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The consequences of health shocks on households: Evidence from China

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ABSTRACT

Unexpected health shocks may bring catastrophic consequences for households. This paper examines the effect of unexpected adverse health shocks on household members' physical and mental health, labor supply, household income and asset, and health behaviors in China by analyzing two nationally representative datasets and adopting a difference-in-differences method augmented with coarsened exact matching. We find that an unexpected health shock results in a discounted out-of-pocket medical expenditure of 16,943 RMB (US$ 2647) over five years for an average household, a reduction of household income per capita of 841 RMB per year (US$ 131, or 6.0% of household annual income per capita), and a loss of net household asset per capita of 13,635 RMB (US$ 2130, or 9.7% of household asset per capita). It raises the probability of an average household applying for public poverty relief allowance by 2.8 percentage points. In addition, we document a strong intra-household spillover effect of health shocks on mental health and health behaviors. A simple back-of-envelope calculation shows that the health shock induces a private cost of 34,966 RMB (US$ 5463) over 5 years for an average household, and incurs a social financial burden of 6066 RMB (US$ 948) in 5 years per household in medical reimbursement and social welfare transfers. At a national scale, the total social burden of health shocks from cardiovascular and cerebrovascular diseases amounts to 1.1 trillion RMB (US$ 172.1 billion) over 5 years.

1. Introduction

Adverse health shocks present a major economic risk for households around the world. WHO shows that there are more than 150 million individuals fall into poverty due to adverse health shocks every year.[1] Dobkin, Finkelstein, Kluender and Notowidigdo (2018) find that in the United States hospital admissions are responsible for about 4–6% of bankruptcies for non-elderly adults. The situation is worse in developing countries. Mitra, Palmer, Mont, and Groce (2016) find that the out-of-pocket medical spending of hospitalizations crowds out 26.4% of household education expenditure for an average working-age household in Vietnam. The long-term impacts of health shocks on health, labor productivity, human capital accumulation, and overall well-being in developing countries are

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[1] Source: A 2015 speech by Margaret Chan, the Director-General of the World Health Organization (WHO) delegating the People's Republic of China for 2006–2017. See at http://cn.chinagate.cn/news/2015-10/16/content_36824345.htm

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understudied and deserve more investigation.

Being the largest developing country with a rapidly aging population, China faces a daunting quest of protecting its 500 million households from an increasing disease burden. By 2015, more than 28 million individuals had been impoverished due to severe illnesses, accounting for 40% of total registered poverty-stricken population.[2] A much larger population is facing the threat of severe illnesses (Fang, Eggleston, Hanson, & Wu, 2019). In a nationally representative sample of Chinese households, we find that the average out-of-pocket medical spending accounts for 31% of annual household income, a proportion much higher than those in developed countries (e.g., 2.6% in the US, Dobkin et al. (2018)). This suggests a particularly high financial vulnerability of the average Chinese household to major illnesses. Based on a sample of elderly population (aged 50 to 59) in China, Mommaerts, Raza, and Zheng (2020) find that the increase in direct out-of-pocket hospitalization costs after a hospital admission amounts to a staggering 93% of pre-hospitalization income, a share one order of magnitude higher than those in the US (2.9%) and European countries (1.5%). Considering the staggering immediate economic cost of health shocks, it is imperative to assess how Chinese households respond to an acute and unexpected health event.

We aim to quantify the causal effects of a sudden acute onset of severe diseases (hereafter referred to as a health shock) on households' health, income, and behavioral responses in China. We adopt two nationally representative longitudinal surveys in China—China Family Panel Studies (CFPS) and China Health and Retirement Longitudinal Survey (CHARLS), both of which record detailed medical history of household members so that we can track the onset of a health shock for each individual and observe the resulting changes of a rich set of household socioeconomic and health outcomes. By analyzing a health shock on a representative sample of Chinese households, our results shed light on the causal effect of adverse health events on household behaviors and circumstances in China and other developing countries with similar health care systems.

We adopt a difference-in-differences (DID) design augmented with coarsened exact matching (CEM) method. Our empirical analyses follow three steps. First, we define a health shock as the first onset of an unexpected, acute cardiovascular or cerebrovascular health event, such as a nonfatal stroke or a heart attack. These health events are the leading causes of disease burden in China (Zhou et al., 2019) and for the world (Johnson, Onuma, Owolabi, & Sachdev, 2016), and are recognized by the literature as acute emergency events whose particular timing is unpredictable (Chandra & Staiger, 2007; Doyle, 2011; Fadlon & Nielsen, 2019, 2021). This definition of a health shock allows us to exploit the unexpected timing of health shocks as a source of exogenous variation in individual's health. Second, we adopt a CEM algorithm to control for observable heterogeneities of individuals and their households. This ensures that the treatment group (individuals who just experienced their first health shock in the previous year, and their households) and the control group (individuals who have never experienced any health shock before or during the sample period, and their households) are comparable in observable characteristics before the onset of the health shock. Third, we estimate a DID model with individual and survey-wave FEs on the matched sample of treatment and control groups to control for unobserved individual and household heterogeneities as well as potential secular trends. Overall, the CEM-DID design allows us to estimate an average treatment effect on households who have experienced a health shock (i.e., an ATT effect of health shock).

We find three sets of main results. First, the health shock leads to a large, persistent reduction in household income per capita for the average household in China. Although the effect on labor supply is temporary and dissipates quickly over time, the negative effect on income and assets lasts for years—the estimated reduction remains statistically significant after 5 years, the end of our observational window. The health shock causes a loss of annual household income per capita of 841 RMB in inflation-adjusteded 2020 price (US$ 118, or 6.6% of household annual income per capita) and a loss of household net asset per capita of 13,635 RMB (US$ 2130, or 9.7% of household net asset). It also statistically significantly increases the household's risk of falling under poverty line by 2.8 percentage points (*pp*), or about 14% of baseline poverty rate during our sample period (19.6 *pp*). Over time, an adverse health shock results in an increase of 16,943 RMB (US$ 2647) in direct, out-of-pocket medical expenditure and a reduction of 17,743 RMB (US$ 2772) in household income over five years for an average household in China. Most of the post-shock reduction in household income is not insured by income insurance, and about 6.3% is compensated by the increase in social welfare transfers.

Second, we document a strong and persistent intra-household spillover effects of health shocks on household members' mental health and health behaviors. Health shocks significantly reduce spouse's mental health, possibly due to financial stress caused by the large medical expenditure and a salience effect triggered by concerns over the spouse's own health status (Fadlon & Nielsen, 2019). The health shock also induces a noticeable change in spouse's preventive care behaviors, shown by an increase in physical exercises and large expenditure on fitness and health supplements. We find a small and insignificant effect of the health shock on spouse labor supply. This may be due to a cancelling-out of a negative effect on spousal labor supply due to a higher demand for informal care and a positive effect to compensate the income loss.

Third, we estimate a large social burden caused by health shocks. As about 22.6% of total hospitalization expenditure is reimbursed by the public health insurance in our sample, a health shock increases the financial burden of the public insurer by 4947 RMB (US$ 773) per household in five years. We estimate that a health shock leads to an average increase of 1119 RMB (US$ 174) in public welfare transfer per household in five years. Considering that there were a total of 26.85 million hospitalizations due to cardiovascular and cerebrovascular diseases in 2019 (National Center for Cardiovascular Diseases, 2021), the estimated overall increase in public financial burden due to cardiovascular and cerebrovascular health shocks amounts to 120.1 billion RMB ($=26.85 \times (3863 + 1119)/1000$) over five years, in terms of public expenditure on medical reimbursement and public welfare transfers.

Overall, we find a large and persistent negative impact of adverse health shocks on individual's health, income, household asset,

[2] Source: Official report from the Chinese State Council Leading Group Office of Poverty Alleviation and Development in 2015. See at http://nrra.gov.cn/art/2020/9/8/art_624_183213.html

and household members' well-being. The health shock also incurs large social cost due to higher financial burden on the social insurance and public welfare system. Our finding suggests that unexpected diseases pose an imminent threat to the health and financial well-being of Chinese households as well as the sustainability of China's public health insurance system and the safety net program.

There is a large economic literature documenting the economic consequences of health shocks in developed countries (Andersen, Parise, & Peijnenburg, 2021; Blundell, Britton, Costa Dias, & French, 2016; Bonekamp & Wouterse, 2021; Conti, Heckman, & Urzua, 2010; De Nardi, Pashchenko, & Porapakkarm, 2017; Dobkin et al., 2018; Hai & Heckman, 2019; Heckman, Humphries, & Veramendi, 2018; Keane, Capatina, Maruyama, et al., 2019; Pelkowski & Berger, 2004; Smith, 1999, 2004). The literature has unanimously found that the health shock not only incurs immediate out-of-pocket medical expenditure, but also creates a sustained reduction in labor productivity, income and wealth, human capital accumulation, and health behaviors over the life cycle. The scale of the effect varies across countries. For example, Dobkin et al. (2018) finds a hospital admission leads to an 11-*pp* decline in the labor market participation and 20% reduction of pre-admission individual income among non-elderly US population. Fadlon and Nielsen (2021) find a smaller, 3.4% reduction in household income after a nonfatal health shock in Denmark.

However, much less is known about the economic consequences of health shocks in developing countries. Notable exceptions include Gertler and Gruber (2002), who find that worsened health status of the household head reduces labor supply and income in Indonesia, although the effect varies in sign and size for different health shock measures. Wagstaff (2007) and Mitra et al. (2016) find evidence that health shocks lead to large reduction in consumption, income, and labor supply in Vietnam, in particular for uninsured households. Ghatak, Madheswaran, et al. (2011) document an average 21.6% reduction in annual household income due to health reasons in India, particularly among the rural poor. For Chinese households, Lindelow and Wagstaff (2005) find that worsened health status causes a 15% reduction of labor market participation and 6.2% reduction of household per capita income.

Due to data limitations, these prior studies in developing countries mostly rely on self-assessed health status, all-cause hospitalization, or extremely rare events such as death of a household member as measures of a health shock, and exploit cross-sectional variations to assess the relationship between health status and labor market outcomes. Our study contributes to this strand of literature by focusing on a set of acute and unexpected health shocks and identifying the first onset of health shocks as a change of health. We adopt CEM and DID methods with fixed effects to remove both observable and unobservable heterogeneities of patients and households. This helps us to separate the impact of the adverse health event on economic outcomes from other potential secular trends and from the potential endogeneity of reported health to economic circumstances. In addition, we investigate a wide range of household health and socioeconomic outcomes, in particular, measures of mental health and the household receipt of public poverty-alleviation allowance, and assess both the private and social cost of health shocks in a nationally representative sample of Chinese population.

Our study also contributes to the growing literature on quantifying the impact of health shocks on the entire household, particularly the intra-household spillover effects (Arrieta & Li, 2021; Fadlon & Nielsen, 2019, 2021; Frimmel, Halla, Paetzold, & Schmieder, 2020; Kristiansen, 2021). When a family member falls ill, other members play the main role of financial support and informal care (Behson, 2005; Given, Given, & Kozachik, 2001; Gooding et al., 2011). Health shocks may also change the family health behaviors through learning about genetic and life-style-related health risks and the salience of health shocks itself (Fadlon & Nielsen, 2019). However, existing studies in developed countries have found mixed results on the magnitude and even the existence of a spillover effect on other household members. For example, Jeon and Pohl (2017) document that cancer diagnoses substantially *decrease* the labor supply of the spouse in Canada. However, in Denmark, health shocks significantly *increase* the spouse's labor supply to compensate for the loss of household income (Fadlon & Nielsen, 2021). In Netherlands, parental health shocks lead to *no* significant change in their adult children's income and labor supply (Rellstab, Bakx, Garcia-Gomez, & Van Doorslaer, 2020). This wide range of estimated intra-household spillover effects naturally reflects the institutional differences in the public and private health insurance system as well as the social support system across countries, such as the existence and functioning of long-term care (Einav, Finkelstein, & Mahoney, 2018).

Evidence on the effect of health shocks on family health behaviors is thin for developing countries. The potential intra-household spillover effects in developing countries are expected to be very different from those in developed countries due to the underdevelopment of the social support systems such as income insurance and long-term care (Feng et al., 2020; Loyalka, Liu, Chen, & Zheng, 2014). Existing evidence in developing countries mostly focus on family's consumption and income-related outcomes (e.g., Ghatak et al. (2011); Lindelow and Wagstaff (2005); Wagstaff (2007)), with a lack of evaluation on mental health, time use, or health behaviors of family members. Our work contributes to filling this gap in knowledge by quantifying the impacts of adverse health shocks on mental health and health behaviors for both the respondent and the spouse. We find that the health shock worsens spousal mental health but leads to a notable improvement in spouse's health-promoting behaviors, including reducing smoking and drinking and increasing the spending on fitness and health supplements. These behavioral adjustments are long-lasting. These findings suggest that family members actively adjust their health behaviors to reduce their health risks after a health shock in the family. These findings based on Chinese households has broader implications on other developing countries.

The remainder of the paper proceeds as follows. Section 2 describes the institutional background and discusses stylized facts on adverse health shocks in China. Section 3 describes the data and summary statistics. Section 4 discusses the empirical methodology. Sections 5 presents the main findings. Section 6 presents the heterogeneity analyses and Section 7 provides robustness checks. Section 8 quantifies the overall private and social cost of a health shock and Section 9 concludes.

2. Background

In this section, we briefly discuss the list of sudden and acute diseases, ischaemic heart disease and stroke in particular, that we

define as health shocks. We then skim through the public health insurance system and the poverty relief allowance system in China as the institutional background for our discussion of empirical findings later. Further details on China's health and social insurance systems are discussed in the Appendix Section A.

2.1. Health shocks

Sudden onset of adverse health conditions poses an imminent health threat globally. According to the Global Burden of Disease Study 2019, ischaemic heart disease is the top driver of the rising burden of disease for the world population, with stroke being among the top three (Vos et al., 2020).[3] Ischaemic heart disease is the leading cause of death for global adult population, with stroke being the top six.[4]

In China, ischaemic heart disease and stroke were the top two leading causes of death and burden of disease in 2017 (Zhou et al., 2019), and population growth and aging has led to a steady increase in the burden of ischaemic heart disease and stroke (Zhang et al., 2018). In particular, the age-standardised incidence of ischaemic heart disease in China was 1507 per 100,000 population, and death rate was 138 per 100,000 population (Liu et al., 2019); the age-standardised incidence of stroke in China was 1115 per 100,000 population, and death rate was 149 per 100,000 population (Wang et al., 2020). Overall, ischaemic heart disease and stroke, the main forms of health shocks, have become a serious public health challenge for China, with increasingly important health and economic consequences for the affected households and the society.

Ischaemic heart disease and stroke are widely recognized as sudden and acute events whose particular timing is unpredictable. We loosely refer to these two diseases, with a small set of acute and unpredictable cardiovascular and cerebrovascular diseases, as health shocks. The estimation strategy we adopt in the empirical analyses, which aims to estimate households' ex post responses to realizations of these health shocks (rather than in anticipation of them), relies on the identification assumption that the exact timing of these shocks may be as good as random, which has been exploited for identification in a variety of settings (Chandra & Staiger, 2007; Doyle, 2011; Fadlon & Nielsen, 2019, 2021).

2.2. The public health insurance system in China

China's public health insurance is the primary form of protection against large medical spending for most Chinese households. More than 1.3 billion individuals have enrolled in China's public health insurance, which cover 95% of the whole population in China in 2011, and close to 100% in 2013.

The public health insurance system in China has undergone major changes in recent years. Before 2014, three types of public health insurance existed in China to provide coverage for different groups of population, including Urban Employee Basic Medical Insurance (UEBMI) for public and private employees in urban areas, Urban Residents Basic Medical Insurance (URBMI) for nonemployed urban residents (including students and the retired), and New Rural Cooperative Medical Insurance (NRCMI) for rural residents. These three types of insurance had significant differences in both premium and coverage.[5] In general, rural households have lower insurance coverage and also paid lower premium. Since 2014, the Chinese goverment started to integrate URBMI and NRCMI into the Basic Medical Insurance for Urban and Rural Residents, so that most urban and rural residents can enjoy the same level of benefits of insurance coverage. Our empirical results show that there exists no significant rural-urban difference in health or income responses after experiencing a health shock. This may be explained, at least partially, by the fact that urban-rural difference in insurance coverage has been mostly removed in the recent decade.

2.3. Poverty relief allowance in China

If a household experiences a devastating health shock and falls into poverty, they can apply for a government-provided monthly poverty relief allowance (called minimum livelihood guarantee, or *dibao* in Chinese).

Dibao is a social assistance system in which the government provides direct money transfers to underprivileged households in order to help them maintain basic living standards. In 2020, 4.9 million *urban* households (8.05 million individuals) received *dibao* transfers in China, with an average annual transfer of 8131.2 RMB (US$ 1270) per person; comparatively in rural area, 19.85 million *rural* households (36.208 million individuals) received *dibao* transfers, with an average annual transfer of 5962.3 RMB (US$ 931.6) per person.[6] In 2020, the Chinese government spent approximately 19.36 billion RMB on *dibao* transfer, accounting for roughly 0.8% of China's annual fiscal expenditure.

The urban *dibao* system was established in the early 1990s, with the primary objective of alleviating poverty of urban laid-off workers and ensuring minimum living standards. The program has made significant contributions in improving urban residents'

[3] The full list of top ten leading contributors to global burden of disease is ischaemic heart disease, diabetes, stroke, chronic kidney disease, lung cancer, age-related hearing loss, HIV/AIDS, other musculoskeletal disorders, low back pain, and depressive disorder.

[4] See https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-leading-causes-of-death.

[5] See Dong (2009) for detailed discussion on the institutional background and development of these three public health insurance schemes.

[6] Source: Offical statistics from the Ministry of Civil Affairs of the People's Republic of China. See at http://images3.mca.gov.cn/www2017/file/202109/1631265147970.pdf

living standards, relieving urban poverty, and maintaining social stability (Gao, Garfinkel, & Zhai, 2009; Gao, Yang, & Li, 2015; Gustafsson & Quheng, 2011). In 2007, the State Council expanded the *dibao* transfers to eligible rural households. There exist large differences in both the eligibility income threshold and the level of transfers bewteen rural and urban *dibao* households (see Appendix Table A1), largely due to the urban-rural differences in income level and the cost of living. Substantial differences in *dibao* standards also exist across provinces. Overall, China's *dibao* program is the largest safety net program in the world and has been shown to raise the standard of living for millions of disadvantaged households in China (He, Fang, Rose, Zheng, & Rozelle, 2021; Li & Walker, 2018).

3. Data

In this section we discuss the main data sources, define primary outcome variables, and describe the construction of the analytical sample. Lastly, we present the summary statistics.

3.1. Data source

We adopt two nationally representative longitudinal surveys in China: China Family Panel Studies (CFPS) and China Health and Retirement Longitudinal Survey (CHARLS), both of which provide a comprehensive set of household financial and health variables that characterize household's responses to health shocks. We adopt CFPS as our primary dataset and CHARLS as supplementary one.[7]

CFPS collects individual and household-level data to record the changes in Chinese society, economy, population, education, and health over time, and is designed based on the US Panel Study of Income Dynamics (Huang & Zhang, 2021). The first survey was conducted in 2010 with a nationally representative sample that covered 16,000 households from 162 counties in 25 provinces in China. The population of the 25 provinces covers 95% of China's total population except for Hong Kong, Macau, and Taiwan. As shown in Appendix Fig. B1, the age-gender structure of CFPS (left panel) is very similar to that of the whole population as depicted in the 2010 National Population Census of China (right panel). We use CFPS data from suvey waves 2010, 2012, 2014, 2016, and 2018.

CFPS data fits our study of the household responses to health shocks very well. First, the long-time span enables us to examine both the short- and medium-term effects of health shocks on household outcomes. Second, the dataset contains detailed information on health (such as physical and mental health, and health behaviors) and economic outcomes (such as household income, asset, and daily expenditure), which offers a thorough depiction of household's response to health shocks. Third, the survey's coverage of both the respondents and their spouses allows us to study whether there will be an intra-household spillover effect of health shocks.

We adopt the CHARLS as a supplementary dataset. CHARLS collects a nationally representative sample of Chinese residents ages 45 and older to facilitate research on the Chinese elderly (Zhao, Hu, Smith, Strauss, & Yang, 2014).[8] We draw evidence from CHARLS survey waves 2011, 2013, 2015, and 2018. We conduct the same set of statistical analyses on the CHARLS sample to validate the robustness of our baseline results on the elderly population in CFPS sample. More details about CHARLS data are discussed in the Appendix B.

3.2. Variable definition

We hereby discuss the definition of an unexpected health shock as well as the main categories of outcomes: income and asset, physical and mental health, and health behaviors. Table 2 presents the summary statistics for the definition of health shock and main outcome variables.

Health shock As discussed in Section 2.1, we define the ischaemic heart disease (commonly known as a heart attack), stroke, and a small set of acute and unpredictable cardiovascular and cerebrovascular diseases, as health shocks. It is clinically acknowledged that the precise timing of the onset of these diseases is unpredictable even in poor health (Chandra & Staiger, 2007; Doyle, 2011; Fadlon & Nielsen, 2019, 2021). The full list of health shocks includes angina pectoris, acute myocardial infarction, other ischemic heart disease, and cerebrovascular disease (see Appendix Table A4). We also define a health shock as the first diagnosis of cancer in the robustness analysis (see the list of CFPS included cancer types in Appendix Table A5).

