge changes in the past 25 years, with the per capita net income increasing from 1.08 thousand yuan in 1991 to 28.11 thousand yuan in 2015, and the proportion of households with 6

Table 1 Characteristics of Respondents Over Years

Variables	1991 (N=3513)	1993 (N=3259)	1997 (N=3355)	2000 (N=3677)	2004 (N=2617)	2006 (N=2286)	2009 (N=2353)	2011 (N=3461)	2015 (N=3814)
Age of household head, years									
Mean (SD)	45.65 (13.56)	46.82 (13.20)	48.28 (13.34)	49.79 (12.97)	53.65 (13.95)	55.07 (13.89)	56.55 (13.31)	56.06 (13.28)	57.87 (12.51)
Gender of household head									
Men, n (%)	2958 (84.20)	2774 (85.12)	2849 (84.92)	3180 (86.48)	2192 (83.76)	1916 (83.81)	1998 (84.91)	2662 (76.91)	2963 (77.69)
Women, n (%)	555 (15.80)	485 (14.88)	506 (15.08)	497 (13.52)	425 (16.24)	370 (16.19)	355 (15.09)	799 (23.09)	851 (22.31)
Income, RMB thousand yuan									
Mean (SD)	1.08 (0.82)	1.51 (1.37)	3.08 (2.64)	4.01 (4.23)	6.50 (6.70)	8.48 (11.38)	13.29 (17.52)	19.15 (20.28)	28.11 (44.86)
Educational attainment of household head									
Illiterate, n (%)	644 (18.33)	520 (15.96)	474 (14.13)	368 (10.01)	242 (9.25)	254 (11.11)	215 (9.14)	219 (6.33)	158 (4.14)
Elementary, n (%)	1329 (37.83)	1228 (37.68)	1254 (37.38)	1278 (34.76)	885 (33.82)	663 (29.00)	701 (29.79)	800 (23.11)	863 (22.63)
Middle school, n (%)	978 (27.84)	941 (28.87)	975 (29.06)	1167 (31.74)	809 (30.91)	690 (30.18)	798 (33.91)	1168 (33.75)	1295 (33.95)
High school, n (%)	456 (12.98)	462 (14.18)	551 (16.42)	674 (18.33)	509 (19.45)	485 (21.22)	460 (19.55)	855 (24.70)	1007 (26.40)
University, n (%)	106 (3.02)	108 (3.31)	101 (3.01)	190 (5.17)	172 (6.57)	194 (8.49)	179 (7.61)	419 (12.11)	491 (12.87)
Marital status of household head									
Unmarried, n (%)	57 (1.62)	30 (0.92)	76 (2.27)	118 (3.21)	61 (2.33)	22 (0.96)	26 (1.10)	30 (0.87)	28 (0.73)
Married, n (%)	3166 (90.12)	2957 (90.73)	2992 (89.18)	3254 (88.50)	2267 (86.63)	2010 (87.93)	2055 (87.34)	3009 (86.94)	3411 (89.43)
Others, n (%)	290 (8.26)	272 (8.35)	287 (8.55)	305 (8.29)	289 (11.04)	254 (11.11)	272 (11.56)	422 (12.19)	375 (9.83)
Household size									
1, n (%)	65 (1.85)	61 (1.87)	91 (2.71)	99 (2.69)	178 (6.80)	150 (6.56)	171 (7.27)	229 (6.62)	258 (6.76)
2–5, n (%)	2253 (64.13)	2113 (64.84)	2397 (71.45)	2738 (74.46)	2088 (79.79)	1874 (81.98)	1873 (79.60)	2848 (82.29)	3016 (79.08)
≥6, n (%)	1195 (34.02)	1085 (33.29)	867 (25.84)	840 (22.84)	351 (13.41)	262 (11.46)	309 (13.13)	384 (11.10)	540 (14.16)
Basic medical insurance									
No, n (%)	2330 (66.33)	2320 (71.19)	2412 (71.89)	2742 (74.57)	1745 (66.68)	1035 (45.28)	179 (7.61)	130 (3.76)	94 (2.46)
yes, n (%)	1183 (33.67)	939 (28.81)	943 (28.11)	935 (25.43)	872 (33.32)	1251 (54.72)	2174 (92.39)	3331 (96.24)	3720 (97.54)
Living areas									
Urban, n (%)	1134 (32.28)	972 (29.83)	1015 (30.25)	1181 (32.12)	974 (37.22)	892 (39.02)	892 (37.91)	1821 (52.61)	1853 (48.58)
Rural, n (%)	2379 (67.72)	2287 (70.17)	2340 (69.75)	2496 (67.88)	1643 (62.78)	1394 (60.98)	1461 (62.09)	1640 (47.39)	1961 (51.42)
Geographic regions									
Eastern China, n (%)	1282 (36.49)	1163 (35.69)	1228 (36.60)	1651 (44.90)	1301 (49.71)	1188 (51.97)	1243 (52.83)	2040 (58.94)	2249 (58.97)
Central China, n (%)	1326 (37.75)	1253 (38.45)	1280 (38.15)	1198 (32.58)	806 (30.80)	651 (28.48)	635 (26.99)	636 (18.38)	735 (19.27)
Western China, n (%)	905 (25.76)	843 (25.87)	847 (25.25)	828 (22.52)	510 (19.49)	447 (19.55)	475 (20.19)	785 (22.68)	830 (21.76)

members and over decreasing from 34.02% to 14.16%. During the past 25 years, the households living areas and geographic regions also dramatically changed in samples, with the proportion of households lived in urban areas increasing from 32.28% to 48.58%, and the proportion of household living in Eastern China jumping from 36.49% to 58.97%.

Figure 1 shows the distribution of CHE among income groups over time. There was an upward trend in the incidence of CHE in China from 1993 to 2004. Although this upward trend was changed after the 2004, the incidence of CHE maintained at a high level in the following years. Poorest households continuously had the highest incidence of CHE compared to households with better economic status in each year. The incidence of CHE for the poorest households showed an overall upward trend from 1991 to 2015, but declined in 1993 and 2011. The incidence of CHE for richest households decreased rapidly after 2000. The incidence gap of CHE between the richest and poorest became increasingly wider over time.

Table 2 presents the determinants of CHE obtained from two-level logistic random intercept model. Age of household head and living in Central China increased the risk of CHE incidence. Higher income, living in urban areas and larger household size decreased the risk of suffering from CHE. There is no significant association between university education and CHE. It is worth noting that being covered by basic medical insurance did not result in a reduction of the incidence of CHE.

The crude concentration indexes and adjusted concentration indexes of CHE over time are shown in Table 3. The concentration indexes were all negative in each year, indicating the poor households were more likely to incur CHE. In general, the values of concentration indexes were diminishing over time, indicating there was an upward trend in the inequality of CHE from 1991 to 2015.

Table 4 shows the contribution of determinants on the concentration indexes of CHE over the years. Income consistently showed the largest contribution on this inequality in each year, making CHE concentrated among the poor. Insurance showed the second largest contrition on the inequality of CHE in 2004 and before. However, this contribution began to decline after 2006. Educational attainment of household head increased the contribution of catastrophic health payment inequality over time.