Physical health and medical expenditure We adopt a wide range of variables to measure physical health status of the respondent and spouse. These variables include (1) self-reported health status (1–7 as very poor health to very good health, we define an indicator of being healthy if self-reported as good or very good), (2) interviewer-rated health status (based on a similar scale of the self-reported health status), (3) a dummy of whether being hospitalized last year, (4) out-of-pocket hospitalization expenditure last year if ever hospitalized, and (5) a physical difficulty score of performing daily routines (measured by 7 questions designed to assess whether the respondent has difficulty performing routine tasks independently). Each question elicits a yes-or-no answer on whether having difficulty with outdoor activities, eating, cooking, taking public transportation, shopping, doing chores, and washing clothes.

Labor supply, income, and asset We consider two measures of labor market participation for both the respondents and their

[7] CHARLS is nationally representative for the elderly population (aged 45 and older). The average age for survey respondents is 60. We describe the CHARLS survey strategy, construction of our analytical sample, and summary statistics in the Appendix B.2. Summary statistics about CHARLS dataset is shown in the Appendix Table A2 and A3.

[8] CHARLS is designed based on the Health and Retirement Survey (HRS) in the US and related aging surveys such as the English Longitudinal Study of Aging (ELSA) and the Survey of Health, Aging and Retirement in Europe (SHARE).

Table 1
Balance of pre-shock covariates.

	Before CEM		After CEM	
	Treatment	Control	Treatment	Control
	(1)	(2)	(3)	(4)
Predisposing Factors (Including Demographic and Socioeconomic Characteristics)				
Female	0.5890	0.5087	0.6013	0.6041
Age	58.1703	46.2297	57.5657	57.5121
Whether working	0.5386	0.7136	0.5595	0.5518
Number of children	2.2962	1.8272	2.3434	2.3712
Education				
Illiterate/Not finish primary school	0.4371	0.2737	0.4628	0.4616
Primary school	0.2218	0.2284	0.2176	0.2169
Middle school	0.2146	0.2929	0.2097	0.2121
High school or above	0.1265	0.2049	0.1100	0.1094
Enabling Factors (Including *Hukou* and Financing Factors)				
Rural hukou	0.7065	0.7400	0.7255	0.7209
Whether having car	0.1389	0.1787	0.1005	0.0982
Whether having dibao	0.2831	0.2183	0.2634	0.2485
Housing type				
Apartment	0.1585	0.1434	0.1638	0.1566
Bungalow	0.4586	0.4245	0.4897	0.4433
Quadrangle courty	0.0581	0.0504	0.0625	0.0536
Villa	0.0085	0.0068	0.0071	0.0095
Low-rise house	0.1950	0.2510	0.1930	0.2534
Needs for Healthcare (Health Status)				
Pre-existing conditions[*]				
Respiratory/digestive/urinary	0.0827	0.0532	0.0666	0.0837
Circulatory/musculoskeletal	0.1687	0.0554	0.1347	0.1182
Mental/cognitive disorder	0.0007	0.0012	0.0008	0.0015
Having any of the above	0.2352	0.1018	0.1868	0.1855
Number of unique individuals	1533	77,555	1264	14,263

Notes: This table presents the summary statistics of the individual and household characteristics at the survey wave before the health shock. We use these variables are matching keys in the CEM.

[*] : These four dummy variables of pre-existing conditions indicate that whether the respondent has experienced any of the listed diseases in the last year.

spouses: a dummy for whether currently working and hours worked per month. Household income is the sum of five income components: salary income, business income, property income, transfer income, and other income. We focus on household income rather than individual income because the variable of individual income contains a large number of missing values and has nonuniform variable definition across survey waves.[9] Net household asset is defined as assets (cash, deposits, stocks, funds, business assets, and money lent out to others) minus liabilities (financial debts). Appendix Fig. B2, Panels A and B present the distribution of net household income and asset respectively.

We focus on the household's per capita financial outcome—i.e., per capita income, per capita asset, and per capita transfer—as the primary outcome variables in the analysis on household financial well-being. A family's living standard is better reflected by these per capita variables than by the household total (Cutright, 1971). We report results on total household income and total household asset as robustness checks. All monetary terms are adjusted for inflation to 2020 price using consumer price indices.

Poverty and transfers We measure household poverty using an indicator for whether a household receiving the government-provided monthly poverty relief allowance (Minimum Livelihood Guarantee, *dibao* in Chinese). A household is eligible to apply for dibao if their annual income per household member is below the local subsistence level, which is usually below 30% of local average household income (see Appendix Table A1). In our sample, household transfer includes private transfer (e.g., transfer from children, parents, or other relatives) and public transfer (e.g., *dibao* transfer as the primary source of public transfer, other government transfers, and community transfers).

Mental health We measure the mental health status of the respondent and the spouse using the clinically validated Center for Epidemiologic Studies Depression Scale (CESD) (Radloff, 1977a). Each CESD question is rated 1 to 4, with a higher score indicating

[9] We do not use individual income for three reasons. First, the variable on individual income contains a large number of missing values. Second, in the 2016 survey, work-related information of respondents whose primary job did not change between 2014 and 2016 was not collected or recorded (a sample of 4901 respondents, accounting for 20% of all employed respondents in 2016 survey wave), resulting in a large number of missing values for individual wage income. Second and more importantly, the definition of individual income is not uniform across survey waves. For example, individual income in 2010 includes transfer income; however, that in 2012 does not include transfer income but includes retirement pensions. We therefore cannot make a sound assessment on the effect of a health shock on individual income due to potentially nonrandom missing values and measurement errors in this variable.

worse mental health status. Because a complete 20-item version, a 12-item version, and a short 6-item version of CESD are adopted in turn across CFPS survey waves, we focus on four questions that are consistently asked across all waves and calculate a depression score as the sum of item-specific scores.[10] The depression scores ranges from 0 to 16. We define an indicator of moderate depression one if the score exceeds 8, and an indicator of severe depression if the score exceeds 12.

Health behavior We analyze three categories of health behaviors: (1) physical exercises, (2) consumption of health-harmful substance and/or activities, such as smoking and drinking, and (3) consumption of health-improving substance and/or activities, such as expenditure on health supplement, fitness activities, and preventive care expenditure.

3.3. Sample restriction and summary statistics

We make four sample restrictions. First, we include households with both husband and wife present to allow an analysis of potential within-household spillover effect of health shocks. Among 55,963 individuals interviewed in the CFPS, 37,280 were married and had their spouse interviewed as well. Second, we exclude respondents that appeared only once in the survey (4386 respondents). These respondents are excluded in the fixed-effect (FE) estimation as we include individual FEs to eliminate time-invariant individual heterogeneities. Third and most importantly, we exclude households that have already experienced health shocks before the survey window, because prior onset of health shocks may significantly increase the likelihood of recurring shocks (Govender, Al-Shamsi, Soteriades, & Regmi, 2019; Taravatmanesh et al., 2017; Wattanakit, Folsom, Chambless, & Nieto, 2005) and households with prior shocks may behave differently in unobservable ways prior to recurring shocks. Specifically, we exclude 1824 respondents who reported having experienced health shock when they were surveyed for the first time in CFPS. In addition, we exclude pairs of respondents and their spouses who have both experienced health shocks at the same survey wave. Such simultaneous occurrence of health shocks on both members of the family is rare (6 pairs of household heads and spouses). Lastly, we set an age range for both spouses to be 20–80 years at their first survey wave. This last sample restriction excludes 658 respondents. After all sample restrictions, there are 30,400 respondents (15,200 pairs of spouses) in the matching pool for CEM.

We focus on the group of individuals who have experienced their *first onset* of a health shock during the sample period. This group consists of 1533 individuals (630 men and 903 women) diagnosed with a health shock for the first time between 2010 and 2018. We hereafter refer to this group of individuals as the treatment individuals, and their households as the treatment households.

Summary Statistics Table 1 Columns 1 tabulates the pre-health-shock characteristics for treatment individuals. The treatment-group individuals are on average 58 years old and have an average 2.3 children; about 59% are females; 71% are from rural areas (i.e., having rural *hukou*); 65.9% have primary school education or below, and 12.7% have finished high school or above; about 24% of them have reported to have been sick during last year.

Column 2 tabulates the characteristics for the rest of the sample, that is, individuals who have never experienced any health shock before or during our sample period. A simple comparison against Column 1 reveals substantial differences in demographic and socioeconomic characteristics between the treatment group and the rest of the sample. For example, treatment individuals are older, have lower education attainment, lower income, and are more likely to have pre-existing chronic conditions before having their first health shock. To balance the observable characteristics between individuals who have experienced a health shock and those who have not, we implement a coarsened exact matching algorithm to obtain a matched sample of treatment and control groups before turning to a DID estimation.

4. Empirical methodology

As discussed above, in addition to exploiting the unpredictability of the timing of health shocks as a source of exogenous variation, we combine the coarsened exact matching (CEM) method with a difference-in-differences (DID) strategy to control for observed and unobserved heterogeneities across individuals. In what follows, we describe details of the CEM algorithm and DID specification.

4.1. Coarsened exact matching

Because of the differences in characteristics between the treatment individuals and the rest of the sample, a challenge to DID estimation of the effect of health shocks is that the treatment individuals might behave differently from others prior to the onset of the health shock. The exogeneity of the timing of the health shock is unlikely to eliminate all pre-existing differences in health behaviors. To overcome this challenge, we conduct a coarsened exact matching (CEM) method to balance the observable characteristics between treatment and control groups.[11]

CEM is a multidimensional exact matching algorithm applied to “coarsened” blocks of covariate values generated by discretizing

[10] Each question is elicited an answer of 1 to 4, with 1 indicating seldom feeling any negative emotions and 4 indicating feeling constantly depressed in the last month. These four questions include: (1) how often do you feel depressed and cannot cheer up no matter what you are doing, (2) how often do you feel hopeless about the future, (3) what is your sleep quality, and (4) how often do you think that everything is complicated and difficult.

[11] Ho, Imai, King, and Stuart (2007) demonstrate that preprocessing raw data using matching procedures before the parametric analysis makes the parametric model much more reliable for the estimation of causal effects; in particular, the estimation of causal effects is less dependent on the choice of model specification.

continuous variables into intervals or by regrouping categorical variables into fewer categories. CEM has some notable advantages compared to other methods of selection on observables. First, CEM performs exact matching on a set of coarsened covariates and the matched sample is more balanced after matching. The other commonly used matching algorithm, propensity score matching (PSM), on the other hand, is performed based on a calculated propensity score and relies on estimating parametrically a model of covariates. The validity of PSM thus relies on a correct function-form specification of the propensity score (King & Nielsen, 2019). Besides, CEM requires no ex-post balance checking as the maximal acceptable imbalance is pre-determined by imposing bins of covariates in which the observations are matched (Iacus, King, & Porro, 2012).

Second, CEM matches treatment and control units by stratifying observations into bins with the same coarsened values of all matching variables (matching keys), and ensuring common support by excluding all unmatched observations. Third, in each stratum, a matching weight is calculated to reweight observations in the matched sample. Specifically, a matching weight of one is assigned to each treatment unit, and a weight assigned to each control unit in stratum i equals to the ratio of the treatment sample size (n_t^i) to the control sample size (n_c^i) in each stratum i multiplied by the ratio of the total size of the control sample (N_c) to the total size of the treatment sample (N_t). These matching weights rebalance the empirical distributions of the matching variables between the treatment and control samples (Iacus et al., 2012). The weighted DID estimates on the matched sample thus represent an average treatment effect on individuals that experienced the health shock (Fadlon & Nielsen, 2021; Jeon & Pohl, 2017).

The Matching Procedure We implement CEM in the following steps. First, we select a set of pre-shock covariates as matching keys. Our choice of matching keys is based on the guiding framework of Anderson's behavioral model of health services utilization (Andersen, 1995; Njagi, Groot, & Arsenijevic, 2021; Zhang, Chen, & Zhang, 2019). The Anderson's behavioral model suggests that healthcare utilization is determined by three key factors: predisposing factors (demographics, socioeconomic status, and health reference), enabling factors (income-related variables and factors that change the affordability of healthcare services), and needs for healthcare (health and disease status) (Aday & Andersen, 1974; Andersen, 1995; Andersen & Newman, 1973).[12] In our matching process, predisposing factors include gender, coarsened age bins, number of children, working status, and educational attainments; enabling factors include *hukou* status, whether owning a car, whether having *Dibao* (below the poverty line), and house types as proxies for household wealth; individual needs for healthcare are proxied by a list of dummies for pre-existing chronic conditions (see Table 1 for the list of matching keys). We implement CEM on this set of matching keys. Overall, this set of pre-shock covariates as chosen to ensure that the treatment and control group individuals are comparable in observable characteristics that determine their healthcare behaviors and the demand for healthcare services before the health shock.

Second, we specify four groups of pre-matching treatment units based on the year of their first onset of health shocks: individuals who experienced the shock between 2010 and 2012 wave, those between 2012 and 2014, those between 2014 and 2016, or those between 2016 and 2018. For each group of treatment units, we use the CEM algorithm to select a group of matched control units from individuals who have *never* experienced any health shock before and during the sample period. For example, for treatment units who experienced the shock between 2010 and 2012, we match a group of control units based on the 2010 values of matching keys and compute the corresponding matching weights. All unmatched observations are dropped from the sample. Overall, we have matched more than 80% of pre-match treatment units. The post-match sample includes 1264 treated units (not including spouse) and 14,263 control units.

Table 1, Columns 3 and 4 demonstrate that observable individual and household pre-shock characteristics are well balanced between the matched treatment and control groups. Appendix Table A6 presents the univariate L1 metric for each pre-shock characteristics (as matching key) as well as the multivariate L1 distance of all matching keys both before and after the matching procedure (Blackwell, Iacus, King, & Porro, 2009). For each group, univariate L1 metrics have reduced to close to zero after the matching, and the multivariate imbalance of all matching keys have dropped from more than 0.9 to less than 0.4, a more than 50% imbalance reduction.

4.2. Difference-in-difference estimation

Baseline specification As CEM balances the observable characteristics between treatment and control groups, we adopt a DID estimation method to further control for unobservable, time-invariant individual heterogeneities. We estimate the following DID specification:

$$y_{it} = \beta_0 + \beta_1 shock_{it} + \alpha_i + \eta_t + \epsilon_{it} \tag{1}$$

where y_{it} is the outcome of interest for individual i at wave t, $shock_{it}$ equals to one after individual i has experienced his/her first onset of a health shock at wave t, and zero for all control individuals. We include individual fixed effects (FEs), α_i, to control for individual's unobservable time-invariant characteristics. Unobservable individual heterogeneities, such as one's risk preference (Lin & Sloan, 2015), may correlate with both the probability of a health shock and the outcomes of interest. The inclusion of individual FEs thus eliminates the potential confounding influence of such time-invaraint individual heterogeneities on individual's probability of

[12] In particular, predisposing factors include demographic characteristics (e.g., age, sex, race/ethnicity, marital status), socioeconomic characteristics (e.g., education, social class, and employment status), and health beliefs (e.g., attitudes, values, and knowledge of health and health services). Enabling factors include financing and organizational variables that are considered to serve as conditions enabling health services utilization. Enabling factors include health insurance, household income, wealth, availability of services, and ruralâ€“urban strata. The needs for health service mainly depend on the general health, functional state and illness symptoms of the respondents, as well as the professional assessments by the doctors.

experiencing a health shock and post-shock outcomes. We also include the survey wave FEs η_t to control for population-wide time-varying factors that may affect individual's health and health behaviors. These population-wide factors may include the implementation of national public health policies, the national trend of diseases and disease control, and the change of public awareness of the prevention and treatment of health shocks. CEM matching weights are used and robust standard errors are clustered at the household level. Considering the large set of outcome variables under investigation, in order to reduce the likelihood of type I errors (false rejection of zero effect), we perform multiple hypotheses tests and report the unadjusted p-values, bootstrap-based adjusted p-values, and Anderson (2008)'s sharpened q-values throughout our baseline estimation tables.

Overall, the estimation of Eq. 1 exploits the exogenous timing of the health shock, the balance of observable characteristics between treatment and control groups, and the control for unobservable time-invariant heterogeneities with individual FEs. The coefficient of β_1 can be interpreted as a causal estimate of the average treatment effect of health shocks on those who have experienced the shock.

Event-study specification We estimate an event-study specification to estimate the dynamic effects of health shock:

$$y_{it} = \beta_0 + \sum_{k=-3}^{2} \beta^k shock_{it}^k + \alpha_i + \eta_t + \epsilon_{it}, \tag{2}$$

where $shock_{it}^k$ is a set of time-to-treatment dummies that measures the number of waves since a treatment group individual experienced his/her first onset of the health; $k = 0$ indicates the first survey wave since the health shock, and $k = -1$ is omitted as the reference period.[13] Other covariates and FEs are specified similarly as in Eq. 1. Robust standard errors are clustered at the household level.

The coefficients of interest are the set of β^k's. The pre-treatment coefficients ($k < -1$) measures the difference in the change of outcomes (relative to the reference period) between the treatment and control groups before the onset of the health shock. These pre-treatment coefficients can be used to assess the parallel pre-trends assumption for the DID specification. The post-treatment coefficients ($k \geq 0$) measures the persistence of the impacts of the health shock years after the onset of the health shock.

Heterogeneous-effect specification We also estimate the potentially heterogeneous treatment effects of health shocks on different subgroups of individuals and their spouses using the following specification:

$$y_{it} = \beta_0 + \beta_1 shock_{it} + \beta_2 shock_{it} \times z_i + \alpha_i + \eta_t \times z_i + \epsilon_{it}, \tag{3}$$

where z_i is the dimention of individual or household heterogeneity of interest. Other covariates and FEs are specified similarly as in Eq. 1. We allow the time trend to differ by the dimension of individual or household heterogeneity by including the interaction $\eta_t \times z_i$. Robust standard errors are also clustered at the household level. Our parameter of interest is β_2, which captures the extent to which the effect of a health shock on household outcomes differs across individuals and households according to the dimension of heterogeneity z_i.

5. Baseline results

We aim to provide a holistic view of the impact of an unexpected adverse health shock on a household's financial and health well-beings. We investigate three main categories of household outcomes: (1) physical health and medical expenditure, (2) economic outcomes, including labor supply, income, household asset, and poverty status, and (3) mental health and health behaviors.

5.1. Physical health and medical expenditure

We expect that the occurrence of a health shock will have an immediate impact on one's physical health; however, the size and time persistence of the effect is unclear a priori. We estimate the immediate and medium-term (2–5 years) impact of a health shock on individual's and their spouse's physical health. The time pattern of the health shock's impact on individual's physical health and medical expenditure will justify the unpredictability of health shock and lay the foundation for our discussion of the medium-term impact of the shock on household income, assets, mental health, and health behaviors in later sections.

We find that the occurrence of a health shock substantially reduces individual's physical health and increases the medical expenditure. Table 3 reports the estimation results of Eq. 1 using five measures of individual's physical health outcomes. Columns (1) and (2) show that the health shock has a large reduction in self-reported and interviewer-rated health status. In particular, the occurrence of a health shock reduces the self-reported health by 20% of sample mean. Column (3) shows that the health shock leads to a 18.2-*pp* increase in the probability of being hospitalized last year, and an increase of RMB 4075 in annual hospitalization expenditure (217% of sample mean, Column 4). In addition, the health shock also significantly impairs the individual's ability to independently perform daily routines, as shown by a statistically significant increase in the difficulty score (Column 5).[14]

Fig. 1 shows that the impact of health shock on health and medical expenditure is immediate and large, and is persistent over time.

[13] Because we have five waves of CFPS data and we restrict that all treatment individuals have not yet experienced any health shock in the first wave, we can track a treatment individual at most four waves after the health shock and at most four waves before the health shock. In estimation, we combine the first two pre-shock bins as $k = -3$ and the last two post-shock bins as $k = 2$ due to the small bin size at the two ends.

[14] The difficulty score is measured by eliciting a yes-or-no answer to seven questions, including whether having difficulty with outdoor activities, eating, cooking, public transit, shopping, household chores, and washing clothes. As a robustness check, we estimate the effect of the health shock on each of the seven items of the difficulty score. Appendix Table A7 show that the results are consistent.