Discussion

In theory, a sound national financing system could effectively protect households against health shocks. Our study found that the incidence of CHE increased from the 1990s to the 2010s. The Chinese government explored market-based ways
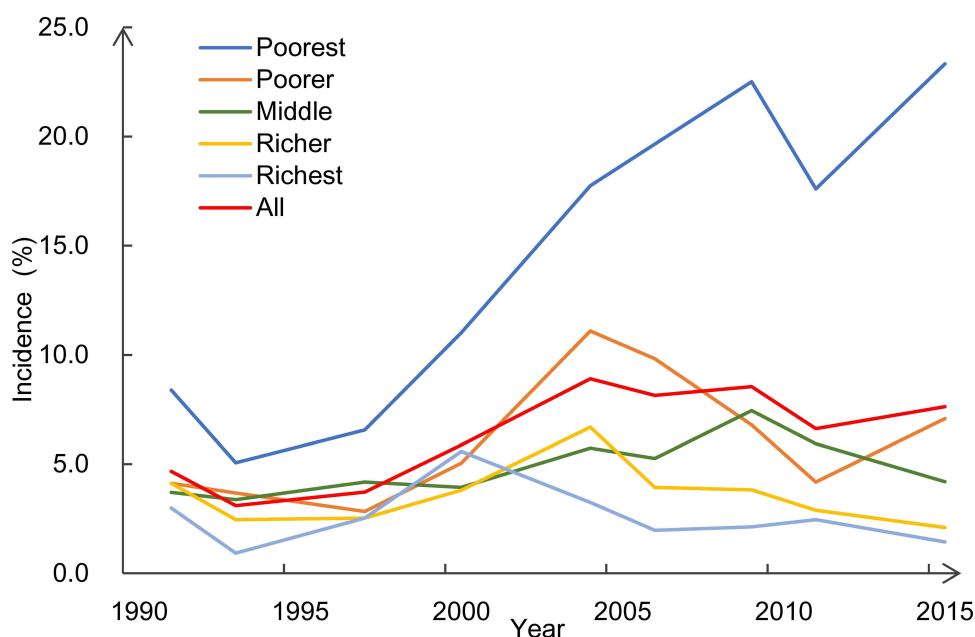

Figure 1 Incidence of CHE over years.

Table 2 Association Between Catastrophic Health Expenditure and Its Determinants

Variables	Coefficient	Std. Error	P	95% CI	
				Lower	Upper
Age of Household Head (years)	0.040	0.002	<0.001***	0.035	0.044
Gender of household head					
Men (ref)					
Women	0.164	0.080	0.040*	0.007	0.321
Income (RMB thousand yuan)	−0.053	0.004	<0.001***	−0.061	−0.046
Educational attainment of household head					
Illiterate (ref)					
Elementary	0.142	0.087	0.102	−0.028	0.312
Middle school	0.225	0.099	0.023*	0.031	0.419
High school	−0.001	0.116	0.995	−0.228	0.227
University	−0.118	0.171	0.491	−0.454	0.218
Marital status of household head					
Unmarried (ref)					
Married	−0.335	0.187	0.074	−0.702	0.032
Others	−0.817	0.204	<0.001***	−1.216	−0.417
Household size					
1 (ref)					
2–5	−0.292	0.140	0.037*	−0.566	−0.018
≥6	−0.536	0.149	<0.001***	−0.829	−0.243
Basic medical insurance					
No (ref)					
Yes	0.352	0.060	<0.001***	0.234	0.470
Living areas					
Rural (ref)					
Urban	−0.129	0.063	0.040*	−0.253	−0.006
Geographic regions					
Eastern China (ref)					
Central China	0.263	0.065	<0.001***	0.135	0.392
Western China	0.124	0.072	0.083	−0.016	0.264

Note: ***For *P* < 0.001, *For *P* < 0.05.

Table 3 Crude and Adjusted Concentration Indexes of Catastrophic Health Expenditure Over Years

Year	Concentration Index			Adjusted Concentration Index		
	Index	Std. Error	p	Index	Std. Error	p
1991	−0.192	0.044	<0.001	−0.202	0.046	<0.001
1993	−0.260	0.056	<0.001	−0.268	0.058	<0.001
1997	−0.215	0.051	<0.001	−0.223	0.053	<0.001
2000	−0.196	0.038	<0.001	−0.208	0.040	<0.001
2004	−0.323	0.036	<0.001	−0.354	0.039	<0.001
2006	−0.446	0.040	<0.001	−0.486	0.043	<0.001
2009	−0.451	0.038	<0.001	−0.494	0.041	<0.001
2011	−0.428	0.036	<0.001	−0.459	0.039	<0.001
2015	−0.566	0.031	<0.001	−0.613	0.034	<0.001

to allocate health resources for the whole country from the 1990s. Under such circumstances, the Chinese government's contribution to national total health expenditure significantly reduced. Rural residents who make up the majority of the population and urban residents without formal employment were not covered by any social medical insurance. Due to the

Table 4 Decomposition Analysis of Concentration Index in Catastrophic Health Expenditure Over Years