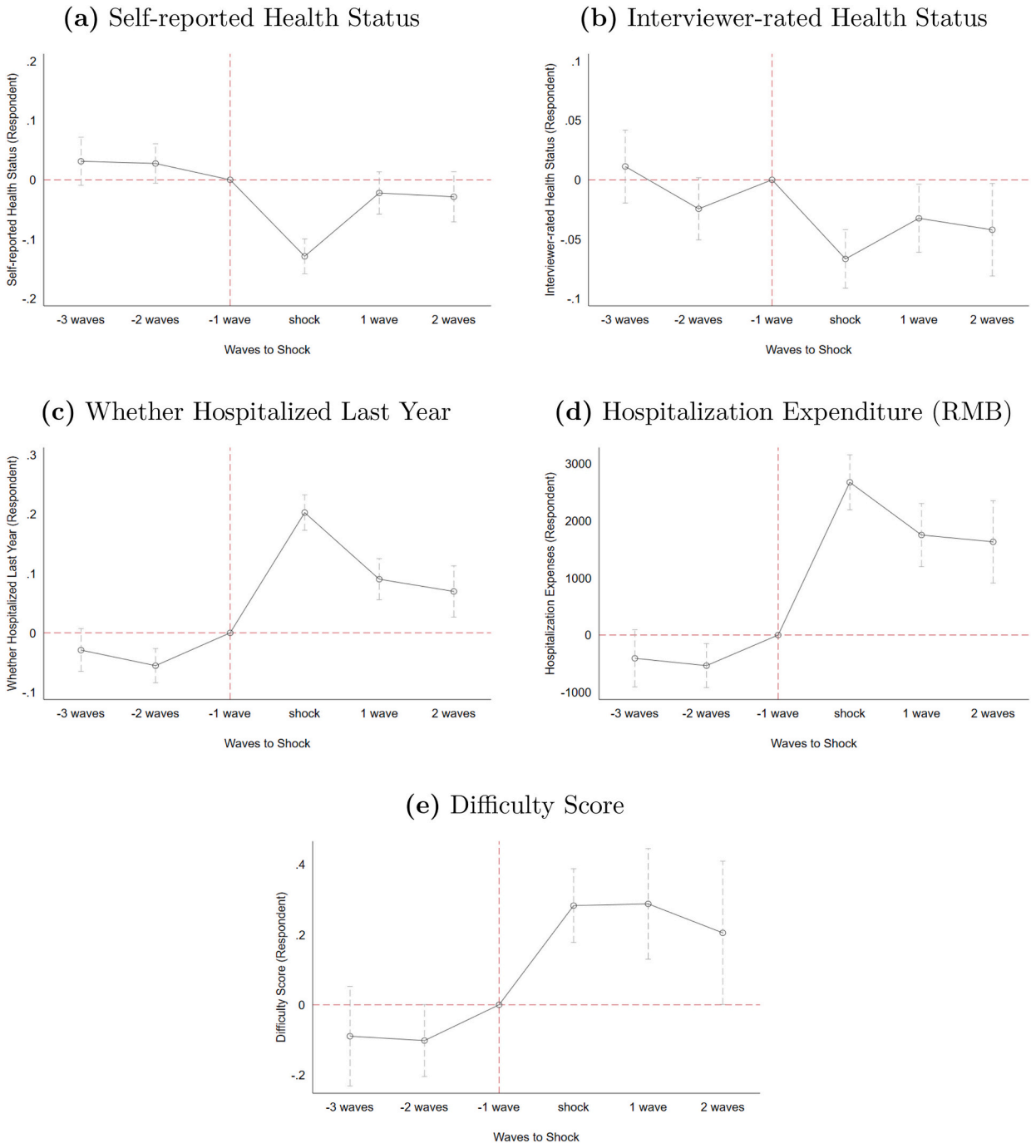

Fig. 1. Event-study Estimates of the Effects of Health Shocks on Physical Health.
Notes: This figure presents the dynamic effects of health shocks on different measures of respondent's physical health. The regression specification is specified in Eq. 2 and discussed in details in Section 4.2. We plot the estimated coefficients of time-to-treatment dummies (β^ks in Eq. 2) together with the corresponding 90% confidence intervals in the figure.

For example, the probability of being hospitalized increases by more than 20 *pp* in the first wave after the shock, or 150% over the sample average probability of 13.7 *pp* (Table 2); the on-impact effect on hospitalization expenditure is consistent. In addition, the impacts on physical health and medical expenditure are long-lasting. After an initial sharp increase in hospitalization, the impact on the probability of hospitalization is reduced over time but remains economically and statistically significant after three survey waves, or six years (Panels C and D). The post-shock reduction in individual's self-rated and interviewer-rated health status remains sizable and statistically significant (Panels A and B). Furthermore, the effect of the shock on individual's difficulty score remains sizable and

Table 2
Summary Statistics of the Analytical Sample.

Variable	Obs	Mean	S.D.	Min	Max
Panel A: Health Shocks					
Having experienced a health shock	70,085	0.083	0.276	0	1
Panel B: Physical Health Status					
Self-report health status (respondent)	70,001	0.504	0.500	0	1
Self-report health status (spouse)	63,442	0.528	0.499	0	1
Whether hospitalized last year (respondent)	68,743	0.137	0.344	0	1
Whether hospitalized last year (spouse)	60,885	0.126	0.332	0	1
Hospitalization expenses (respondent)	68,655	1874	10,853	0	547,000
Hospitalization expenses (spouse)	60,838	1854	11,074	0	437,600
Panel C: Household Economic Status					
Whether working (respondent)	69,720	0.521	0.500	0	1
Whether working (spouse)	62,800	0.544	0.498	0	1
Net income per capita (RMB)	69,679	14,075	14,522	89	189,846
Net asset per capita (RMB)	68,180	141,030	262,220	−7638	3,685,467
Whether having dibao	70,063	0.291	0.454	0	1
Whether eligible for dibao	68,021	0.196	0.397	0	1
Panel D: Mental Health					
Depression score (respondent)	68,346	5.828	2.337	4	16
Depression score (spouse)	60,565	5.621	2.183	4	16
Moderate depression (respondent)	68,346	0.204	0.403	0	1
Moderate depression (spouse)	60,565	0.172	0.378	0	1
Severe depression (respondent)	68,346	0.033	0.180	0	1
Severe depression (spouse)	60,565	0.025	0.156	0	1
Panel E: Health Behaviors					
Whether exercising (respondent)	70,085	0.403	0.490	0	1
Whether exercising (spouse)	63,540	0.426	0.494	0	1
Whether drinking (respondent)	68,698	0.147	0.354	0	1
Whether drinking (spouse)	60,848	0.208	0.406	0	1
Whether smoking (respondent)	68,703	0.261	0.439	0	1
Whether smoking (spouse)	60,850	0.351	0.477	0	1
Health and fitness expenditure per capita	69,467	1869	6108	0	437,600

Notes: This table presents the summary statistics of main outcome variables. The analytical sample includes observations from all five CFPS survey waves of the CEM-matched group of respondents. The statistics also include a selected set of household and spousal outcomes of matched respondents.

statistically significant years after the shock (Panel E), suggesting that individuals cannot fully recover in their physical and motor functions. Overall, these results suggest that the health shock will cause long-lasting adverse effect in individual's daily life.

Exogenous Timing of the Health Shock We conduct two robustness analyses to verify that the onset of the health shock is unpredictable, that is, the timing of the shock is exogenous. First, we conduct a placebo test using spouse's physical health outcomes as the dependent variable. A challenge to our identification strategy is that the timing of a health shock—such as a health attack or a stroke—may systematically correlate with individual's unobserved time-varying preferences and health behaviors. Had this been the case, we would observe a similar deterioration in spouse's physical health after the respondent's health shock because of shared family consumption and health behaviors. Appendix Table A8 reports the estimation results on spouse's physical health outcomes and show a lack of any statistically significant effect on spouse's health.[15]

Second, the event-study estimates of the pre-shock coefficients, as shown in Fig. 1, validate the parallel pre-trend assumption of the DID specification. Had the health shock is expected or correlates with unobserved health behaviors, we expect that some pre-shock coefficients would pick up such pre-trend and be estimated statistically significant. Instead, we find that all pre-shock coefficients are close to zero and statistically insignificant. This validates that there exist no unobserved factors prior to the onset of a health shock that would drive the post-shock deviation in health outcomes between the treatment and control groups.

5.2. Economic outcomes

As the unexpected health shock induces a substantial and long-lasting deterioration of individual's physical health, such health impact naturally manifest itself in individual's and household's financial and economic decision-making. We investigate three types of household economic outcomes: labor supply and income, household net asset, and the status of poverty.

Labor Supply and Income We analyze the labor supply of both the respondent and spouse and the household income per capita.[16] We find limited evidence that the health shock significantly reduces household labor supply. Table 4, Column 1 shows that individual's

[15] Appendix Table A9 shows a consistent pattern of no effect of respondent's health shock on spouse's difficulty in performing daily tasks. Event-study estimates of the effects of health shocks on various spousal health outcomes show a consistent pattern (Appendix Figure B3).

[16] We do not analyze individual income due to a large number of missing values and potential measurement errors in this variable (as discussed in section 3.2).

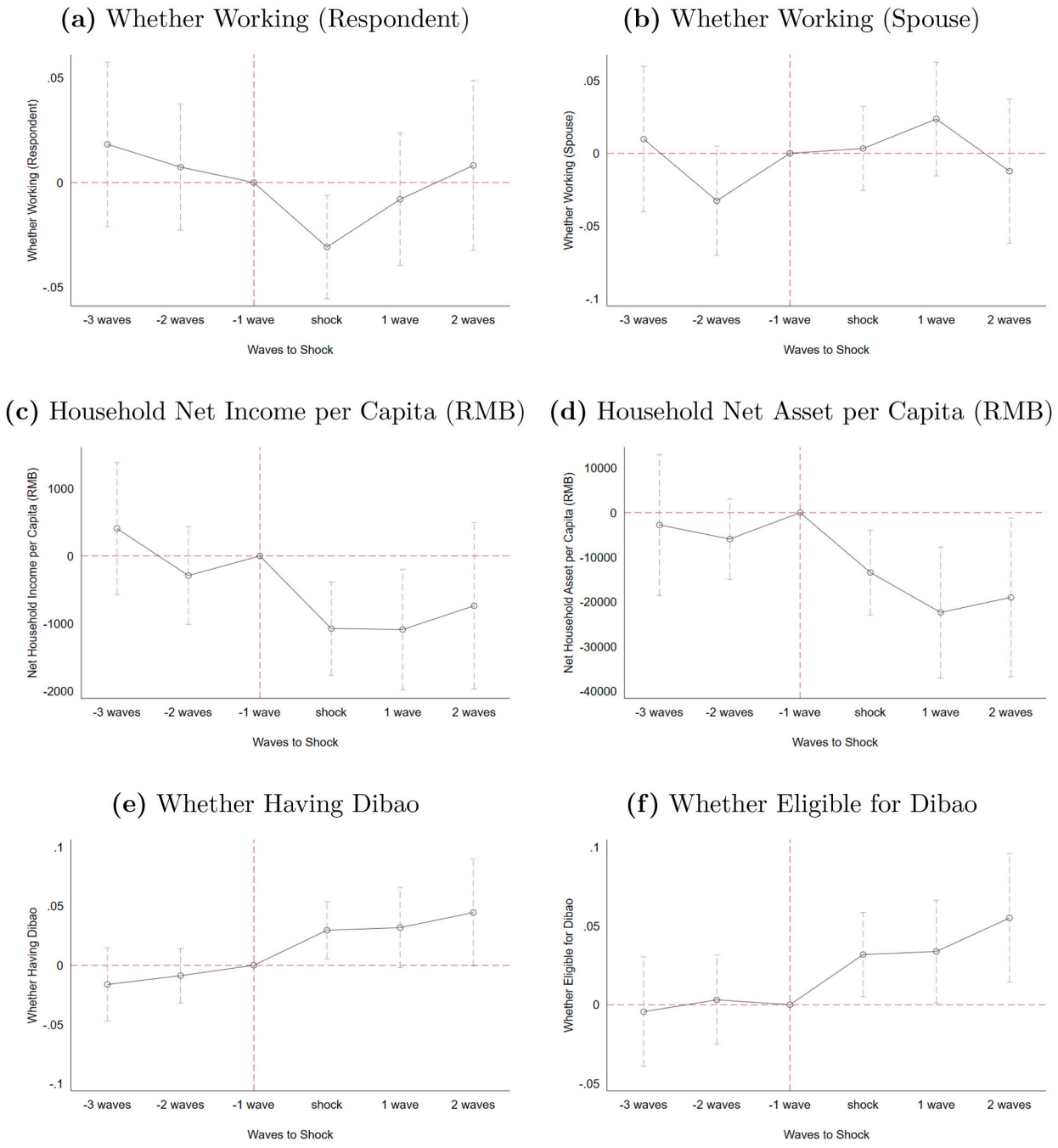

Fig. 2. Event-study Estimates of the Effects of Health Shocks on Household's Economic Outcomes.
Notes: This figure presents the dynamic effects of health shocks on different measures of health behaviors. The regression specification is specified in Eq. 2 and discussed in details in Section 4.2. We plot the estimated coefficients of time-to-treatment dummies (β^ks in Eq. 2) together with the corresponding 90% confidence intervals in the figure.

probability of currently working decreases by 2.6 *pp* (5.0% of sample average) after the health shock. However, event-study plot in Fig. 2, Panel (A) shows that the reduction in individual's probability of working is only temporary: The effect dissipates after one waves (1–2 years). In the intensive margin, we do not find a statistically significant decrease in individual's working hours per month (Appendix Table A10, Columns 1–2). In spousal labor supply, respondent's health shock had a close-to-zero and statistically insignificant effect on spousal labor supply in terms of both labor participation (Table 4, Column 2) and monthly working hours (Appendix Table A10, Columns 3–4); and there is no noticable dynamic pattern in spousal labor supply (Fig. 2, Panel B). Overall, we find that the health shock has a small and temporary effect on respondent's labor supply and does not affect the spousal labor supply in

Table 3
Effect of health shocks on individual's physical health.

Variables	(1)	(2)	(3)	(4)	(5)
	Self-reported Health Status	Interviewer-rated Health Status	Whether Hospitalized Last Year	Medical Expenses (RMB)	Difficulty Score
Shock	−0.101***	−0.048***	0.182***	4074.817***	0.329***
	[0.014]	[0.011]	[0.014]	[548.955]	[0.053]
Unadjusted *p*-value	0.000	0.000	0.000	0.000	0.000
Bootstrap-based *p*-value	0.010	0.010	0.010	0.010	0.010
Anderson's *q*-value	0.001	0.001	0.001	0.001	0.001
Observations	70,001	66,665	68,743	68,655	68,840
R-squared	0.0362	0.0141	0.0259	0.0121	0.0846
Individual FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Outcome mean	0.504	0.885	0.137	1874	0.428

Notes: This table reports the baseline results on the effect of health shocks on individual's physical health. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

an economically meaningful way.

Despite the lack of strong labor-supply responses, we find a substantial negative impact of health shock on household income per capita. Table 4, Column 3 shows that household annual income per capita decreases by RMB 841 per year, or 6.0% of the sample average household income per capita, after the health shock. This estimate is statistically significant at the 5% level. Appendix Table A11 reports results using the log of household income per capita as outcome variable and shows a consistent pattern. Besides per-capita income, we also investigate the total household income and find that the health shock results in a reduction in total annual household income of RMB 3387, or US$ 529, per year (Appendix Table A12, Column 1). Our estimated 6.0% reduction in annual per-capita income is comparable to the estimate of Lindelow and Wagstaff (2005) based on 1991–2000 waves of China Health and Nutrition Survey (CHNS), who estimate a 6.2% reduction in annual per-capita income for Chinese households after a health shock measured by self-assessed health status. Our estimate adds a recent update for Chinese households to the global literature on evaluating the income effect of health shocks.

We break down income into subcomponents and find that the reduction in total household income is mostly driven by salary income and business income (Appendix Table A13). In addition, the effect on household income is not just a transitory shock that dissipates quickly; rather, the estimated reduction in houshold income remain large and statistically significant at 10% level at least 3 years after the health shock (Fig. 2, Panel C). The estimated reduction remains sizable though not statistically significant in the 5th year after the health shock. These results suggest that although the health shock does not have a long-lasting impact on household labor supply, it persistently reduces the labor productivity and disrupts the family business. Such reduction in labor and business productivity may be explained by the reduction in individual's physical health, as evidenced in Table 3, and a significant deterioration of individual's and their spouse's mental health, which we discuss in Section 5.3.

We compare the scale of the income reduction in China to estimates in other countries. In a setting most similar to ours, Fadlon and Nielsen (2021) estimate household responses to the first onset of a heart attack or a stroke in the Danish population and find a 3.4% reduction in individual's annual income. They find all the income reductions are driven by a reduction of individual earning of the person who experienced the shock; the health shock has little impact on the labor supply or income of the spouse. Garcia-Gomez, Van Kippersluis, O'Donnell, and Van Doorslaer (2013) find that an acute hospitalization in Netherland results in a 5% reduction of individual income two years after the shock. In the US, Dobkin et al. (2018) find a 19.3% reduction in annual individual income for non-elderly, insured US adults in three years after a hospitalization (they cannot link or identify other family members in the data). In developing countries, Gertler and Gruber (2002) find that in Indonesia, illness of the household head reduces the head's earning by 12.8% but results in a compensatory increase in the labor supply and earning of other household members, leading to a small and insignificant change in total household income. Wagstaff (2007) finds that a health shock generally reduces total household income in Vietnam, but the sign, size, and statistical significance of the estimated income effect varies with the type of health shocks as well as the insurance status of the household. Overall, the estimated income effect of a health shock varies substantially across countries due to differences in the formal earning insurance system and informal self-insurance strategies such as through the compensatory spousal labor supply. Our estimated 6.0% reduction in household per-capita income lies in the mid range of the international estimates.

Household Asset Considering the sharp increase in medical spending and reduction in household income, we expect that the health shock would significantly reduce the household net asset. Table 4, Column 4 confirms our expectation and shows that household net asset per capita reduces by RMB 13,635 after the shock (or 9.7% of household net asset per capita). The estimate is statistically

Table 4
Effect of health shocks on household's economic outcomes.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Whether Working (Self)	Whether Working (Spouse)	Net HH Income per Capita (RMB)	Net HH Asset per Capita (RMB)	Having Dibao	Eligible for Dibao
Shock	−0.026*	0.014	−840.576**	−13,635.014**	0.028**	0.022*
	[0.014]	[0.014]	[358.149]	[5762.509]	[0.014]	[0.012]
Unadjusted *p*-value	0.063	0.312	0.013	0.018	0.040	0.069
Bootstrap-based *p*-value	0.020	0.168	0.010	0.010	0.010	0.020
Anderson's *q*-value	0.134	0.415	0.042	0.052	0.097	0.139
Observations	69,720	62,800	69,679	68,180	70,063	68,023
R-squared	0.0663	0.0690	0.0753	0.0616	0.2339	0.0372
Individual FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Outcome mean	0.521	0.544	14,075	141,030	0.291	0.196

Notes: This table reports the baseline results on the effect of health shocks on individual's and household's economic outcomes. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

significant at the 5% level. Appendix Table A12, Column 2 shows that the total household net asset decreases by RMB 29,028 after the health shock.

We further analyze the effect of a health shock on subcomponents of household net asset as well as the time pattern of the impact. Appendix Table A14 shows that the sign of the estimated effect of health shock on each subcomponent is expected: Health shock reduces household's cash and deposit per capita by RMB 1715, reduces business assets per capita by RMB 143,110, and raises financial debt per capita by RMB 496. Howerver, none of these estimates are statistically significant. Appendix Table A15 reports results based on log household asset per capita and shows consistent results. Finally, Fig. 2, Panel (D) shows that, similar to the time persistency in the effect on income, the negative effect of health shock on household asset is also persistent and statistically significant at 10% level two to three waves after the shock.

Poverty Status Because the health shock generates a long-lasting negative effect on individual's physical health, income, and net asset, we expect that it raises the household's probability of falling into poverty. In China, a household is regarded and officially recorded as falling into poverty if the household's per capita income falls under an official minimum substance level. This income threshold differs across cities/regions and is roughly 10–20% of the regional average household income (see Appendix Table A1 for a list of income thresholds and average income across regions). Below this threshold income level, households can apply for the government-provided monthly poverty relief allowance, called Minimum Livelihood Guarantee, or *dibao* in Chinese.[17] We hereafter use this minimum substance income level as the measure of poverty line in China's context.

Table 4, Column 5 shows that the occurrence of a health shock increases the probability of a household's having dibao status by 2.8 *pp* (statistically significant at the 5% level). This increase in dibao probability is large and statistically significant at 10% in the first year after the health shock and remains sizable two to three survey waves later (Fig. 2, Panel E). Alternatively, we define a dummy for whether a household is eligible for the dibao allowance, i.e., falling under the local poverty line. Table 4, Column 6 shows that the occurrence of a health shock increases a household's *dibao* eligibility by 2.2 *pp* (statistically significant at the 10% level). Again, this effect remains large and statistically significant at 10% level three waves after the health shock (Fig. 2, Panel F).

Appendix Table A16 shows that the health shock significantly increases household receipt of social welfare transfers, particularly the mean-tested, poverty-alleviation allowance (*dibao* transfer). The annual social welfare transfers per capita increase by 105 RMB per year, which compensates for about 12.5% of the 841 RMB reduction in household income per capita. In addition, the private transfers increase as well: Appendix Table A17 shows that family transfers per capita increase by 105 RMB after a health shock.

Overall, we find that the occurrence of an unexpected health shock has a substantial and long-lasting impact on household's economic well-being: the shock has significantly reduced the household income per capita, reduced the household net asset per capita, and increased the probability of a household's falling under local poverty line. These effects are highly time-persistent.

[17] Besides having per capita income below the local minimum substance level, households need to pass a set of household asset checks, such as whether having cars, multiple housings, and registered business, before being eligible for the *dibao* status. Nevertheless, the income requirement is the most important eligibility rule for *dibao* status.

Table 5
Effect of Health Shocks on Family Mental Health.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Self Mental Health			Spouse Mental Health		
	Depression Score	Moderate Depression	Severe Depression	Depression Score	Moderate Depression	Severe Depression
Shock	0.700***	0.131***	0.035***	0.138**	0.032**	0.005
	[0.069]	[0.013]	[0.008]	[0.067]	[0.013]	[0.006]
Unadjusted *p*-value	0.000	0.000	0.000	0.039	0.010	0.404
Bootstrap-based *p*-value	0.010	0.010	0.010	0.010	0.010	0.366
Anderson's *q*-value	0.001	0.001	0.001	0.097	0.034	0.503
Observations	68,346	68,346	68,346	60,565	60,565	60,565
R-squared	0.2411	0.1062	0.0105	0.2262	0.0864	0.0060
Individual FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Outcome mean	5.828	0.204	0.0334	5.621	0.172	0.0248

Notes: This table reports the baseline results on the effect of health shocks on self and spouse's mental health. The dependent variable, depression score, is the sum of scores from four CESD questions and ranges from 4 to 16. An indicator of moderate depression is defined to be one if the score exceeds 8, and severe depression if the score exceeds 12. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5.3. Mental health and health Behaviors

We find that the occurrence of a health shock significantly reduces individual's mental health. In addition, the shock leads to two important forms of intra-household spillover effects: mental health and health behaviors.

Mental Health The health shock has an adverse and long-lasting effect on individual's mental health. Table 5 presents the estimated effect of a health shock on three measures of individual's and spouse's mental health: the depression score, and indicators for moderate and severe depression. Two results are noteworthy. First, respondents who have experienced the health shock have substantially worse mental health: their depression score increases by 0.70 units after the shock (18.6% of mean score), the probability of moderate depression (score$\geq$8) increases by 13.1 *pp* (64.2% of mean probability), and the probability of severe depression (score$\geq$12) increases by 3.5 *pp* (10.5% of mean probability). Moreover, the effect of the shock on individual's mental health is long-lasting: the effect remains sizable and statistically significant three waves after the shock (Fig. 3, Panels A, C, and E).

Appendix Table A18 reports results on each item of the depression score and find that the shock leads to a statistically significant worsening of mental health in all four dimensions. In particular, the shock statistically significantly increases individual's self-rated extent of feeling down, not being able to go on with life, feeling everything was an effort, and not being able to sleep well. In addition, the health shock reduces an individual's average sleep time by 0.16 h per day.

The occurrence of a health shock also leads to a strong intra-household spillover effect to spouse's mental health. The spousal depression score increases by 0.138 units (2.5% of mean score, Table 5 Column 4), and the spousal probability of moderate depression increases by 3.2 *pp* (18.6% of mean probability, Column 5).[18] The negative effect of a health shock on spouse's mental health is possibly due to financial stress caused by the large medical expenditure, as well as a salience effect triggered by concerns over the spouse's own health status (Fadlon & Nielsen, 2019).

Overall, the substantive deterioration of both respondent's and their spouse's mental health and the decline of their sleep quality may impair their cognitive and noncognitive functioning (Ellis, Walczyk, Buboltz, & Felix, 2014; Goetzel, Hawkins, Ozminkowski, & Wang, 2003), which helps to explain why the health shock induces a long-lasting negative effect on individual's labor productivity and family's business performance as discussed in Section 5.2.

Health Behaviors We find that the health shock reshapes some of family's health behaviors. Because the impact of the first health shock is substantial and salient, we expect that affected individuals would go to great lengths to prevent recurrence—such as by eating healthier and doing more exercise—and such healthier behaviors would also be adopted by other family members. We investigate four dimensions of family health behaviors: physical exercises, smoking, drinking, and the expenditure on health supplements and fitness.

Table 6, Columns 1–3 show that individuals increase their likelihood of physical exercises by 5 *pp* and reduce the likelihood of drinking and smoking by 2.4 and 1.9 *pp*, respectively. All three estimates are statistically significant at the 5% level. Individuals statistically significantly increase their average time in physical exercise by 0.8 h per week after the health shock (Appendix Table A20). These results suggest that the individuals who have experienced their first onset of a health shock actively

[18] Appendix Table A19 reports results on each item of the spousal depression score.

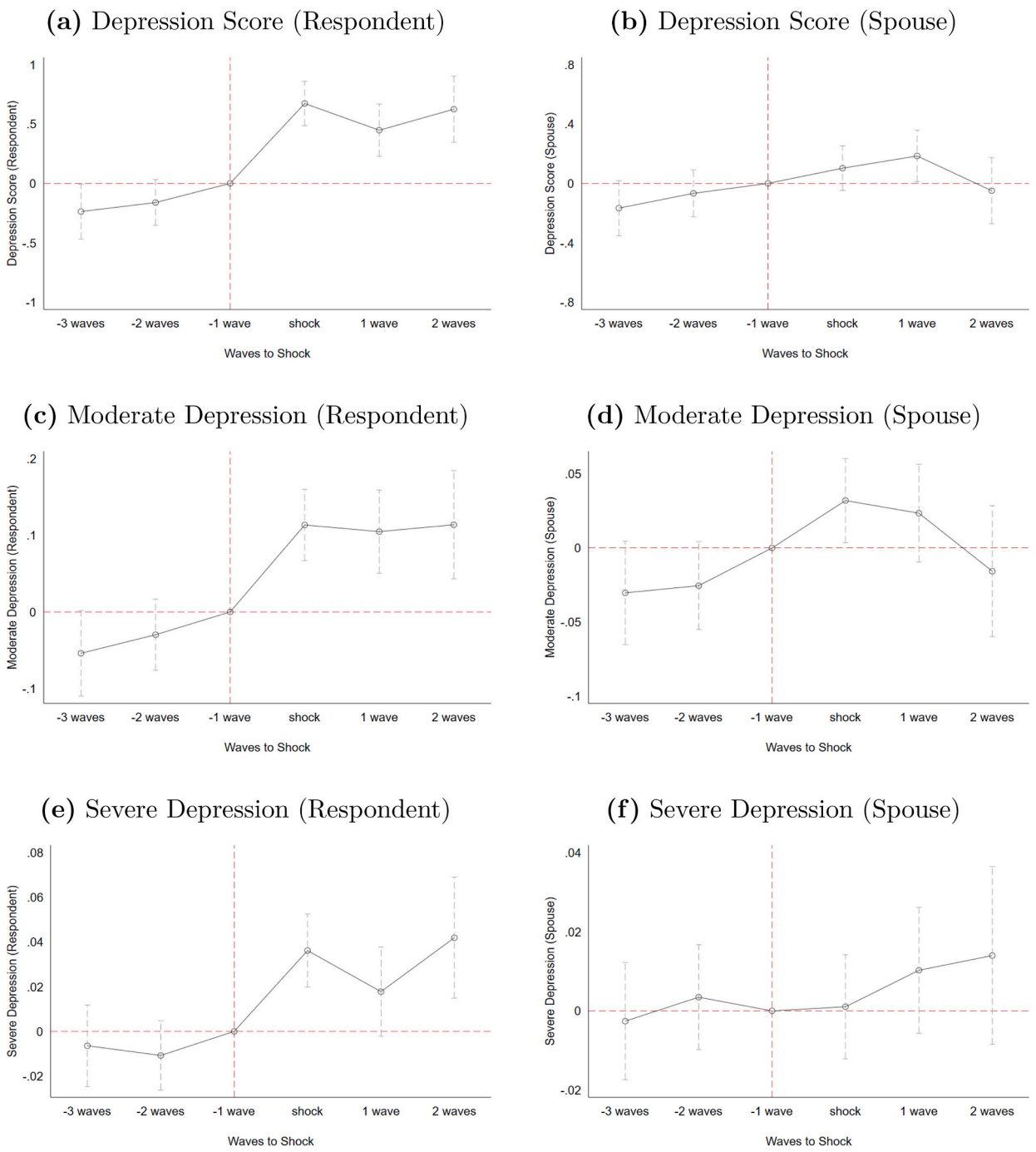

Fig. 3. The Effect of Unexpected Health Shock on Mental Health.
Notes: This figure presents the dynamic effects of health shocks on different measures of health behaviors. The regression specification is specified in Eq. 2 and discussed in details in Section 4.2. We plot the estimated coefficients of time-to-treatment dummies (β^ks in Eq. 2) together with the corresponding 90% confidence intervals in the figure.

change their lifestyle to improve their health and prevent recurring health shocks.

Furthermore, we document an intra-household spillover effect of healthier lifestyle. Spouses of the affected individuals likewise increase their likelihood of physical exercises by 2.8 *pp* and reduce the likelihood of drinking by 1.8 *pp*. Spouses increase their average exercise time by 0.76 h per week and increase their probability of having any health insurance by 1.8 *pp* (from a baseline insurance coverage of 91.5 *pp*) (Appendix Table A20). In addition, we find that the household expenditure on health supplements and fitness per capita increase by RMB 868 after the shock, which is an over 45% increase from the sample mean. Considering that household's income

Table 6
Effect of health shocks on family health behaviors.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Self Health Behaviors			Spouse Health Behaviors			Household Expenditure per Capita
	Whether Exercising	Whether Drinking	Whether Smoking	Whether Exercising	Whether Drinking	Whether Smoking	Health and Fitness
Shock	0.050***	−0.024***	−0.019**	0.028*	−0.018*	0.000	868.365***
	[0.014]	[0.008]	[0.008]	[0.015]	[0.010]	[0.008]	[190.043]
Unadjusted *p*-value	0.000	0.003	0.013	0.059	0.060	0.989	0.000
Bootstrap-based *p*-value	0.010	0.010	0.010	0.030	0.030	0.980	0.000
Anderson's *q*-value	0.002	0.014	0.042	0.130	0.130	0.813	0.000
Observations	70,085	68,698	68,703	63,540	60,848	60,850	69,467
R-squared	0.0611	0.0018	0.0082	0.0599	0.0006	0.0089	0.0074
Individual FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
Outcome mean	0.403	0.147	0.261	0.426	0.208	0.351	1869

Notes: This table reports the baseline results on the effect of health shocks on self and spouse's health behaviors. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

per capita decreases substantially (841 RMB), the increased investment in health and fitness accounts for over 100% of the income loss and suggests a major shift of family consumption pattern of the affected household towards a healthier one.

Our findings on the spousal and family health behaviors are consistent with those documented by Fadlon and Nielsen (2019) in the Danish population, who find an increase of family health-promoting behaviors in preventive care, medical screening, harmful consumption, and chronic disease management for spouses and adult children of the individuals who experienced a nonfatal heart attack or stroke. Hodor (2021) finds a consistent pattern of an increase in health investment after a household member experiences a health shock in the US.

We provide one of the first investigation on the intra-household spillover effects of a health shock in developing countries. Compared to the pattern in developed countries, the scale of the post-shock change in family health investment *relative to* household income is substantial for Chinese households. For example, Hodor (2021) find that in the US population, spouse of the individual who experienced a nonfatal health attack or stroke increase their medical spending by $813 per year, or 1.44% of the sample annual household income ($56,457). In comparison, a health shock increases the Chinese households' per-capita health investment in fitness and health supplement by 868 RMB, or 6.17% of the sample per capita annual household income (14,075 RMB). The relative increase in health-promoting investment is four times larger in China than in the US, reflecting a strong precautionary incentive of Chinese households to avoid a recurring health shock or a health shock on other family members. This suggests the general insufficiency of China's social insurance system in providing income insurance and social welfare support after a health shock.

6. Heterogeneous analysis

We now investigate whether the effect of a health shock differs between individuals and households with different characteristics. We explore four dimensions of heterogeneities: household rural status (rural vs urban *hukou*), income (low vs high income), gender, and age.

Rural vs. Urban We first investigate the heterogeneous effect of a health shock between rural and urban households. In China, rural population accounts for a large proportion of the total population. Annual income of rural households is lower than their urban counterparts. In our CFPS sample, the average household income is 41,914 RMB (US$ 6549) for rural households, and 78,823 RMB (US $ 12,316) for urban households. Rural households generally do not have access to urban-equivalent social pensions, unemployment insurance, and less generous public health insurance coverage.

We do not find a statistically significant rural-urban difference in the effects of a health shock on physical health (Appendix Table A21) and economic outcomes (Appendix Table A22). This result stands in contrast to that of Liu, Dow, Fu, Akin, and Lance (2008), who find that rural households are more vulurable to health shocks in China. This difference may be attributed to the fact that Liu et al. (2008) utilize a dataset covering years from 1991 to 1997, while ours covers 2010 to 2018. A comprehensive health insurance targetting the rural households, called New Rural Cooperative Medical System (NRCMS), was launched in 2002 to narrow the rural-urban gap in health insurance coverage. The NRCMS has completed extending the insurance coverage to nearly all the rural residences by 2008. In addition, from 2016, the Chinese government has integrated the urban and rural medical insurance schemes so

that urban and rural residents can enjoy the same public health insurance benefits. These recent development of rural public health insurance programs help to explain why we do not find a noticeable difference in the effect of health shock between the rural and urban households.

It is worth noting that the effect of a health shock on mental health is stronger in rural individuals as compared to urban ones. Appendix Table A23, Column 1 shows that the depression scores increase by a larger extent for rural individuals than urban ones after a health shock, and the difference is statistically significant at the 10% level. There is no significant rural-urban difference in the effect on spouse's mental health (Column 2). Rural individuals significantly increase their probability of physical exercises after the health shock, while this effect on physical exercises is close to zero for urban individuals (Column 3).

Low-income vs High-income We then assess the heterogeneous effect of a health shock between high- and low-income households. We divide our sample into two income groups according to the average pre-shock annual household income. In terms of physical health, we find suggestive evidence that low-income households experience a less severe health impact than high-income households. Appendix Table A24, Columns 1 and 2 show that the estimated reductions in self-reported health status for both the respondent and spouse are smaller for low-income household, but the differences are statistically insignificant. The increase in hospitalization expenditure is statistically significantly lower for low-income households (Column 3).

In terms of labor market and income-related outcomes, we find that the low-income respondents have a smaller reduction in working probability after the health shock than high-income counterparts. Appendix Table A25, Columns 1 shows that the health shock reduces the respondent's probability of working by 5.8 *pp* for high-income individuals, but only by 1.2 *pp* for low-income individuals. This is likely because low-income individuals may have stronger incentives to, or have to, continue working even after experiencing a health shock due to their higher vulnerability to financial burden. Spouses of low-income households also have a larger (but insignificant) increase in working probability after the health shock (Columns 2). The estimated differences in health shock's impact on household income per capita and household asset per capita are statistically insignificant between the low- and high-income households (Columns 3 and 4). However, the effect of the health shock on household poverty is stronger for low-income households: the probabilities of having *dibao* and being eligible for *dibao* both increase by a larger extent for low-income households, although the differences are not statistically significant (Columns 5 and 6). We do not find significant differences in the mental health effect of health shock between the low- and high-income households (Appendix Table A26). Overall, we find limited evidence of heterogeneous impacts of a health shock on health and economic status between the low- and high-income households.

Heterogeneous Effects in Gender and Age We continue to explore the potentially different effects of a health shock in two other dimemsions: gender and age. Specifically for age, we define two age groups based on two alternative cutoffs: age 60 for the full sample, and the official retirement age for the urban sample (65 for male and 60 for female). For ease of reading, we plot the estimated difference in the effect of a health shock (estimate of β_2 in Eq. 3) in figures. The estimated differences in effects on physical health and medical expenditure are plotted in Appendix Fig. B4, income, asset, and poverty status in Appendix Fig. B5, and mental health and health behaviors in Appendix Fig. B6. Across these two dimemsions of heterogeneities and across all outcomes, we find limited evidence on heterogeneous effects of a health shock: Most of the estimates of β_2 in Eq. 3 are statistically insignificant.

A notable exception is that females suffer less in self-reported health, have smaller increase in hospitalization expenditure, and correspondingly, have smaller reduction in household asset, after a health shock (see Appendix Figs. B4 and B5). This pattern is consistent with prior medical research that females generally have lower mortality from cardiovascular diseases and stroke than males (Bots, Peters, & Woodward, 2017). In China's context, this can be attributed to the fact that females have much lower intensity of smoking and alcohol drinking than males, both of which are primary risk factors of cardiovascular diseases and stroke.[19] In China, female smoking rate is only 2.1% compared to 50.5% for males; 33% of males reported drinking alcohol in most weeks, compared with only 2% in females (National Center for Cardiovascular Diseases, 2021). This gender difference in harmful health behaviors helps explain why females suffer less in physical health from a health shock in our sample. Despite the lower reduction in physical health for females, we do not find evidence of a significant gender difference in the impact of a health shock on labor market participation, household income and assets, household poverty rate, or mental health and health behaviors.

7. Robustness check

We conduct a series of robustness checks. First, we investigate alternative sample constructions and model specifications, including (1) the inclusion of additional matching keys in the CEM matching process, (2) the inclusion of additional control variables in the DID estimation, (3) the sensitivity of results to missing values in outcome variables, and (4) the sensitivity to extreme values in income variables. Second, we construct another treatment group using the first onset of cancer (e.g., malignant neoplasm of the nasopharynx, malignant neoplasm of the esophagus, and leukemia) as the definition of a health shock and assess the household responses to the diagnosis of cancer. Third, we analyze the CHARLS data to check the external validity of our results.

7.1. Alternative sample construction and model specification

Additional matching keys We test whether the inclusion of region of residence (three region dummies) in the CEM match process

[19] Smoking and drinking are among the top causes of cardiovascular diseases and stroke. In particular, over 1.9 million individuals die of cardiovascular disease caused by smoking or secondhand smoke exposure, accounting for one-fifth of all cardiovascular disease mortality worldwide (National Center for Cardiovascular Diseases, 2021).

will change the baseline estimation results. The existing matching keys are selected according to a model of individual's health care utilization and aim to ensure comparability in pre-shock health and healthcare behaviors between individuals (Andersen, 1995). The newly included region of residence helps to control for potentially region-specific differences in local health systems and local economic development. A tradeoff of this inclusion is a reduction of the post-match sample (about 40% of the baseline control-group individuals are dropped; the baseline treatment group is not affected). The DID estimation results based on the new post-match sample are presented in Appendix Tables A27 and A28 and are similar to the baseline results.

Additional control variables We test the sensitivity of our baseline results to the inclusion of additional control variables in the DID estimation. First, we include an indicator of any health insurance coverage and dummies for specific types of health insurance if covered. Although the population coverage of basic public health insurance was over 90% in our sample period (2010–2018), there existed large differences in insurance benefits between the basic medical insurance for urban residents and that for rural residents before 2016 (these two types of insurance were integrated in 2016).[20] These insurance differences may contribute to the effect of health shock on patients' health and economic outcomes.

We include the aforementioned controls on health insurance and reestimate the baseline specification. The full set of results on health and economic outcomes are presented in Appendix Tables A29 and A30. All results are similar with the baseline. Such a similarity to the baseline suggests that the variation in health insurance types in our sample has been effectively controlled for in the CEM matching process by the hukou status and households' pre-shock characteristics such as income status and educational attainments. This also suggests an absence of unobserved factors that correlate with the health insurance ownership to confound the causal impact of a health shock on health and socioeconomic outcomes of the household (Altonji, Elder, & Taber, 2005).

Second, we control for province-specific linear time trend to eliminate other regional-specific, time-varying confounders, such as the province-specific improvement in the health delivery system or province-specific economic and social development. All results are reported in Appendix Tables A31 and A32 and are consistent with the baseline.

Sensitivity to excluding missing values in outcome variables We test the sensitivity of our results to missing values in outcome variables. The pattern of missing data differs across outcome variables. In general, the proportion of missing variables in the original sample is 0.5% for respondent's working status, 2.9% for net household income per capita, 0.03% for *dibao* indicator, 0.1% for respondent's physical health indicator, less than 2.5% for respondent's depression score, and close to zero for health behavior variables (such as whether exercising). These missing values lead to a small change in the size of regression samples across tables and columns.

For each of the 14 outcome variables we have analyzed in the baseline results, we reconstruct a sample with no missing value for a given targeted outcome variable. For example, we construct a sample with no missing values on respondent's working hours, and reestimate Eq. 1 over all 14 outcome variables on this sample. In these 14 regressions, the sample under estimation have no missing values on respondent's working hours regardless of the outcome variable. In a similar fashion, we construct 14 samples targetting each of the 14 outcome variables and run a total of 14×14 regressions.

We compare the estimated effect of a health shock on each outcome variable over all 14 different samples. For example, Appendix Fig. B7, Panel (A) plots the estimated effects of a health shock on individual's self-reported physical health over 14 reconstructed samples. Similarly, we compare the effect of a health shock on each outcome variable of interest in Appendix Figs. B7, B8, and B9. Across the board, all coefficient estimates are similar in size and significance levels, suggesting that our baseline results are robust to the missing values in outcome variables.