Variables	2000			2004			2006			2009			2011			2015		
	Contrib[a]	%[b]	Rank	Contrib[a]	%[b]	Rank	Contrib[a]	%[b]	Rank	Contrib[a]	%[b]	Rank	Contrib[a]	%[b]	Rank	Contrib[a]	%[b]	Rank
Age of household head (years)	−0.003	0.015	10	−0.003	0.010	11	−0.004	0.008	9	−0.002	0.005	12	−0.004	0.009	11	−0.003	0.005	8
Gender of household head																		
Men (ref)																		
Women	−0.005	0.028	6	0.001	−0.002	13	0.001	−0.003	13	0.003	−0.007	10	0.006	−0.014	10	0.002	−0.003	10
Income (RMB thousand yuan)	−0.158	0.807	1	−0.361	1.118	1	−0.752	1.686	1	−0.305	0.675	1	−0.398	0.930	1	−1.048	1.853	1
Educational attainment of household head																		
Illiterate (ref)																		
Elementary	−0.002	0.009	12	0.005	−0.014	10	−0.006	0.014	7	0.017	−0.037	4	0.022	−0.052	5	−0.033	0.058	2
Middle school	0.000	0.001	15	0.000	0.001	15	0.003	−0.007	10	0.005	−0.012	9	0.002	−0.006	13	−0.014	0.025	6
High school	−0.007	0.034	5	−0.007	0.021	6	−0.002	0.005	11	−0.042	0.092	2	−0.015	0.036	6	0.018	−0.032	5
University	0.004	−0.019	9	0.007	−0.023	5	0.011	−0.024	5	−0.027	0.059	3	−0.023	0.054	4	0.029	−0.052	4
Marital status of household head																		
Unmarried (ref)																		
Married	−0.004	0.023	7	−0.006	0.019	7	0.053	−0.120	2	0.006	−0.014	6	0.082	−0.191	3	−0.001	0.003	11
Others	0.004	−0.022	8	0.011	−0.033	3	−0.033	0.074	3	−0.002	0.005	11	−0.099	0.232	2	0.003	−0.004	9
Household size																		
1 (ref)																		
2–5	−0.002	0.009	13	0.001	−0.002	14	0.000	0.001	15	0.002	−0.004	14	0.000	−0.001	14	0.000	0.000	15
≥6	0.000	−0.001	14	0.001	−0.004	12	0.002	−0.005	12	−0.002	0.004	13	0.000	0.000	15	0.010	−0.018	7
Basic medical insurance																		
no (ref)																		
yes	0.030	−0.155	2	0.026	−0.080	2	−0.007	0.016	6	−0.002	0.003	15	−0.004	0.009	12	0.000	0.000	14
Living areas																		
Rural (ref)																		
Urban	0.008	−0.042	4	−0.005	0.016	8	0.016	−0.037	4	0.006	−0.013	7	−0.007	0.017	9	0.031	−0.055	3
Geographic regions																		
Eastern China (ref)																		
Central China	−0.018	0.090	3	−0.005	0.015	9	0.000	−0.001	14	−0.006	0.012	8	−0.010	0.023	8	−0.001	0.002	12
Western China	0.002	−0.011	11	0.007	−0.023	4	0.006	−0.013	8	−0.009	0.020	5	−0.015	0.035	7	0.001	−0.001	13

Notes: [a]Represents the contribution of independent variables on the concentration indexes of catastrophic health expenditure. [b]Represents the percentage contribution of independent variables on the concentration indexes of catastrophic health expenditure.

long-time low government investment, the public hospitals were in blind pursuit of economic interests, causing phenomena such as "over treatment" and "doctors make living on prescribing medicines".[26] Therefore, it is easy to explain why the incidence of CHE increased rapidly from 1991 to 2004. The insurance schemes for rural residents and urban residents were conducted by Chinese government in 2003 and 2007, respectively.[27–29] As for the decline in the incidence of CHE in the poorest in 1993, the government policies in favor of poor regions might have worked. The Chinese government advocated efforts to support the construction of sanitation facilities in remote and impoverished areas in 1991 and further strengthened financial support for township health centers in economically underdeveloped areas in 1992.[30] It was an effective way to improve access to medical care for the poor and enable individuals who are sick to seek treatment on time, reducing the risk of CHE.