Sensitivity to excluding extreme values in income variables We test the sensitivity of results on income-related outcomes, such as household income and asset, to the extreme values. Both household income and household net asset are highly right-skewed (see income and asset distributions in Appendix Fig. B2). For example, the largest per capita income in our sample is 189,846 RMB, more than 13 times the sample average; similarly, the average net asset per capita is 3,685,467 RMB, more than 26 times the sample average. To check that our baseline results on income and asset are not driven by these extreme values, we conduct three sets of winsorization on extreme values of the variables on income and asset. In particular, we winsorize the top and bottom 1%, 2% and 3%, respectively, of household income per capita and household net asset per capita.

Results based on winsorized income and asset are reported in Appendix Table A33. The coefficient estimates and the corresponding standard errors are smaller after winsorization, which is expected as richer households suffer a larger loss in income and asset (in level terms). The largest difference between the baseline and the post-winsorization coefficient is for net household asset per capita: −13,635 vs −11,204, or a difference of 17.83%, when top and bottom 3% of net household asset are winsorized (Column 6). The *t*-statistics of estimated coefficients across columns are slightly larger than the baseline counterparts due to the smaller standard errors. Overall, results in Appendix Table A33 suggest that our baseline results are not mainly driven by a small set of households with extreme values of income or asset.

7.2. *Cancer as alternative proxy of health shock*

We construct an alternative treatment group based on the first diagnosis of cancer as the definition of unexpected adverse health shock. See the detailed definition of cancer categories in Appendix Table A5. Cancer is among the leading cause of death worldwide, accounting for nearly 10 million deaths in 2020, or nearly one in six deaths (Pineros et al., 2021). For most cancer cases, diagnosis is often unexpected and happens at an advanced stage of cancer development, after certain symptoms have been salient (Zahnd et al.,

[20] See an official announcement by the Stata Council on the integrated Urban-rural Basic Medical Insurance in http://english.www.gov.cn/news/top_news/2016/08/22/content_281475423154762.htm.

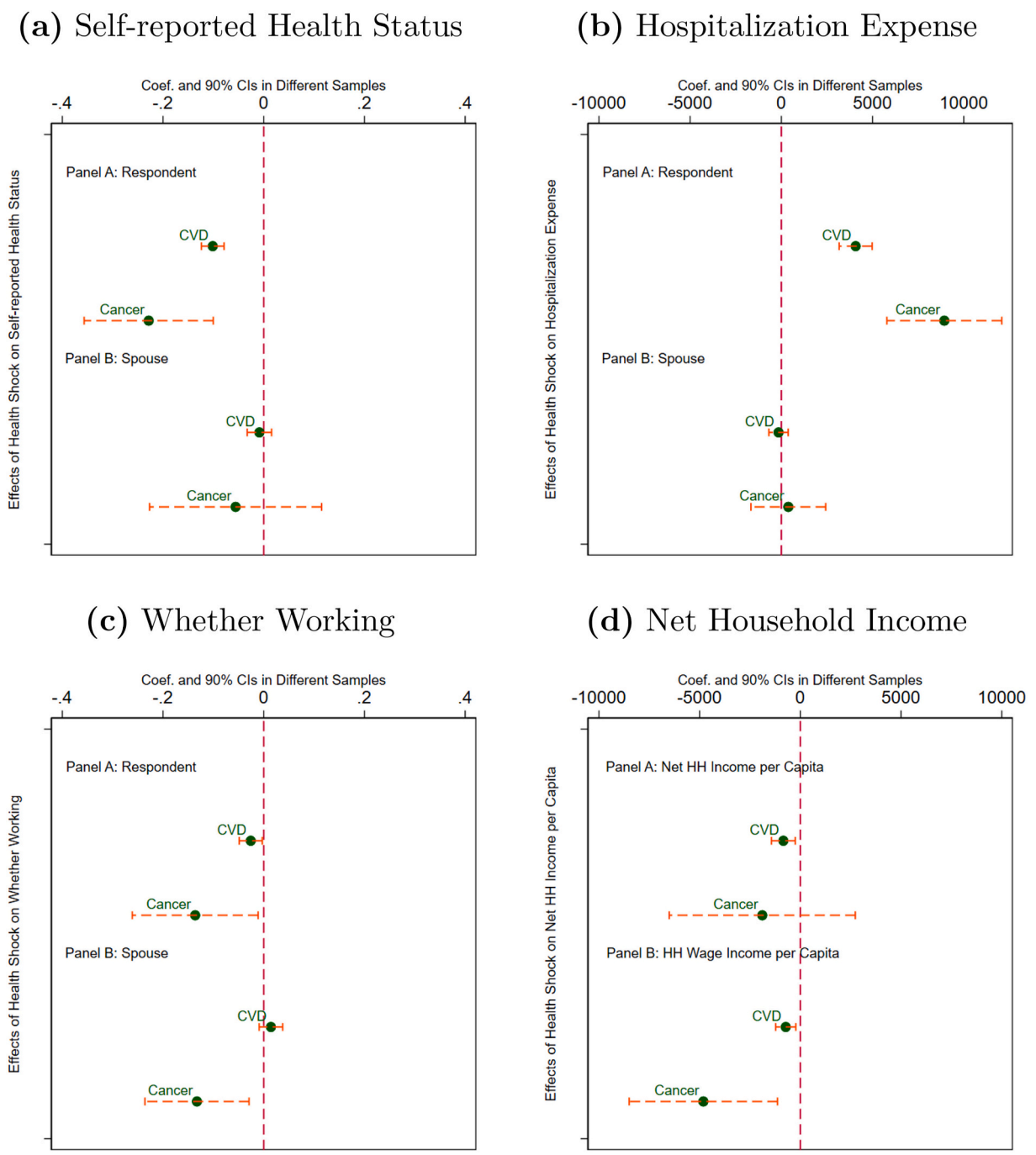

Fig. 4. Effects of Cancer Diagnosis on Various Household Outcomes.
Notes: This figure presents and compares the impact of different health shocks (cardiovascular v.s. cancer) on various household outcomes. All regression specifications and sample restrictions are the same as in Eq. 1. Our baseline definition of a health shock is a set of selected cardiovascular diseases discussed in Section 3.2 and listed in Appendix Table A4. The definition of cancer as a health shock is discussed in details in Section 7.2 and listed in Appendix Table A5. We plot the estimated effect of a health shock (β_1 in Eq. 1) together with the corresponding 90% confidence intervals in the figure.

2018). This makes the first diagnosis of cancer a good proxy for a health shock, both physically and mentally, for most households. A limitation of using cancer as a proxy of health shock is that the proportion of individuals newly diagnosed with cancer is low in our sample, with fewer than 1% of individuals in each survey wave. This results in a small sample size after matching and a lower precision in estimation. We thus analyze cancer only as a robustness check.

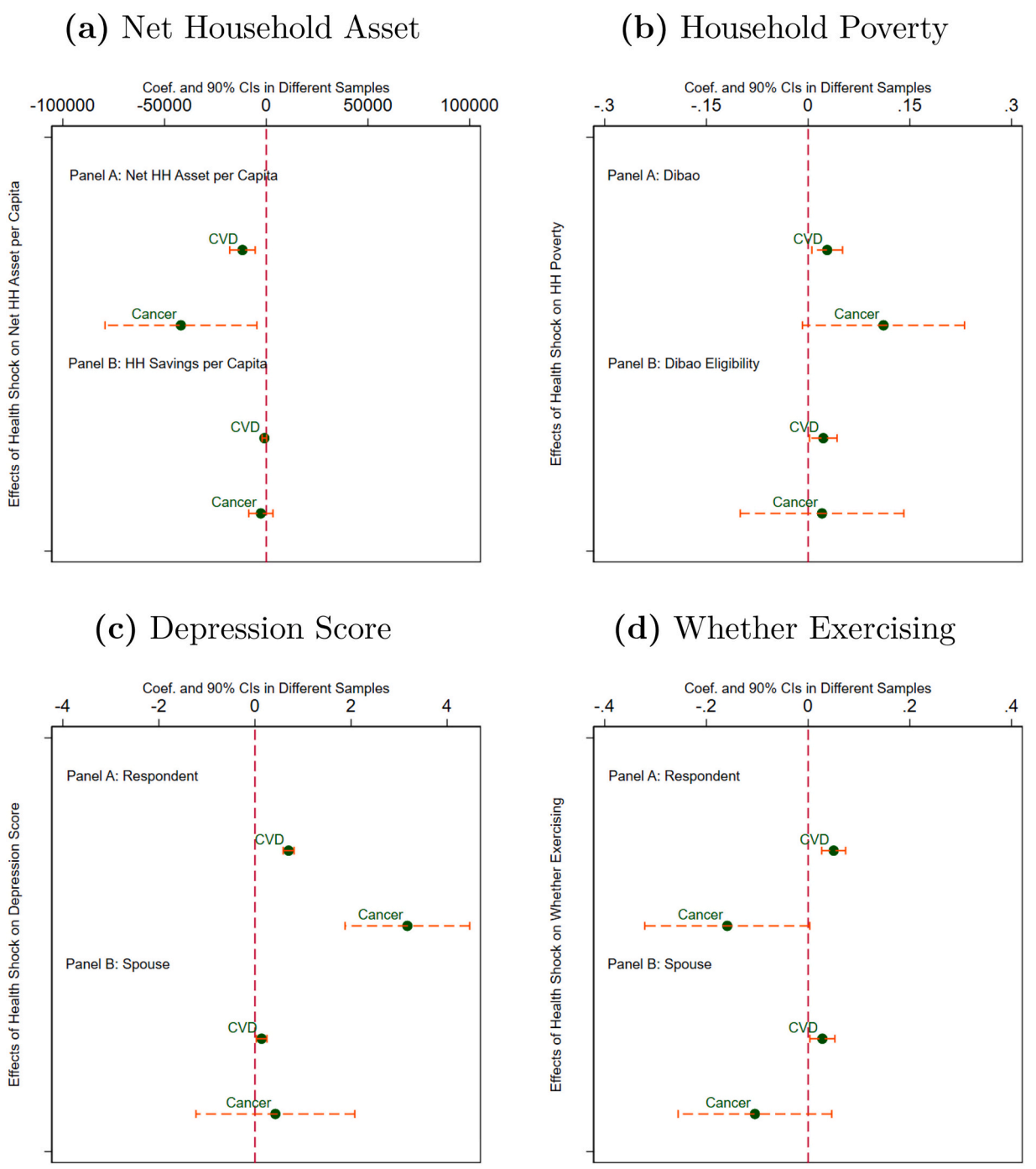

Fig. 5. Effects of Cancer Diagnosis on Various Household Outcomes (Continued).
Notes: This figure presents and compares the impact of different health shocks (cardiovascular v.s. cancer) on various household outcomes. All regression specifications and sample restrictions are the same as in Eq. 1. Our baseline definition of a health shock is a set of selected cardiovascular diseases discussed in Section 3.2 and listed in Appendix Table A4. The definition of cancer as a health shock is discussed in details in Section 7.2 and listed in Appendix Table A5. We plot the estimated effect of a health shock (β_1 in Eq. 1) together with the corresponding 90% confidence intervals in the figure.

Through all estimation results, we test the robustness of our main results to this alternative definition of a health shock. We are also interested to investigate the potentially different impacts of cancer onset on individual's health and household's economic well-beings from the impact of a health attack or stroke (our primary definition of a health shock). The estimated effects (β in Eq. 1) are plotted in Figs. 4 and 5 for the ease of reading and comparison. Overall, the results are expected.

Table 7
Robustness analyses on CHARLS dataset.

	(1)	(2)	(3)	(4)
Panel A: Physical Health				
Variables	Self-Report Health (Self)	Whether Hospitalized Last Year (Self)	Hospitalization Expenses (Self)	Difficulty Score (Self)
Shock	−0.136***	0.108***	3953.536***	0.623***
	[0.013]	[0.012]	[994.292]	[0.052]
Observations	59,425	60,609	55,912	57,589
Outcome mean	0.767	0.110	605.5	1.869
Panel B: Household Economic Outcomes				
Variables	Whether Working (Self)	Net HH Income per Capita (RMB)	Net HH Asset per Capita (RMB)	Whether Having Dibao
Shock	−0.093***	−647.298	−1183.262*	0.021***
	[0.011]	[416.463]	[657.792]	[0.007]
Observations	60,608	60,243	54,557	60,623
Outcome mean	0.709	9046	8943	0.0861
Panel C: Mental Health and Health Behaviors				
Variables	CESD 10 Score (Self)	CESD 10 Score (Spouse)	Smoking and Drinking/Year (RMB)	Smoking and Drinking/Total Expenditure
Shock	0.609***	0.528***	−69.039	−0.007***
	[0.170]	[0.152]	[248.150]	[0.002]
Observations	52,988	50,209	58,811	48,531
Outcome mean	7.796	7.446	2558	0.0447

Notes: This table reports results of robustness analyze based on the CHARLS dataset. All regression specifications and sample restrictions are the same as in Eq. 1. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

We find that cancer brings financial catastrophe to households. Fig. 4 shows that the diagnosis of cancer substantially reduces the self-reported physical health, increases the medical expenditure, and reduces an individual's labor market participation and household income. The magnitude of these impacts from cancer are greater than those from a heart attack or stroke. In addition, the spouse of the cancer patient also significantly reduces his/her work probability, while this effect is close to zero for the spouse of patients with a heart attack or stroke. Household income per capita, particularly wage income per capita, falls substantially and by a greater extent than those in our baseline results. Most of the estimated impacts of cancer are statistically significant at 10% level. However, due to the small sample size, most of the estimated effects of cancer are not statistically significantly different from those in our baseline results.

Figs. 5 shows that cancer leads to a substantial reudction in net household asset, implying that households make efforts to finance the large medical cost from cancer treatment. Cancer leads to a larger increase in the probability of household falling under the local poverty line. In both dimensions (asset and poverty), the effects of cancer are larger in magnitude than those of the baseline results. In addition, cancer causes a larger reduction in mental health for both the patient and the spouse. It is noteworthy that cancer causes a large reduction in the spouse's probability of physical exercise, while the onset of a heart attack or stroke increases the probability of exercise for the spouse. This pattern is consistent with the prior result that cancer substantially reduces the spousal working probability (Fig. 4, Panel C). The reduction in spousal time in exercise and labor supply both suggest that the spouse shifts more time to taking care of the cancer patient.

Overall, results on cancer suggest that cancer brings a heavier physical, mental, financial, and time burden on households than a heart attack or stroke. These results call for more public financial support for cancer treatment and the need for social support for families with cancer patient.

7.3. CHARLS as alternative dataset

Finally, we turn to CHARLS as an alternative dataset for analysis. CHARLS provides a nationally representative, longitudinal survey dataset for the Chinese population over the age of 45. We use the same definition of health shock as in baseline analysis, and employ the CEM-DID method as a causal identification strategy. The detailed descriptions of main outcome variables in CHARLS dataset are relegated to Appendix Section B.2; the balance check of pre-shock covariates and summary statistics for main outcome variable are presented in Appendix Tables A2 and A3.

Table 7 presents the results based on CHARLS. All results are similar to our baseline results based on CFPS. The health shock

severely reduces the physical health and increases the medical expenditure (Panel A). Both household income and asset have been substantially reduced, and households' *dibao* probability significantly increases (Panel B). We also observe a large intra-household mental health spillover effect. The depression score, measured by the CESD-10 (10-item version of CESD scale), has increased statistically significantly for both the patient and the spouse; smoking and drinking are reduced (Panel C). Overall, results based on CHARLS are consistent with our baseline.

8. Quantifying total cost of health shock

We conduct a simple back-of-envelope calculation to quantify the private economic cost of a health shock for households as well as the overall financial burden for society as a whole. We consider four sources of economic cost: (1) the out-of-pocket medical spending on the immediate treatment of and the rehabilitation from the disease, which serves as a lower bound for the private cost of health shock; (2) the (expected) medical cost from a higher probability of depression after the health shock; (3) the reduction in household income; and (4) the societal burden from health shock in terms of the medical expenditure reimbursed by the public health insurance and the public funding on mean-tested government transfer such as the poverty-alleviation allowance.

Out-of-pocket Medical Expenditure on Disease Treatment We find that a health shock leads to a sharp increase in annual, out-of-pocket hospitalization expenditure of 4002 RMB in the first year after the health shock,[21] an annual increase of 3472 RMB in the next 2 years, and an annual increase of 3845 RMB in the 4th and 5th years (Column 1, Appendix Table A34). Assuming an annual discount rate of 5%, we estimate a discounted, out-of-pocket hospitalization expenditure of 16,943 RMB (US$ 2647) over 5 years for an average household in China.

This estimate provides a conservative lower bound for total medical spending on disease treatment and rehabilitation as we only have information on hospitalization expenditure but not on outpatient visits or medication; it also does not account for the cost of non-hospital care, such as informal care provided by family members or long-term care.

Out-of-pocket Medical Expenditure on Depression We then estimate the (expected) medical cost on depression treatment due to the health shock. Our estimation takes three elements: First, Table 5 shows that the health shock leads to a statistically significant increase of 13.1 *pp* in the probability of moderate depression (3.5 *pp* for severe depression) for the patient respondent, and an increase of 3.2 *pp* in the probability of moderate depression for the spouse. Second, Lu et al. (2021) find that only 9.5% of depression patients would seek medical treatment in China. Lastly, Hu, He, Zhang, and Chen (2007) provide a comprehensive evaluation on the overall economic burden based on depression patients in clinics and hospitals of five representative Chinese cities in 2004. They estimate an anuual treatment cost of 2957 RMB in 2002 price, or 4682 RMB in CPI-adjusted 2020 price, with more than 95% of the cost incurred in outpatient care and medication.

Taking all three estimates, we compute a direct medical cost on depression treatment of 58 RMB per year for the patient and 16 RMB for the spouse.[22] Assuming an annual discount rate of 5%, this amounts to discounted medical expenditure of 280 RMB over 5 years per household.[23] Because most of this cost on depression treatment consist of spending on outpatient care and medication (Hu et al., 2007), it is not included or double counted in the above hospitalization expenditure on disease treatment.

Reduction in Household Income Appendix Table A34, Column 2 shows that a health shock will reduce the annual household income by 4455 RMB in the first year, 3784 RMB in the 2nd to 3rd years, and 3707 RMB in the 4th to 5th years. These per-year reduction in household income are highly persistent and statistically significantly estimated. See also the event-study plot for per-capita income in Fig. 2, Panel C. Overall, the discounted reduction of household income amounts to 17,743 RMB (US$ 2772) over 5 years after a health shock.[24] This reduction in household income is likely driven by both the reduced labor supply (Fig. 2, Panel A) as well as a reduction in labor productivity.[25] The longer-term reduction may be even higher considering the time persistency of the impacts.

Increase in Public Financial Burden The additional social cost caused by health shock include two parts: the medical expenditure covered by the public health insurance, and the public funding on poverty-alleviation allowance. In our sample, the average ratio of out-of-pocket spending to total medical expending is 77.4%; equivalently, 22.6% of total medical spending is reimbursed by the public basic medical insurance and paid by public insurer. The public-to-private ratio of financial burden from higher medical expenditure is

[21] We consider the first survey wave immediately after a health shock as the first year after a health shock because by construction a health shock is defined as occuring between survey waves (two years between waves).

[22] For the patient, the probability of having depression due to a health shock (13.1%) × the share of seeking formal treatment (9.5%) × annual direct medical cost (4682 RMB) = 58 RMB per year. Similarly, for the spouse, 16 RMB per year.

[23] Figure 3 shows that the increased chance of depression for the patient is highly persistent and remains statistically significant for 5 years, but is statistically significant only in the first year for the spouse. We therefore compute the discounted medical cost on depression as $58 + \frac{58}{1.05} + \frac{58}{1.05^2} + \frac{58}{1.05^3} + \frac{58}{1.05^4} + 16 = 280$ RMB.

[24] We also find that the health shock significantly reduces the household asset (Column 3, Appendix Table A34). However, this reduction in household asset is likely to be used to finance the hospitalization expenditure and to smooth consumption fluctuations due to income reduction. To avoid double-counting the economic cost, we do not include the reduction in household asset in the calculation of the economic cost of the health shock.

[25] The negative spillover effects of individuals' physical and mental health on coworker's productivity are not considered here. For example, prolonged sick leave or depressive symptoms of a colleague may lead to a shift of other team members' roles and lower the productivity of the whole team.

about 3 to 4. As we have estimated an increase of 16,943 RMB in out-of-pocket expenditure for an average household, the increase in public financial burden from a health shock is estimated to be 4947 RMB (US$ 773) over 5 years per household after experiencing a health shock.

A health shock creates additional financial burden on public fund when it increases the likelihood of households falling into poverty and applying for mean-tested public transfers. Indeed, we have found that an average household is 2.8-*pp* more likely to apply for *dibao* after experiencing a health shock, and 2.2-*pp* more likely to be eligible for *dibao*. The CFPS survey records the total amount of public welfare transfer an household received per year. Appendix Table A34, Column (4) shows that a health shock leads to an average increase of 281 RMB in welfare transfer in the first year, 299 RMB in the 2nd to 3rd years, and 285 RMB in the 4th to 5th years. Assuming an annual discount rate of 5%, we compute an additional discounted public financial cost on welfare transfers to be 1119 RMB (US$ 174) in five years for each household that experienced a health shock.[26]

Combining the two sources, we compute an increase of discounted public financial burden of 6066 RMB (US$ 948) over 5 years per household.

Summarizing Total Cost of Health Shock Based on simple back-of-envelope calculations, we have computed that a health shock will lead to substantial economic cost for both the household and the society as a whole. The private cost includes an increase of 16,943 RMB in direct out-of-pocket hospitalization expenditure, an expected increase of 280 RMB in depression treatment expenditure, and a reduction of 17,743 RMB in household income over 5 years. The total incurred public financial burden is 6066 RMB in five years per household.

In summary, our calculations suggest a conservative estimate of total economic cost per household of 41,032 RMB (US$ 6411) over 5 years after a health shock (defined as an acute nonfatal episode of cardiovascular or cerebrovascular disease, such as heart attack or stroke), with 84.5% of the cost driven by direct out-of-pocket medical expenditure and the reduction in household income.

We then compute the national cost of health shock. According to a national report on cardiovascular mortality and morbidity released by China's Center for Disease Control and Prevention (National Center for Cardiovascular Diseases, 2021), there are a total of 14.35 million hospitalizations for cardiovascular diseases and 12.50 million for cerebrovascular diseases in China in 2019. If we assume one patient per household for each of these hospitalizations,[27] the overall economic cost of health shocks from cardiovascular and cerebrovascular diseases amount to 1.1 trillion RMB over 5 years, out of which 587.7 billion RMB as direct hospitalization expenditure,[28] 372.2 billion RMB as losses in household income, and 162.9 billion RMB as public financial burden.

Policy Implications Our estimates suggest a substantial private and social burden of health shocks for the Chinese population, which has important implications for China's policy-making in health care, social insurance, and safety net system. Given that China is challenged by the dual pressures of population aging and steady rise in the prevalence of various chronic conditions, the economic burden caused by health shocks may continue to increase.

Our findings highlight a strong need for the prevention and early detection of cardiovascular and cerebrovascular diseases. It is important to reduce the prevalence through increasing medical resources to primary care and preventive care, and improve rehabilitation services and secondary prevention to reduce the risk of recurrence, re-hospitalization and disability in survivors of health shocks. The recent pilot programs for chronic disease prevention and control provides valuable experience for policy design (Ding et al., 2021).

In addition, considering the estimated long-lasting effect of a health shock on household income and poverty status, our findings call for additional social support for households with disease-induced poverty as well as the need for a long-term care (LTC) and long-term care insurance (LTCI) system. We find that the post-shock increase in social welfare transfer only compensates for about 4% of the reduction in household income. This is consistent with Loyalka et al. (2014), who document the insufficiency of existing social insurance system to offset the income shortfalls from morbidity and disability in China. In addition, the current public LTC system only targets a narrowly defined group of welfare recipients, and the private LTC is underdeveloped, leaving huge gaps of unmet need (Feng et al., 2020). The ongoing LTCI pilots in various cities of China signal the potential use of social insurance as the core financing strategy for LTC for a broad population (Feng et al., 2020; Zhu & Österle, 2019). Further investment and development is urgently needed as the shortage of well-trained LTC workers and allied health professionals still presents a major barrier for quality improvement and for effective integration of medical and LTC services (Chu & Chi, 2008; Shum, Lou, He, Chen, & Wang, 2015).

9. Conclusion

This paper examines the impact of an unexpected health shock on family physical and mental health, economic outcomes, and family health behaviors in China based on the CEM-DID estimation strategy and two nationally representative longitudinal datasets. We find a long-lasting adverse effect on physical health and a persistent increase in medical expenditure after a health shock. The shock leads to a substantial financial burden in terms of household income and household asset, and the impacts persist for at least 5 years after the shock. The health shock significantly raises the probability of the household falling under the local poverty line. In addition,

[26] The welfare transfers, however, compensate for about 6.3% of the income reduction for an average household.

[27] If both spouses experienced the shock, we expect the overall economic losses in household income and associated increased probability of poverty status to be more than double because there is little room for adjustment in household labor supply, time allocation, or caregiving.

[28] We estimate the annual hospitalization expenditure for cardiovascular and cerebrovascular shocks to be 117.5 billion RMB ($= (16943 + 4947) * \frac{14.36 + 12.50}{1000 * 5}$), at the same order of magnitude with the official estimate of 313.4 billion RMB in 2019 in the national report (National Center for Cardiovascular Diseases, 2021).

we document an intra-household spillover effect whereas the health shock reduces the mental health of the spouse and change the spousal health behaviors such as smoking and physical exercises. Overall, the impact of a health shock is substantial and long-lasting for the Chinese households.

A simple back-of-envelope calculation implies substantial private and social cost of a health shock for the Chinese population. The health shock induces a private cost of 34,966 RMB (US$ 5463) over 5 years for an average household, and incurs a social financial burden of 6066 RMB (US$ 948) in 5 years per household in terms of financing the medical reimbursement and social welfare transfers. At a national scale, the total social burden of health shocks from cardiovascular and cerebrovascular diseases amount to 1.1 trillion RMB (US$ 172.1 billion) over 5 years, which is mainly driven by the financial burden of medical expenditure and a large, long-lasting decline in household income. Our findings have important implications for China's policy-making in health care, social insurance, and safety net system. In particular, we highlight a strong need for more efforts in the prevention and early detection of cardiovascular and cerebrovascular diseases. In addition, our findings call for additional social support for households with disease-induced poverty as well as the need for LTC and LTCI systems.

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Data availability

The authors do not have permission to share data.

Appendix A. Institutional background

A.1. The basic health insurance system in China

China's public health insurance is the main form of protection against the large medical spending of health shocks. Before 2016, there were three main types of public basic health insurance in China, including Urban Employee Basic Medical Insurance (UEBMI) for public and private employees in urban areas, Urban Residents Basic Medical Insurance (URBMI) for nonemployed urban residents, and New Rural Cooperative Medical Insurance (NRCMI) for rural residents. More than 1.3 billion people have enrolled in these three types of public health insurance, which cover 95% of the whole population in China by 2011. The total coverage rate has reached almost 100% by 2013.

These three types of insurance operate independently, with significant differences in both premium and coverage.[29] In general, rural households have lower insurance coverage and also paid lower premium. We observe a notable difference in insurance reimbursement rates between urban and rural areas in our CFPS dataset. Between 2010 and 2016, the out-of-pocket spending to total hospitalization spending ratio for rural residents was 73.3%, whereas it was 58.7% for urban residents.

From 2016 onwards, the Chinese goverment started to integrate urban and rural medical insurance programs, so that urban and rural residents can enjoy identical benefits of basic medical insurance. Our empirical results show that there exists no significant rural-urban difference in health or income after experiencing a health shock. This may be explained by two potential reasons. First, there is no urban-rural difference in the severity of health shocks. Second, the urban-rural insurance integration has already smoothed the inequality of coverage between the urban and rural areas.

A.2. Long-term care in China

China has the largest and most rapidly aging population in the world, which dramatically increases its demand for long-term care services. At the same time, the incidence of acute and chronic diseases is on the rise as a result of environmental and lifestyle changes, which aggravates the family's and society's burden of long-term care.[30]

However, there exist no specialized long-term care facilities or a national coverage of long-term care insurance in China. The central government has recently turned attention to long-term care in 2016 and has issued policies to encourage piloting of regional long-term care systems. At present, there exists a substantial regional variation in the availability and price for long-term care services (Yang, Jingwei He, Fang, & Mossialos, 2016).[31] Although home- and community-based long-term care services are preferred by the elderly, the disabled, and their family members, these services remain non-existent in less developed areas due to factors such as a shortage of skilled caregivers and a lack of quality assurance (Feng, Liu, Guan, & Mor, 2012). Publicly funded institutional care is often

[29] See Dong (2009) for a detailed discussion on the institutional background and development of these three public health insurance schemes.

[30] Long-term care systems are well-developed in the Netherlands, Austria, and the United Kingdom. Especially, the Netherlands is the first country in the world to establish the long-term care system in the world in 1964. The government provides many kinds of home care services for free, such as housekeeping, wheelchair assistance, and transportation services, to the disabled with long-term care insurance.

[31] In anticipation of the upcoming demand for long-term care, some cities and provinces in China are piloting long-term care programs. For example, from January 1, 2021, all residents participating in basic medical insurance in Chengdu can apply for a long-term care insurance without additional cost, and severely disabled people can receive up to 903 RMB per month from the local government. The effectiveness and sustainability of these pilots remain to be seen.

limited to those who are extremely poor or have no children, and the price of private care facilities can be hefty for the poor (Feng et al., 2012). Overall, although the system of long-term care and long-term care insurance is rapidly envolving in China, the current accessibility of these services is still limited.

If a household experiences a devastating health shock and falls into poverty, they can apply for a government-provided monthly poverty relief allowance (called minimum livelihood guarantee, or *dibao* in Chinese).

A.3. Dibao system in China

Dibao is a social assistance system in which the government provides direct money transfers to underprivileged households in order to help them maintain basic living standards. In 2020, 4.9 million *urban* households (8.05 million individuals) received *dibao* transfers in China, with an average annual transfer of 8131.2 RMB (US$ 1270) per person; comparatively in rural area, 19.85 million *rural* households (36.208 million individuals) received *dibao* transfers, with an average annual transfer of 5962.3 RMB (US$ 931.6) per person.[32] In 2020, the Chinese government spent approximately 19.36 billion RMB on *dibao* transfer, accounting for roughly 0.8% of China's annual fiscal expenditure.

The urban *dibao* system was established in the early 1990s, with the primary objective of alleviating poverty of urban laid-off workers and ensuring minimum living standards. The program has made significant contributions in improving urban residents' living standards, relieving urban poverty, and maintaining social stability (Gao et al., 2009, 2015; Gustafsson & Quheng, 2011). In 2007, the State Council expanded the *dibao* transfers to eligible rural households. There exist large differences in the eligibility income treshold as well as the amount of transfers bewteen rural and urban *dibao* households (see Appendix Table A1), largely due to the urban-rural differences in income level and the cost of living. Substantial differences in *dibao* standards also exist across provinces. Overall, China's *dibao* program is the largest safety net program in the world and has been shown to raise the standard of living for millions of disadvantaged households in China (He et al., 2021; Li & Walker, 2018).

Appendix B. The CHARLS data

B.1. Introduction of CHARLS data

CHARLS The CHARLS is designed to be the Chinese equivalent of the Health and Retirement Survey in the United States (Huang & Zhang, 2021). The first wave of CHARLS was conducted in 2011 to study the population aged 45 and older in China. It is a nationally representative sample covering 150 counties randomly drawn from 30 provinces in China.

To obtain an unbiased and representative sample, CHARLS conducts sampling at the county-village/community-household-individual level. First, 150 counties were randomly drawn from 30 provinces (excluding Tibet, Taiwan, Hong Kong, and Macau). CHARLS chooses three villages or communities in each county using probability proportionate to size sampling (PPS) at the second stage. After sampling at the village/community level, CHARLS 80 households were randomly drawn from each village or community using the household information form selected by CHARLS-GIS (Mapping software for accurately collecting household information). According to the rejection rate of the 2008 CHARLS trial survey in Gansu and Zhejiang, finally, 23,590 households were sampled from 450 villages or communities. When conducting the survey, the interviewer will randomly select a family member older than 45 years old from each household as the primary respondent and interview the age-eligible respondent. Information of respondents and their spouses is collected within an interviewed household unless they live outside the family or have passed away.

The first wave in 2011 consisted of 10,199 households around China. As of 2018, CHARLS has conducted four nationwide surveys in 2011, 2013, 2015, and 2018 respectively, resulting in a sample size of more than 23,000 respondents in a total of nearly 12,400 households.

B.2. Main outcome variables

We hereby discuss the main categories of outcomes: income and asset, physical and mental health, and health behaviors.

Labor supply, income, and asset We construct a measure of labor market participation for both the respondents and their spouses: a dummy for whether currently working. Household income is the sum of five income components: wage income, agriculture income (income from growing crops and livestock), self-employed income, and transfer income. Net household asset is defined as assets (deposit, bonds, stocks, funds, other assets) minus liabilities (loans).

Poverty and transfers We also define the measure of poverty for Chinese households in CHARLS as an indicator for whether a household receiving the government-provided monthly poverty relief allowance (dibao in Chinese).

Physical Health In CHARLS, General physical health is reported on a scale: very good, good, fair, poor, very poor. We define those who report to have very good or good health as self-reported healthy and use this binary variable as a indicator of physical health.

Mental Health Mental health is proxied by the CES-D 10 score, which is proposed and used to measure the severity of depressive symptoms (Radloff, 1977b) and has been proven to have good credibility and validity in measuring the clinical and non-clinical depressive symptoms of middle-aged and elderly people (Berkman et al., 1986; Himmelfarb & Murrell, 1983). CHARLS asks 10

[32] Source: Offical statistics from the Ministry of Civil Affairs of the People's Republic of China. See at http://images3.mca.gov.cn/www2017/file/202109/1631265147970.pdf

questions to assess the respondent's CES-D 10 score, the questions are listed in the appendix. Each question has a total of 4 options, where the respondent is given a score of 0, 1, 2, and 3 according to the frequency of negative emotions experienced last week, with 0 indicating feelings no negative emotions at all. CES-D 10 score is constructed by summing up the score from the 10 questions and therefore ranges from 0 to 30. A respondent with a score of 10 or above is considered to have obvious depressive symptoms (Andresen, Malmgren, Carter, & Patrick, 1994).

Health Behavior Since the CHARLS questionnaire did not directly contain questions regarding exercise, we use the expenditure on alcohol and tobacco per year and the percentage alcohol and tobacco expenditure on the total consumption as the main outcome variables to measure the health behaviors of the households.

Appendix C. Tables

Table A1
Income threshold for dibao eligibility.

Province	(1)	(2)	(3)	(4)
	Urban		Rural	
	Threshold for *dibao*	Average income/year	Threshold for *dibao*	Average income/year
Beijing	7800	48,531	7587	18,867
Tianjin	7680	31,506	6153	17,014
Hebei	5182	24,141	2543	10,186
Shanxi	4604	24,069	2454	8809
Inner Mongolia	5777	28,349	3633	9976
Liaoning	5433	29,081	3195	11,191
Jilin	4452	23,217	2466	10,780
Heilongjiang	5362	22,609	2764	10,453
Shanghai	8520	48,841	7560	21,191
Jiangsu	6432	34,346	5345	14,958
Zhejiang	6879	40,392	5685	19,373
Anhui	5058	24,838	2828	9916
Fujian	4852	30,722	2732	12,650
Jiangxi	5019	24,309	2638	10,116
Shandong	5422	29,921	2936	11,882
Henan	3945	23,672	1824	9966
Hubei	4931	24,852	2567	10,849
Hunan	4233	26,570	2326	10,060
Guangdong	5453	32,148	3837	12,245
Guangxi	4080	24,669	2028	8683
Hainan	4554	24,486	3355	9912
Chongqing	4428	25,147	2667	9489
Sichuan	4034	24,234	2139	9347
Guizhou	4740	22,548	2116	6671
Yunnan	4315	24,299	2141	7456
Tibet	6407	22,015	2230	7359
Shaanxi	4662	24,365	2262	7932
Gansu	3939	21,803	2275	6276
Qinghai	4211	22,306	2213	7282
Ningxia	3657	23,284	2281	8410
Xinjiang	3950	23,214	2029	8723

Notes: This table presents the income eligibility threshold for *dibao* (subsistence allowance in Chinese) across 32 provinces and municipalities of China in 2014. Columns (1) and (2) present the eligibility thresholds and average household income for urban households, respectively, and Columns (3) and (4) present those for rural households.

Table A2
Balance of Pre-shock Covariates (CHARLS).

	Before CEM		After CEM	
	Treatment	Control	Treatment	Control
	(1)	(2)	(3)	(4)
Predisposing Factors (Including Demographic and Socioeconomic Characteristics)				
Female	0.5443	0.5066	0.5541	0.5548
Age	58.5373	55.9914	58.2030	58.2067
Whether working	0.6887	0.7979	0.7188	0.7149
Number of children	2.6148	2.4954	2.0617	2.6442
Education				

(*continued on next page*)

Table A2 (*continued*)

	Before CEM		After CEM	
	Treatment	Control	Treatment	Control
	(1)	(2)	(3)	(4)
Primary school or below	0.6485	0.6421	0.6722	0.6732
Middle school	0.2226	0.2331	0.2213	0.2207
High school	0.1098	0.1038	0.0971	0.0967
College or above	0.0191	0.0210	0.0.0094	0.0095
Enabling Factors (Including *Hukou* and Financing Factors)				
Rural Hukou	0.7830	0.8258	0.8103	0.8080
Whether having dibao	0.1155	0.0902	0.0910	0.0911
Needs for Healthcare (Health Status)				
Pre-existing conditions[*]				
Respiratory/digestive/urinary diseases	0.4647	0.3538	0.4717	0.4415
Circulatory/musculoskeletal diseases	0.6739	0.4909	0.6787	0.6253
Mental/cognitive disorder	0.0323	0.0233	0.0283	0.0337
Having any of the above diseases	0.7914	0.6347	0.7998	0.7981
Number of unique individuals	1986	24,532	1803	15,110

Notes: This table presents the summary statistics of the individual and household characteristics at the survey wave before the health shock of CHARLS dataset. We use these variables are matching keys in the CEM.

[*] : These four dummy variables of pre-existing conditions indicate that whether the respondent has experienced any of the listed diseases in the last year.

Table A3
Summary statistics of main outcome variables (CHARLS).

Variable	Obs	Mean	S.D.	Min	Max
Panel A: Health Shocks					
Having experienced a health shock	60,633	0.105	0.306	0	1
Panel B: Physical Health Status					
Self-report health status (respondent)	59,425	0.767	0.423	0	1
Whether hospitalized last year (respondent)	60,609	0.110	0.312	0	1
Hospitalization expenses (respondent)	55,912	605.471	9013.172	0	1,400,000
Difficulty score (respondent)	57,589	1.869	2.039	0	9
Panel C: Household Economic Status					
Whether working (respondent)	60,608	0.709	0.454	0	1
Net HH income per capita (RMB)	60,243	9046	14,585	0	224,000
Net HH asset per capita (RMB)	54,557	8943	24,020	0	335,344
Whether having dibao	60,623	0.086	0.281	0	1
Panel D: Mental Health					
CES-D 10 score (respondent)	52,988	7.796	6.016	0	30
CES-D 10 score (spouse)	50,209	7.446	5.799	0	30
Panel E: Health Behaviors					
Expenditure on smoking and drinking/year	58,811	213.170	692.286	0	42,857
Smoking and drinking/total expenditure	48,531	0.045	0.065	0	0.5

Notes: This table presents the summary statistics of the outcome variables. The table includes all the five survey waves of CHARLS.

Table A4
Definition of health shocks (Selected cardiovascular diseases).

CFPS code	Disease	Detail description
11.61	Angina Pectoris	Heart attack
11.62	Acute Myocardial Infarction	
11.63	Other Ischaemic Heart Disease	Myocardial Ischemia
		Insufficient Myocardial Blood Supply
11.67	Cerebrovascular Disease	Cerebral Thrombosis
		Cerebral Infarction
		Cerebral Infarction
		Cerebral Insufficiency
		Cerebral Hemorrhage
		Cerebral Atrophy
		Cerebral Arteriosclerosis
		Cerebral Ischemia
		Cerebral Vasospasm
		Unspecified Cerebrovascular Disease
		Arachnoid Hemorrhage
		Cerebral Infarction Sequelae
11.65	Other Acute Cardiovascular Disease	Unspecified Heart Disease
		Abnormal Heartbeat

(*continued on next page*)

Table A4 (*continued*)

CFPS code	Disease	Detail description
		Irregular Heart Rate (Rhythm)
		(Ventricular Or Atrial) Premature Beats
		Hypertensive Heart Disease
		Valvular Heart Disease
		Bradycardia (Slow Heartbeat)
		Tachycardia
		Myocarditis
		Ventricular Hypertrophy
		Heart Failure
		Palpitations
		Ventricular Septal Defect
		Sudden Arrest
		Fascicular Block
		Hydropericardium (Fluid)
		Cardiac Insufficiency
		Myocarditis Viral
		Ventricular Septal Hypertrophy

Notes: This table presents the list of diseases we have defined as a health shock from the CFPS survey dataset.

Table A5
Definition of health shock (Cancer).