In 2009, China officially launched a new health care system reform. One aim of the reform is to tackle the issue of "It is too expensive to get the medical treatment". The Chinese government investment on health has been largely increased, the coverage of medical insurance has been expanded, a national essential medicine system has been established to reduce medicine prices and free medical treatments has been promoted for targeted populations.[31,32] In this scenery, the NHCR reform took effect and the incidence of CHE had a decreasing trend before 2011. However, it is worth discussing the potential reasons that the incidence of CHE was still at a high level in China. WHO has pointed out three factors that contributed to the occurrence of CHE: the availability of health services requiring out-of-pocket payments; low house-hold capacity to pay; and lack of prepayment mechanisms for risk pooling.[33] Since the household capacity to pay and the government investment in health have been largely improved with the development of Chinese economy and NHCR respectively, the rapid increase in health services cost and the design of medical insurance reimbursement may be the main reasons for the increasing incidence. Although the medical service prices for the most popular medical services are regulated by Chinese government, health care providers are more likely to choose to provide new health services items without the price restriction by government as alternatives, eg new medicines, new technologies, which will increase the cost for patients. China has achieved universal health coverage in recent years; however, the actual reimbursement ratio of basic medical insurance has been maintained at a low level for a long time. Take Shaanxi Province for example, our unpublished data showed that the actual reimbursement ratio for New Rural Cooperative Medical Insurance Scheme was still over 50% in 2013. The study also provided evidence that the current medical insurance system is not generous enough to prevent the risk of suffering from CHE. Under such circumstances, it is not enough to protect households from CHE or poverty by only increasing the breadth of medical insurance coverage. Furthermore, fee-for-service is still the predominately adopted provider payment method transferring funds from the insurance agency to the providers of health services. Since the payment methods of basic health insurance could influence the provider income and costs for providing the service, different payment methods, such as capitation, fee-for-service, and pay-for-performance, result in varied provider behavioral incentives related to service supply.[34] Previous studies have found that, although a fee-for-service system has good organizational access, continuity, and accountability, this kind of reimbursement method results in supplier-induced demand, encouraging more consultations, more diagnostic tests, higher drug use, higher surgical rates and higher costs than other pre-payment systems.[35,36] Besides, fee-for-service may lead to the moral hazard of the demander, and patients would make use of more health services. Basic medical insurance reimburses only a certain percentage of medical expenses, and patients also have to pay for it. Even if covered by basic medical insurance, therefore, the patient will pay more health care cost if he receives more health services. In this context, more introduction of prepaid reimbursement methods, eg diagnosis-related group (DRG)-based payment, capitation, and global payment, would be helpful to control the irrational increase of health care cost of urban and rural residents. Previous international literature and evidence from pilot studies in some areas of China have found that the financial access of these prospective payment system is better than fee-for-services in motivating health services providers to control the rising cost actively.[37,38] Some papers have been published to measure the incidence of CHE in China in the context of health-care reform.[39–42] As with these studies, we have found that the incidence of CHE in China was higher than that of most countries in the world.[43–46] However, since the methods used in the measurement of CHE are different, comparison between our study and other studies should be interpreted with caution.

Our study found that there was inequality in the incidence of CHE in China. The poor households were more likely to incur CHE. This phenomenon was also observed in previous studies.[47–49] The phenomenon may be predominately

caused by two factors: poor ability to pay, and lack of generous health insurance. There is still some disparity in insurance generosity for publicly financed medical insurance schemes in China. While Urban Employee's Basic Medical Insurance generously benefits the targeted participants, Urban Resident Basic Medical Insurance and New Rural Cooperative Medical Insurance provide limited benefits to their participants.[29] Unemployed urban and rural residents were less likely to enroll in private medical insurance. Another finding of our study was that the CHE was more concentrated among the poor over time.[42] The poorest households faced more severe CHE which may cause the "illness-engendered poverty" in the later stages of the investigation. The Chinese government has been trying to solve the problem of poverty alleviation with the implementation of New Health Care Reform in the past decades. However, the question is who benefit the most from these initiatives. Our study observed that the poorest households actually benefit less from these initiatives. Poor financial access and geographical distance were frequently mentioned factors considered as barriers to benefit the package provided by the Chinese government. In the policies implementation process, the key consideration would be an accurate identification of the poorest households to receive the support provided by the Chinese government.

Similar to previous studies, our study found that income was the largest contributor on the inequality of incurring CHE in each year.[47,48] Since higher income was considered as a protecting factor of CHE, this characteristic made the incidence of CHE more concentrated among the poor. Our study observed that the contribution of basic medical insurance on the inequality of CHE varied in each year. The basic medical insurance showed the second contribution in 2000 and 2004, whereas it showed just a little contribution after 2009. The expanding basic medical insurance coverage for the poor and the rich may be the main reason for this phenomenon. Most rural and urban residents without formal employment have been covered by medical insurance since 2005 and 2008, respectively. The distribution of cover by medical insurance was severely concentrated in the rich before the implementation of Urban Resident Basic Medical Insurance and New Rural Cooperative Medical Insurance. The gap between different income groups narrowed after implementation of universal coverage.

Our study has important implications for future policy development to reduce the incidence of CHE and alleviate health inequalities. Firstly, further improvement in the compensation design of basic health insurance is needed so as to raise the actual reimbursement ratio, especially the New Rural Cooperative Medical Insurance and Urban Residents Basic Medical Insurance. Secondly, the scale of coverage expansion alone is not enough to reduce the incidence of CHE, and reform of health insurance payment methods needs to be carried out simultaneously. It may be an effective solution to explore prepaid system of health insurance and establish mixed payment methods such as DRGs, capitation, and global payment in order to control the irrational increase of health-care cost. Thirdly, health policy should be tilted in favor of resource-poor population in the future reform. The social medical aid system needs to be further improved with the aim of ongoing strengthening of financial protections for the poor. Fourthly, there is a need for urgency in the establishment of a tiered healthcare delivery system that can coordinate cooperation between hospitals at different levels, and between hospitals and primary care institutions. The diagnosis and treatment mode of primary treatment and two-way referral is beneficial to promote the optimal allocation of health resources and improve the capability of primary care. Lastly, the use of big data tools and techniques to effectively identify economic status of households could significantly improve the precision of the policies targeted at poor households.

This study has some limitations. Firstly, the data were collected at multiple points, and those observation periods were pre-determined and could not take into account whatever happened in between those touch points. Secondly, all data were self-reported. This may introduce reporting bias. Thirdly, the determinants of the CHE considered in the study were from the preselected questions in the CHNS, other unobserved confounders were not included in the multi-level logit regression model. Fourthly, the choice of household wealth measure is often driven by data availability. In this study, household economic status was measured by per capita net household income, which might not be a preferred indicator.

Conclusion

In conclusion, although China has experienced a remarkable increase in economy, the incidence of CHE increased from 4.67% in 1991 to 7.63% in 2015. Furthermore, the income-related inequalities of CHE were also increased during this

period. Although many measures have been taken by Chinese government, there is still an upward trend in the incidence of CHE for the poorest households. Using big data tools and techniques to effectively identify the economic status of the households, and strengthening the social medical aid system would be beneficial to decrease the inequality in CHE. Higher income, living in urban areas, and large household scale were negatively associated with the occurrence of CHE, whereas age, gender, and living in central and western China were positively associated with the incidence of CHE. Income made the largest contribution of CHE in each year. Our study suggests that improving the generosity of existing basic medical insurance, and reforming medical insurance payment system are helpful to reduce the incidence of CHE.

Abbreviations
NHCR, New Health Care Reform; CHNS, China Health and Nutrition Survey; NINH, National Institute for Nutrition and Health; CCDC, Chinese Center for Disease Control and Prevention; DRG, diagnosis-related group.

Ethics Approval and Informed Consent
Approval for this study was given by the medical ethics committee of Health Science Center of Xi'an Jiaotong University (approval number 2019-1168). All respondents gave written informed consent prior to data collection.

Acknowledgments

Funding

Disclosure
The authors report no conflicts of interest in this work.

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