CFPS code	Disease	Detail description
3.19	Malignant Tumor of Nasopharynx	
3.20	Malignant Tumor of Esophagus	
3.21	Malignant Tumor of Gastrectomy	
3.22	Malignant Tumor of Colon	
3.23	Malignant Tumor of Rectum And Anus	
3.24	Malignant Tumor of Hepatica	
3.25	Malignant Tumor of Pancreas	
3.26	Malignant Tumor of Trachea, Bronchus, and Lung	
3.27	Tumor Malignant of Breast	
3.28	Malignant Tumor of Uterine Cervix	
3.29	Leukemia	Chronic Lymphocytic Leukemia
3.30	Other Malignancies	Unspecified Malignant Tumor
		Neuromalignant Tumor
		Vascular Malignant Tumor
		Bone Malignant Tumor
		Bone Marrow Malignant Tumor
		Thymic Malignant Tumor
		Lymph Node Malignant Tumor
		Thyroid Malignant Tumor
		Renal Malignant Tumor
		Bladder Malignant Tumor
		Testicular Malignant Tumor
4.31	Tumor of Uterus	Uterine Leiomyoma
4.32	Tumor of Brain	Pituitary Tumor, Glioma, Cerebral Aneurysm, Intracranial Cyst
4.33	Other Tumor	Tumor of Parotid Gland, Subcutaneous Cyst, Tongue Cyst, Lumbar Cyst, Rectal Cyst
4.34	Orthotopic Tumor	Thyroid Tumor
4.35	Tumor Meter With Undetermined Or Unknown	Aortic Aneurysm

Notes: This table presents the list of cancer types we have defined as a health shock from the CFPS survey dataset.

Table A6
Univariate and multivariate L1 distance of pre-shock covariates.

	2012		2014		2016		2018	
	Before CEM	After CEM	Before CEM	After CEM	Before CEM	After CEM	Before CEM	After CEM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Predisposing Factors								
Female	0.1445	0.0000	0.0824	0.0000	0.0459	0.0000	0.0699	0.0000
Age	10.9650	0.1107	10.9420	0.0489	11.2860	0.0733	9.6816	0.1140
Whether working	0.2170	0.0000	0.2068	0.0000	0.1620	0.0000	0.1376	0.0000
Number of children	0.4669	0.0290	0.3640	0.0000	0.4494	0.0000	0.3227	0.0000
Illiterate/Not finish primary school	0.1398	0.0000	0.1243	0.0000	0.1493	0.0000	0.1474	0.0000
Primary school	0.0283	0.0000	0.0086	0.0000	0.0009	0.0000	0.0246	0.0000
Middle school	0.0546	0.0000	0.0547	0.0000	0.0992	0.0000	0.1257	0.0000
High school or above	0.0568	0.0000	0.0781	0.0000	0.0493	0.0000	0.0462	0.0000
Enabling Factors								

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Table A6 (*continued*)

	2012		2014		2016		2018	
	Before CEM	After CEM	Before CEM	After CEM	Before CEM	After CEM	Before CEM	After CEM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Hukou	0.0977	0.0000	0.0564	0.0000	0.0681	0.0000	0.0360	0.0000
Whether having car	0.0242	0.0000	0.0498	0.0000	0.0415	0.0000	0.0769	0.0000
Whether having Dibao	0.0427	0.0000	0.0311	0.0000	0.0733	0.0000	0.0640	0.0000
Apartment	0.0245	0.0000	0.0510	0.0000	0.0160	0.0000	0.0242	0.0000
Bungalow	0.0602	0.0000	0.0152	0.0000	0.0102	0.0000	0.0836	0.0000
Quadrangle courty	0.0176	0.0000	0.0174	0.0000	0.0138	0.0000	0.0182	0.0000
Villa	0.0011	0.0000	0.0002	0.0000	0.0092	0.0000	0.0005	0.0000
Low-rise house	0.0934	0.0000	0.0814	0.0000	0.0261	0.0000	0.0857	0.0000
Needs for Healthcare								
Pre-existing conditions[*]								
Respiratory/digestive/urinary	0.0307	0.0000	0.0328	0.0000	0.0349	0.0000	0.0319	0.0000
Circulatory/musculoskeletal	0.0982	0.0000	0.0605	0.0000	0.1548	0.0000	0.1276	0.0000
Mental/cognitive disorder	0.0013	0.0000	0.0009	0.0000	0.0016	0.0000	0.0025	0.0000
Having any of the above	0.1197	0.0000	0.0869	0.0000	0.1876	0.0000	0.1438	0.0000
Multivariate L1 distance:	0.9698	0.4197	0.9556	0.3921	0.9607	0.3942	0.9681	0.3611
Number of treatment group	235	199	456	395	462	360	380	310
Number of control group	18,594	2840	19,947	4397	20,256	3890	18,758	3136

Notes: This table presents the univariate L1 metric for each pre-shock characteristics (as CEM matching key) and the multivariate L1 distance of all characteristics both before and after the matching procedure.

[*] : These dummy variables of pre-existing conditions indicate whether the respondent has experienced any of the listed diseases in the last year.

Table A7

Estimated effect of health shock on each item of respondent's difficulty score.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Whether Having Difficulty in Performing						
	Outdoor Activities	Eating	Cooking	Public Transit	Shopping	Household Chores	Washing Clothes
Shock	0.038***	0.010	0.047***	0.056***	0.070***	0.049***	0.060***
	[0.009]	[0.007]	[0.009]	[0.011]	[0.010]	[0.009]	[0.009]
Unadjusted *p*-value	0.000	0.144	0.000	0.000	0.000	0.000	0.000
Bootstrap-based *p*-value	0.010	0.020	0.010	0.010	0.010	0.010	0.010
Anderson's *q*-value	0.001	0.240	0.001	0.001	0.001	0.001	0.001
Observations	68,843	68,845	68,844	68,843	68,845	68,845	68,845
R-squared	0.0646	0.0550	0.0584	0.0688	0.0684	0.0571	0.0457
Individual FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
Outcome mean	0.0637	0.0344	0.0569	0.0932	0.0649	0.0512	0.0635

Notes: This table reports the baseline results on the effect of health shocks on each item of the respondent's difficulty score. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A8

Effect of respondent's health shocks on spouse's physical health.

Variables	(1)	(2)	(3)	(4)	(5)
	Self-reported Health Status	Interviewer-rated Health Status	Whether Hospitalized Last Year	Hospitalization Expenses (RMB)	Difficulty Score
Shock	−0.009	−0.009	0.016	−151.043	−0.013
	[0.015]	[0.010]	[0.014]	[321.523]	[0.050]
Unadjusted *p*-value	0.556	0.399	0.255	0.639	0.795
Bootstrap-based *p*-value	0.406	0.208	0.099	0.495	0.733
Anderson's *q*-value	0.619	0.503	0.349	0.680	0.783
Observations	63,442	58,857	60,885	60,838	61,141

(*continued on next page*)

Table A8 (*continued*)

Variables	(1)	(2)	(3)	(4)	(5)
	Self-reported Health Status	Interviewer-rated Health Status	Whether Hospitalized Last Year	Hospitalization Expenses (RMB)	Difficulty Score
R-squared	0.0328	0.0140	0.0153	0.0060	0.0721
Individual FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Outcome mean	0.528	0.892	0.126	1854	0.420

Notes: This table reports the baseline results on the effect of respondent's health shocks on their spouse's physical health. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A9
Estimated effect of health shock on each item of spouse's difficulty score.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Whether Having Difficulty in Performing						
	Outdoor Activities	Eating	Cooking	Public Transit	Shopping	Household Chores	Washing Clothes
Shock	−0.003	−0.008	0.002	0.000	0.002	−0.004	−0.003
	[0.008]	[0.007]	[0.009]	[0.010]	[0.008]	[0.008]	[0.009]
Unadjusted *p*-value	0.690	0.255	0.802	0.982	0.801	0.656	0.746
Bootstrap-based *p*-value	0.604	0.099	0.703	0.970	0.713	0.594	0.634
Anderson's *q*-value	0.722	0.349	0.783	0.813	0.783	0.685	0.775
Observations	61,141	61,141	61,141	61,141	61,141	61,141	61,141
R-squared	0.0526	0.0518	0.0512	0.0587	0.0557	0.0494	0.0427
Individual FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
Outcome mean	0.0584	0.0354	0.0617	0.0843	0.0611	0.0529	0.0664

Notes: This table reports the baseline results on the effect of health shocks on each item of the spouse's difficulty score. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A10
Estimated Effect of Health Shock on Household Labor Supply.

Variables	(1)	(2)	(3)	(4)
	Respondent		Spouse	
	Working Hours/Month	Log (Working Hours/Month)	Working Hours/Month	Log (Working Hours/Month)
Shock	−4.628	−0.113*	1.684	0.060
	[3.429]	[0.068]	[3.571]	[0.068]
Unadjusted *p*-value	0.177	0.096	0.637	0.378
Bootstrap-based *p*-value	0.050	0.020	0.475	0.208
Anderson's *q*-value	0.283	0.179	0.680	0.488
Observations	60,862	60,862	54,979	54,979
R-squared	0.0600	0.0700	0.0678	0.0756
Individual FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Outcome mean	99.94	2.698	111.7	2.903

Notes: This table reports the baseline results on the effect of health shocks on household labor supply. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A11
Estimated effect of health shock on household income per capita (in Log Term).

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Log (Net HH Income per Capita)	Log (Salary Income per Capita)	Log (Business Income per Capita)	Log (Property Income per Capita)	Log (Transfer Income per Capita)	Log (Other Income per Capita)
Shock	−0.084***	−0.305***	−0.309***	0.077	0.012	0.027
	[0.030]	[0.117]	[0.092]	[0.067]	[0.092]	[0.094]
Unadjusted *p*-value	0.004	0.009	0.032	0.260	0.756	0.746
Bootstrap-based *p*-value	0.010	0.010	0.010	0.089	0.693	0.644
Anderson's *q*-value	0.016	0.031	0.087	0.349	0.775	0.775
Observations	69,679	70,041	68,880	69,982	69,935	69,634
R-squared	0.0354	0.0208	0.0882	0.0139	0.1066	0.0520
Individual FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Outcome mean	9.007	6.076	3.424	0.865	3.195	1.725

Notes: This table reports the baseline results on the effect of health shocks on household income and its subcomponents (in log terms). The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A12
Aggregate level HH economic outcomes.

Variables	(1)	(2)	(3)
	Net Family Income (RMB)	Net Family Asset (RMB)	Family Size
Shock	−3387.025***	−29,027.773*	−0.057
	[1242.223]	[15,420.094]	[0.044]
Observations	69,679	68,180	70,085
R-squared	0.0544	0.0713	0.0104
Individual FE	YES	YES	YES
Year FE	YES	YES	YES
Outcome mean	51,268	462,534	4.064

Notes: This table presents the effect of health shocks on household economic outcomes and family size. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A13
Estimated effect of health shock on household income per capita (in Level Term).

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Net HH Income per Capita (RMB)	Salary Income per Capita (RMB)	Business Income per Capita (RMB)	Property Income per Capita (RMB)	Transfer Income per Capita (RMB)	Other Income per Capita (RMB)
Shock	−840.576**	−722.146**	−84.351	−72.700	129.490	123.875
	[358.149]	[303.392]	[114.335]	[66.779]	[91.657]	[93.488]
Observations	69,679	70,041	68,880	69,982	69,940	69,634
R-squared	0.0753	0.0189	0.0086	0.0036	0.0073	0.0050
Individual FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Outcome mean	14,075	8059	1280	367.2	728.6	549.4

Notes: This table reports the baseline results on the effect of health shocks on household income and its subcomponents (in level terms). The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock

before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** p < 0.01, ** p < 0.05, * p < 0.1.

Table A14
Estimated effect of health shock on household assets per capita (in Level Term).

Variables	(1)	(2)	(3)	(4)	(5)
	Net HH Asset per Capita (RMB)	Total Cash & Deposits per Capita (RMB)	Business Asset per Capita (10,000 RMB)	Financial Debt per Capita (RMB)	Money Lent Out per Capita (RMB)
Shock	−13,635.014**	−1715.484	14.311	496.200	−127.900
	[5762.509]	[1517.338]	[23.799]	[461.311]	[635.295]
Unadjusted *p*-value	0.018	0.258	0.055	0.282	0.840
Bootstrap-based *p*-value	0.010	0.079	0.010	0.139	0.822
Anderson's *q*-value	0.052	0.349	0.125	0.373	0.804
Observations	68,180	69,931	69,785	69,763	69,927
R-squared	0.0616	0.0250	0.0469	0.0018	0.0048
Individual FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Outcome mean	141,030	12,582	99.77	2702	1597

Notes: This table reports the baseline results on the effect of health shocks on household net asset and its subcomponents (in level terms). The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** p < 0.01, ** p < 0.05, * p < 0.1.

Table A15
Estimated effect of health shock on household assets per capita (in Log Term).

Variables	(1)	(2)	(3)	(4)	(5)
	Log (Net HH Asset per Capita)	Log (Total Cash and Deposits per Capita)	Log (Business Asset per Capita)	Log (Financial Debt per Capita)	Log (Money Lent Out per Capita)
Shock	−0.289***	−0.074	−0.017	0.086	−0.107
	[0.095]	[0.116]	[0.036]	[0.103]	[0.083]
Unadjusted *p*-value	0.002	0.512	0.877	0.398	0.197
Bootstrap-based *p*-value	0.010	0.386	0.861	0.208	0.089
Anderson's *q*-value	0.010	0.573	0.804	0.503	0.301
Observations	68,180	69,931	69,785	69,763	69,927
R-squared	0.0083	0.2001	0.0456	0.0038	0.0055
Individual FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Outcome mean	10.56	5.296	0.209	1.490	1.043

Notes: This table reports the baseline results on the effect of health shocks on household net asset and its subcomponents (in log terms). The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** p < 0.01, ** p < 0.05, * p < 0.1.

Table A16
Estimated effect of health shock on household's dibao status and government transfer.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Whether Having Dibao	Whether Eligible for Dibao	Dibao Transfer per Capita (RMB)	Log (Dibao Transfer per Capita)	Whether Having Government Transfer	Government Transfer per Capita (RMB)	Log (Government Transfer per Capita)
Shock	0.028**	0.022*	59.947**	0.231***	0.009	105.292***	0.156**
	[0.014]	[0.012]	[26.235]	[0.080]	[0.013]	[31.736]	[0.075]

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Table A16 (*continued*)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Whether Having Dibao	Whether Eligible for Dibao	Dibao Transfer per Capita (RMB)	Log (Dibao Transfer per Capita)	Whether Having Government Transfer	Government Transfer per Capita (RMB)	Log (Government Transfer per Capita)
Unadjusted *p*-value	0.040	0.069	0.022	0.004	0.503	0.001	0.038
Bootstrap-based *p*-value	0.010	0.020	0.010	0.010	0.327	0.010	0.010
Anderson's *q*-value	0.083	0.119	0.058	0.016	0.521	0.004	0.083
Observations	70,063	68,023	69,420	69,420	70,064	70,050	70,046
R-squared	0.2339	0.0372	0.0341	0.2166	0.2040	0.0167	0.1920
Individual FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
Outcome mean	0.291	0.196	165.5	1.469	0.441	208.7	2.302

Notes: This table reports the baseline results on the effect of health shocks on household's dibao status and receipt of government poverty relief transfer. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A17
Estimated effect of health shock on household's private transfer income.

Variables	(1)	(2)	(3)	(4)	(5)
	Whether Having Family Transfer	Family Transfer Amount per Capita(RMB)	Log (Family Transfer Amount per Capita)	Transfer Income per Capita (RMB)	Log (Transfer Income per Capita)
Shock	−0.004	105.233	0.019	210.830**	0.094
	[0.013]	[87.980]	[0.090]	[93.457]	[0.093]
Unadjusted *p*-value	0.786	0.232	0.829	0.024	0.312
Bootstrap-based *p*-value	0.683	0.119	0.752	0.010	0.269
Anderson's *q*-value	0.718	0.304	0.729	0.061	0.365
Observations	69,953	69,974	69,973	69,940	69,935
R-squared	0.0331	0.0050	0.0357	0.0075	0.1071
Individual FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Outcome mean	0.224	523.4	1.440	732.1	3.199

Notes: This table reports the baseline results on the effect of health shocks on household's private transfer. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A18
Baseline results for depression score (Respondent).

Variables	(1)	(2)	(3)	(4)	(5)
	Individual Items of Depression Score				Sleep Quality
	Felt down	Could not get going on with life	Felt everything I did was an effort	Can't sleep well	Sleep hours/day
Shock	0.173***	0.100***	0.184***	0.240***	−0.159**
	[0.026]	[0.020]	[0.027]	[0.028]	[0.074]
Unadjusted *p*-value	0.000	0.000	0.000	0.000	0.033
Bootstrap-based *p*-value	0.010	0.010	0.010	0.010	0.010
Anderson's *q*-value	0.001	0.001	0.001	0.001	0.087

(*continued on next page*)

Table A18 (*continued*)

Variables	(1)	(2)	(3)	(4)	(5)
	Individual Items of Depression Score				Sleep Quality
	Felt down	Could not get going on with life	Felt everything I did was an effort	Can't sleep well	Sleep hours/day
Observations	68,515	68,496	68,620	68,593	44,722
R-squared	0.1158	0.0147	0.2175	0.1647	0.0461
Individual FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Outcome mean	1.500	1.189	1.576	1.566	7.844

Notes: This table reports the baseline results on the effect of health shocks on respondent's mental health and sleep quality. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A19
Baseline results for depression score (Spouse).

Variables	(1)	(2)	(3)	(4)	(5)
	Individual Items of Depression Score				Sleep Quality
	Felt down	Could not get going on with life	Felt everything I did was an effort	Can't sleep well	Sleep hours/day
Shock	0.008	0.035*	0.048*	0.039	−0.011
	[0.024]	[0.018]	[0.027]	[0.027]	[0.068]
Unadjusted *p*-value	0.754	0.054	0.080	0.156	0.866
Bootstrap-based *p*-value	0.663	0.010	0.020	0.050	0.852
Anderson's *q*-value	0.775	0.125	0.151	0.254	0.804
Observations	60,713	60,697	60,791	60,757	40,184
R-squared	0.1071	0.0091	0.1929	0.1573	0.0512
Individual FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Outcome mean	1.446	1.158	1.501	1.517	7.837

Notes: This table reports the baseline results on the effect of health shocks on spouse's mental health and sleep quality. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A20
Baseline results for health behavior.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Respondent			Spouse		
	Whether Exercising	Exercise Hours/ Week	Whether Having Insurance	Whether Exercising	Exercise Hours/ Week	Whether Having Insurance
Shock	0.050***	0.757***	0.004	0.028*	0.853**	0.018**
	[0.014]	[0.265]	[0.009]	[0.015]	[0.332]	[0.009]
Unadjusted *p*-value	0.000	0.004	0.647	0.059	0.010	0.040
Bootstrap-based *p*-value	0.010	0.010	0.584	0.030	0.010	0.010
Anderson's *q*-value	0.002	0.016	0.680	0.130	0.034	0.097
Observations	70,085	54,526	70,085	63,540	48,237	69,639
R-squared	0.0611	0.0824	0.0207	0.0599	0.0822	0.0173
Individual FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Outcome mean	0.403	2.993	0.912	0.426	3.177	0.915

Notes: This table reports the baseline results on the effect of health shocks on respondent's and spouse's health behaviors. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have

experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. We report bootstrap-based *p*-value and Anderson (2008)'s *q*-value for the estimated coefficients in each column. Standard errors in squared parentheses are clustered at the household level. *** p < 0.01, ** p < 0.05, * p < 0.1.

Table A21
Rural-Urban heterogeneous analysis for physical health.

Variables	(1)	(2)	(3)	(4)
	Self-Report Health Status (Respondent)	Self-Report Health Status (Spouse)	Hospitalization Expenses (Respondent)	Hospitalization Expenses (Spouse)
Shock	−0.126***	−0.033	5245.715***	566.878
	[0.025]	[0.029]	[1253.747]	[737.199]
Shock * Rural	0.033	0.034	−1665.992	−1020.663
	[0.030]	[0.033]	[1380.978]	[807.936]
Observations	70,001	63,442	68,655	60,838
R-squared	0.0382	0.0345	0.0140	0.0065
Individual FE	YES	YES	YES	YES
Year FE * Group FE	YES	YES	YES	YES
Outcome mean	0.504	0.528	1874	1854

Notes: This table presents the differences on the effects of health shocks on physical health between rural and urban households. The independent variable, *shock*rural*, equals to one if a rural patient has experienced the health shock and captures the differences between rural and urban households. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. Standard errors in parentheses are clustered at the household level. *** p < 0.01, ** p < 0.05, * p < 0.1.

Table A22
Rural-Urban heterogeneous analysis for economic outcomes.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Whether Working (Respondent)	Whether Working (Spouse)	Net HH Income per Capita (RMB)	Net HH Asset per Capita (RMB)	Whether Having Dibao	Whether Eligible for Dibao
Shock	−0.006	0.025	−745.558	4248.514	0.018	0.013
	[0.019]	[0.021]	[855.623]	[16,594.225]	[0.020]	[0.018]
Shock * Rural	−0.026	−0.013	−167.987	−25,362.565	0.021	0.015
	[0.026]	[0.028]	[920.517]	[17,123.521]	[0.025]	[0.023]
Observations	69,720	62,800	69,679	68,180	70,063	68,023
R-squared	0.0753	0.0767	0.1134	0.0840	0.2881	0.0449
Individual FE	YES	YES	YES	YES	YES	YES
Year FE * Group FE	YES	YES	YES	YES	YES	YES
Outcome mean	0.521	0.544	14,075	141,030	0.291	0.196

Notes: This table presents the differences on the effects of health shocks on various household economic outcomes between rural and urban households. The independent variable, *shock*rural*, equals to one if a rural patient has experienced the health shock and captures the differences between rural and urban households. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. Standard errors in parentheses are clustered at the household level. *** p < 0.01, ** p < 0.05, * p < 0.1.

Table A23
Rural-urban heterogeneous analysis for mental health and health behavior.

Variables	(1)	(2)	(3)	(4)
	Depression Score (Respondent)	Depression Score (Spouse)	Whether Exercising (Respondent)	Whether Exercising (Spouse)
Shock	0.507***	0.188*	−0.002	0.023
	[0.113]	[0.108]	[0.028]	[0.028]
Shock * Rural	0.273*	−0.068	0.075**	0.010
	[0.141]	[0.136]	[0.032]	[0.033]
Observations	68,346	60,565	70,085	63,540
R-squared	0.2425	0.2270	0.0647	0.0652
Individual FE	YES	YES	YES	YES
Year FE * Group FE	YES	YES	YES	YES
Outcome mean	5.828	5.621	0.403	0.426

Notes: This table presents the differences on the effects of health shocks on mental health and health behaviors between rural and urban households. The independent variable, *shock*rural*, equals to one if a rural patient has experienced the health shock and captures the differences between rural and urban households. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. Standard errors in parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A24
Low- and high-income heterogeneous analysis for physical health.

Variables	(1)	(2)	(3)	(4)
	Self-Report Health Status (Respondent)	Self-Report Health Status (Spouse)	Hospitalization Expenses (Respondent)	Hospitalization Expenses (Spouse)
Shock	−0.128***	−0.034	6747.377***	−613.283
	[0.024]	[0.026]	[1323.632]	[572.926]
Shock * Low-income	0.039	0.039	−3985.793***	705.996
	[0.029]	[0.031]	[1406.585]	[684.957]
Observations	70,001	63,442	68,655	60,838
R-squared	0.0366	0.0337	0.0134	0.0064
Individual FE	YES	YES	YES	YES
Year FE * Group FE	YES	YES	YES	YES
Outcome mean	0.504	0.528	1874	1854

Notes: This table presents the differences on the effects of health shocks on physical health between low-income and high-income households. The independent variable, *shock*low − income*, equals to one if a patient from low-income household has experienced the health shock and captures the differences between rural and urban households. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. Standard errors in parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A25
Low- and high-income heterogeneous analysis for HH economic outcomes.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Whether Working (Respondent)	Whether Working (Spouse)	Net HH Income per Capita (RMB)	Net HH Asset per Capita (RMB)	Whether Having Dibao	Whether Eligible for Dibao
Shock	−0.058***	0.004	−1858.487**	−9963.554	0.009	0.029*
	[0.021]	[0.021]	[806.735]	[13,254.882]	[0.022]	[0.017]
Shock * Low-income	0.046*	0.013	1552.565*	−5416.029	0.027	−0.013
	[0.028]	[0.028]	[863.386]	[14,150.472]	[0.028]	[0.023]
Observations	69,720	62,800	69,679	68,180	70,063	68,023
R-squared	0.0685	0.0734	0.0823	0.0704	0.2381	0.0417
Individual FE	YES	YES	YES	YES	YES	YES
Year FE * Group FE	YES	YES	YES	YES	YES	YES
Outcome mean	0.521	0.544	14,075	141,030	0.291	0.196

Notes: This table presents the differences on the effects of health shocks on various household economic outcomes between low-income and high-income households. The independent variable, *shock*low − income*, equals to one if a patient from low-income household has experienced the health shock and captures the differences between rural and urban households. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. Standard errors in parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A26
Low- and high-income heterogeneous analysis for mental health and health behavior.

Variables	(1)	(2)	(3)	(4)
	Depression Score (Respondent)	Depression Score (Spouse)	Whether Exercising (Respondent)	Whether Exercising (Spouse)
Shock	0.769***	0.085	0.004	0.000
	[0.113]	[0.106]	[0.024]	[0.025]
Shock * Low-income	−0.106	0.080	0.069**	0.041
	[0.141]	[0.134]	[0.029]	[0.031]

(*continued on next page*)

Table A26 (*continued*)

Variables	(1)	(2)	(3)	(4)
	Depression Score (Respondent)	Depression Score (Spouse)	Whether Exercising (Respondent)	Whether Exercising (Spouse)
Observations	68,346	60,565	70,085	63,540
R-squared	0.2417	0.2276	0.0615	0.0603
Individual FE	YES	YES	YES	YES
Year FE * Group FE	YES	YES	YES	YES
Outcome mean	5.828	5.621	0.403	0.426

Notes: This table presents the differences on the effects of health shocks on mental health and health behaviors between low-income and high-income households. The independent variable, *shock*low − income*, equals to one if a patient from low-income household has experienced the health shock and captures the differences between rural and urban households. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. Standard errors in parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A27
Robustness analyses with residential region dummies as additional CEM matching keys.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Physical Health						
Variables	Self-reported Health Status	Interviewer-rated Health Status	Whether Hospitalized Last Year	Medical Expenses (RMB)	Difficulty Score	
Shock	−0.095***	−0.056***	0.193***	3778.123***	0.341***	
	[0.015]	[0.013]	[0.015]	[572.139]	[0.059]	
Observations	36,614	34,905	35,940	35,889	35,995	
Outcome mean	0.499	0.881	0.135	1880	0.432	
Panel B: Household Economic Outcomes						
Variables	Whether Working (Self)	Whether Working (Spouse)	Net HH Income per Capita (RMB)	Net HH Asset per Capita (RMB)	Having Dibao	Eligible for Dibao
Shock	−0.045***	0.014	−957.573**	−18,408.574***	0.034**	0.028**
	[0.016]	[0.016]	[389.914]	[5750.873]	[0.015]	[0.014]
Observations	36,463	32,861	36,453	35,663	36,646	35,608
Outcome mean	0.537	0.554	13,854	138,247	0.285	0.198

Notes: This table reports results of robustness analyze after the region of residence—a set of four region dummies—is included into the CEM matching process to form a new post-match sample. All regression specifications and sample restrictions are the same as in Eq. 1. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A28
Robustness analyses with residential region dummies as additional CEM matching keys (cont.)

	(1)	(2)	(3)	(4)	(5)	(6)	
Panel C: Mental Health							
Variables	Depression Score (Respondent)	Moderate Depression (Respondent)	Severe Depression (Respondent)	Depression Score (Spouse)	Moderate Depression (Spouse)	Severe Depression (Spouse)	
Shock	0.753***	0.133***	0.040***	0.157**	0.040***	0.006	
	[0.078]	[0.015]	[0.008]	[0.074]	[0.014]	[0.006]	
Observations	35,741	35,741	35,741	31,698	31,698	31,698	
Outcome mean	5.852	0.209	0.0339	5.621	0.171	0.0243	
Panel D: Health Behaviors							
Variables	Whether Exercising (Respondent)	Whether Drinking (Respondent)	Whether Smoking (Respondent)	Whether Exercising (Spouse)	Whether Drinking (Spouse)	Whether Smoking (Spouse)	Health and Fitness Expense per Capita
Shock	0.041***	−0.026***	−0.022**	0.027**	−0.022*	0.005	764.497***
	[0.016]	[0.009]	[0.009]	[0.016]	[0.011]	[0.009]	[205.089]
Observations	36,657	35,831	35,916	33,233	31,845	31,845	36,361
Outcome mean	0.399	0.149	0.256	0.422	0.210	0.352	1865

Notes: This table reports results of robustness analyze after the region of residence—a set of four region dummies—is included into the CEM matching process to form a new post-match sample. All regression specifications and sample restrictions are the same as in Eq. 1. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have

experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A29
Robustness analyses with insurance control.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Physical Health						
Variables	Self-reported Health Status	Interviewer-rated Health Status	Hospitalized Last Year	Medical Expenses (RMB)	Difficulty Score	
Shock	−0.101***	−0.052***	0.185***	3995.950***	0.334***	
	[0.015]	[0.012]	[0.015]	[559.948]	[0.054]	
Observations	63,458	60,968	62,875	62,790	62,902	
Outcome mean	0.504	0.885	0.137	1874	0.428	
Panel B: Household Economic Outcomes						
Variables	Whether Working (Self)	Whether Working (Spouse)	Net Income per Capita (RMB)	Net Asset per Capita (RMB)	Having Dibao	Eligible for Dibao
Shock	−0.030**	0.012	−955.627**	−10,865.126*	0.033**	0.021*
	[0.015]	[0.015]	[377.176]	[5889.963]	[0.014]	[0.013]
Observations	63,266	57,058	63,109	61,820	63,443	61,673
Outcome mean	0.521	0.544	14,075	141,030	0.291	0.196

Notes: *Notes*: This table reports results of robustness analyses after including the health insurance controls (both whether having health insurance and the types of the health insurance). All regression specifications and sample restrictions are the same as in Eq. 1. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A30
Robustness analyses with insurance control (cont.)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel C: Mental Health							
Variables	Depression Score (Respondent)	Moderate Depression (Respondent)	Severe Depression (Respondent)	Depression Score (Spouse)	Moderate Depression (Spouse)	Severe Depression (Spouse)	
Shock	0.712***	0.134***	0.031***	0.134*	0.036***	0.003	
	[0.073]	[0.014]	[0.008]	[0.070]	[0.013]	[0.006]	
Observations	62,514	62,514	62,514	55,121	55,121	55,121	
Outcome mean	5.828	0.204	0.0334	5.621	0.172	0.0248	
Panel D: Health Behaviors							
Variables	Whether Exercising (Respondent)	Whether Drinking (Respondent)	Whether Smoking (Respondent)	Whether Exercising (Spouse)	Whether Drinking (Spouse)	Whether Smoking (Spouse)	Health and Fitness Expense per Capita
Shock	0.052***	−0.024***	−0.019**	0.036**	−0.016	0.000	777.930***
	[0.015]	[0.009]	[0.008]	[0.016]	[0.010]	[0.009]	[192.872]
Observations	63,462	62,831	62,836	57,714	55,381	55,383	62,918
Outcome mean	0.403	0.147	0.261	0.426	0.208	0.351	1869

Notes: *Notes*: This table reports results of robustness analyses after including the health insurance controls (both whether having health insurance and the types of the health insurance). All regression specifications and sample restrictions are the same as in Eq. 1. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A31
Robustness analyses with province-specific linear trend.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Physical Health						
Variables	Self-reported Health Status	Interviewer-rated Health Status	Hospitalized Last Year	Medical Expenses (RMB)	Difficulty Score	
Shock	−0.110***	−0.042***	0.183***	4108.826***	0.316***	
	[0.014]	[0.011]	[0.014]	[567.410]	[0.053]	
Observations	69,991	66,665	68,743	68,655	68,840	
Outcome mean	0.504	0.885	0.137	1874	0.428	
Panel B: Household Economic Outcomes						
Variables	Whether Working (Self)	Whether Working (Spouse)	Net HH Income per Capita (RMB)	Net HH Asset per Capita (RMB)	Having Dibao	Eligible for Dibao
Shock	−0.036**	0.004	−751.836**	−7593.796	0.033**	0.021*
	[0.014]	[0.014]	[350.040]	[5720.738]	[0.014]	[0.012]
Observations	69,712	62,792	69,671	68,171	70,053	68,019
Outcome mean	0.521	0.544	14,075	141,030	0.291	0.196

Notes: This table reports results of robustness analyses after including the province-specific linear trend. All regression specifications and sample restrictions are the same as in Eq. 1. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A32
Robustness analyses with province-specific linear trend (cont.)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel C: Mental Health							
Variables	Depression Score (Respondent)	Moderate Depression (Respondent)	Severe Depression (Respondent)	Depression Score (Spouse)	Moderate Depression (Spouse)	Severe Depression (Spouse)	
Shock	0.706***	0.127***	0.035***	0.168**	0.036***	0.007	
	[0.069]	[0.013]	[0.008]	[0.068]	[0.013]	[0.006]	
Observations	68,346	68,346	68,346	60,563	60,563	60,563	
Outcome mean	5.828	0.204	0.0334	5.621	0.172	0.0248	
Panel D: Health Behaviors							
Variables	Whether Exercising (Respondent)	Whether Drinking (Respondent)	Whether Smoking (Respondent)	Whether Exercising (Spouse)	Whether Drinking (Spouse)	Whether Smoking (Spouse)	Health and Fitness Expense per Capita
Shock	0.050***	−0.026***	−0.017**	0.028*	−0.018*	0.004	917.674***
	[0.014]	[0.008]	[0.008]	[0.015]	[0.010]	[0.008]	[193.468]
Observations	70,075	68,698	68,703	63,531	60,846	60,848	69,463
Outcome mean	0.403	0.147	0.261	0.426	0.208	0.351	1869

Notes: This table reports results of robustness analyses after including the province-specific linear trend. All regression specifications and sample restrictions are the same as in Eq. 1. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases. Standard errors in squared parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A33
Robustness analyses (Winsoring the data).

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Winsorize the top and bottom 1%		Winsorize the top and bottom 2%		Winsorize the top and bottom 3%	
	Net Household Income per Capita (RMB)	Net Household Asset per Capita (RMB)	Net Household Income per Capita (RMB)	Net Household Asset per Capita (RMB)	Net Household Income per Capita (RMB)	Net Household Asset per Capita (RMB)
Shock	−825.246**	−11,720.494**	−763.783**	−11,683.470***	−765.167***	−11,204.081***
	[327.504]	[4592.992]	[304.026]	[3783.851]	[285.140]	[3426.085]
Observations	69,679	68,180	69,679	68,180	69,679	68,180
R-squared	0.0826	0.0749	0.0840	0.0815	0.0849	0.0871
Individual FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Outcome mean	13,902	134,240	13,700	127,443	13,489	122,822
Baseline estimate	−840.576**	−13,635.014**	−840.576**	−13,635.014**	−840.576**	−13,635.014**
	[358.149]	[5762.509]	[358.149]	[5762.509]	[358.149]	[5762.509]
Diff to baseline estimate (%)	1.82	14.04	9.14	14.31	8.97	17.83

Notes: This table reports results of robustness analyses after winsoring the data. All regression specifications and sample restrictions are the same as in Eq. 1. The independent variable, *shock*, equals to one after the respondent has experienced the first onset of a health shock. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases. Samples in columns (1) and (2) are winsorized at the top and bottom 1%; columns (3) and (4) at the top and bottom 2%; columns (5) and (6) at the top and bottom 3%. Standard errors in squared parentheses are clustered at the household level. Baselise estimates are obtained from Table 4. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A34
Back-of-envelope analysis.

Variables	(1)	(2)	(3)	(4)
	Hospitalization Expenses (Respondent)	Net Household Income (RMB)	Net Household Asset (RMB)	Government Transfer Amount (RMB)
Post-shock (1st year)	4002.008***	−4455.365***	−31,483.309*	280.728***
	[646.666]	[1477.028]	[16,466.467]	[108.515]
Post-shock (2 − 3rd year)	3471.964***	-3783.805**	−48,859.149**	314.467*
	[976.827]	[1859.020]	[23,934.555]	[182.621]
Post-shock (4-5th year)	3845.111***	−3707.186	−44,598.308	150.580
	[1110.247]	[2368.663]	[32,555.355]	[156.589]
Observations	68,655	69,679	68,180	70,050
R-squared	0.0123	0.0550	0.0718	0.0175
Individual FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Outcome mean	1874	51,268	462,534	741.2

Notes: This table presents the dynamic effect of health shocks on some financial outcomes. All regression specifications and sample restrictions are the same as in Eq. 2. The sample is restricted to individuals who have experienced the first health shock during the sample period (treatment group) and those who have never experienced any health shock before or during the sample period (control group). Health shock is defined as heart attack, stroke, or any of the sudden acute cardiovascular diseases listed in Appendix Table A4. Standard errors in parentheses are clustered at the household level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix D. Figures

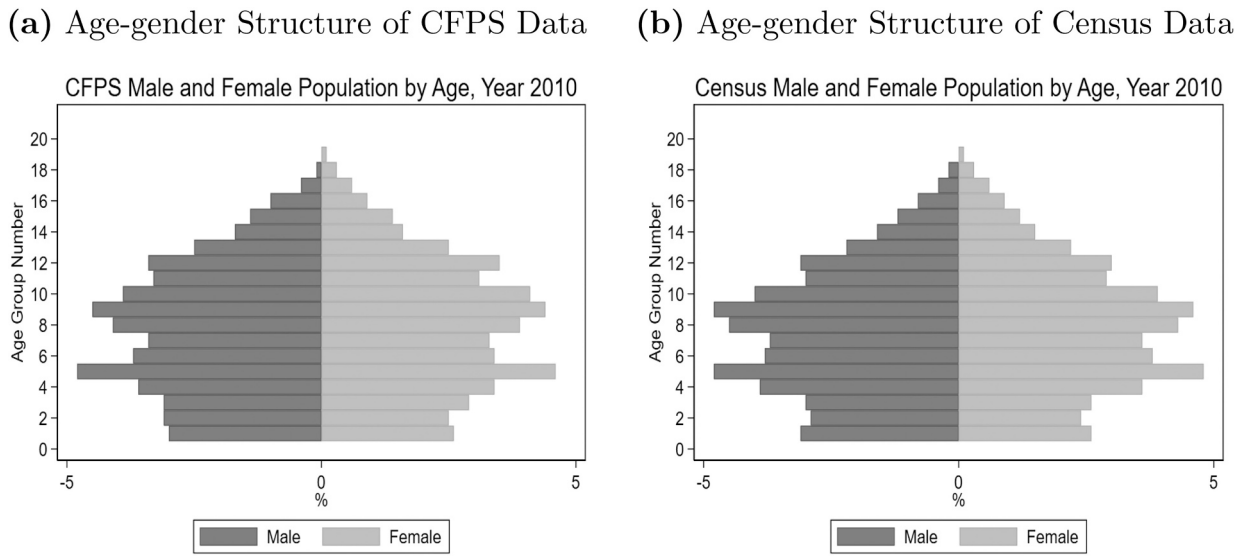

Fig. B1. Age-gender structure of CFPS and census data.
Notes: The whole population from each sample are grouped by 21 age groups. From bottom to top, the age groups are 0–4, 5–9, 10–14, 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, 85–89, 90–94, 95–99, and more than 100 years old respectively.

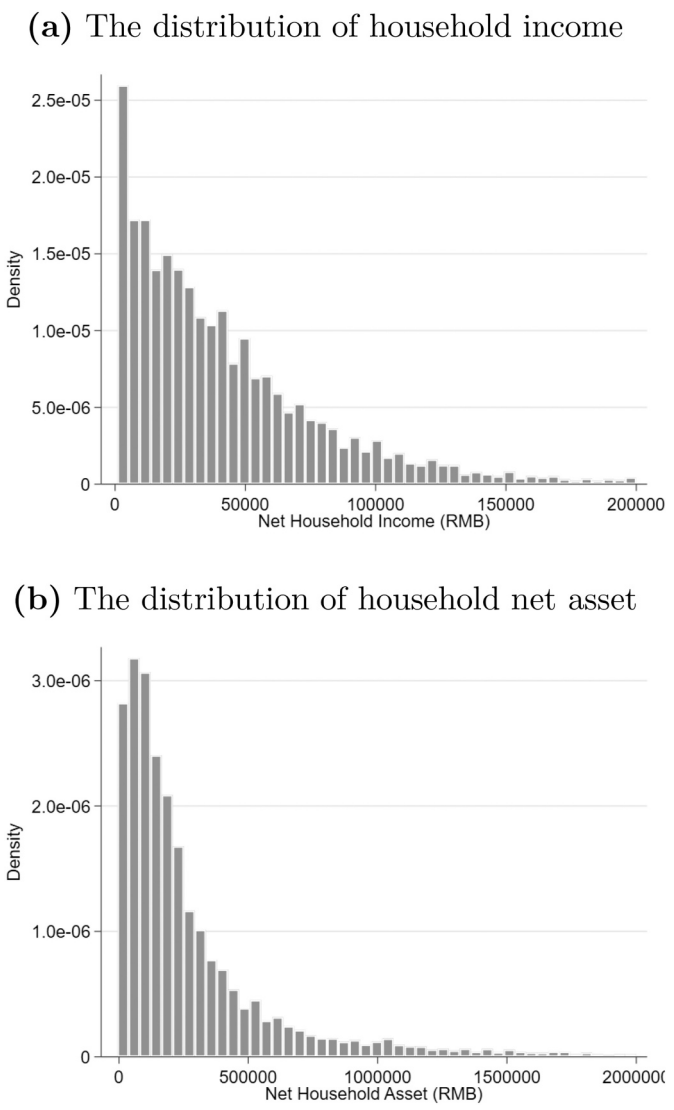

Fig. B2. The distribution of household income and asset.
Notes: This figure presents the distribution of household income (panel A) and net asset (panel B).

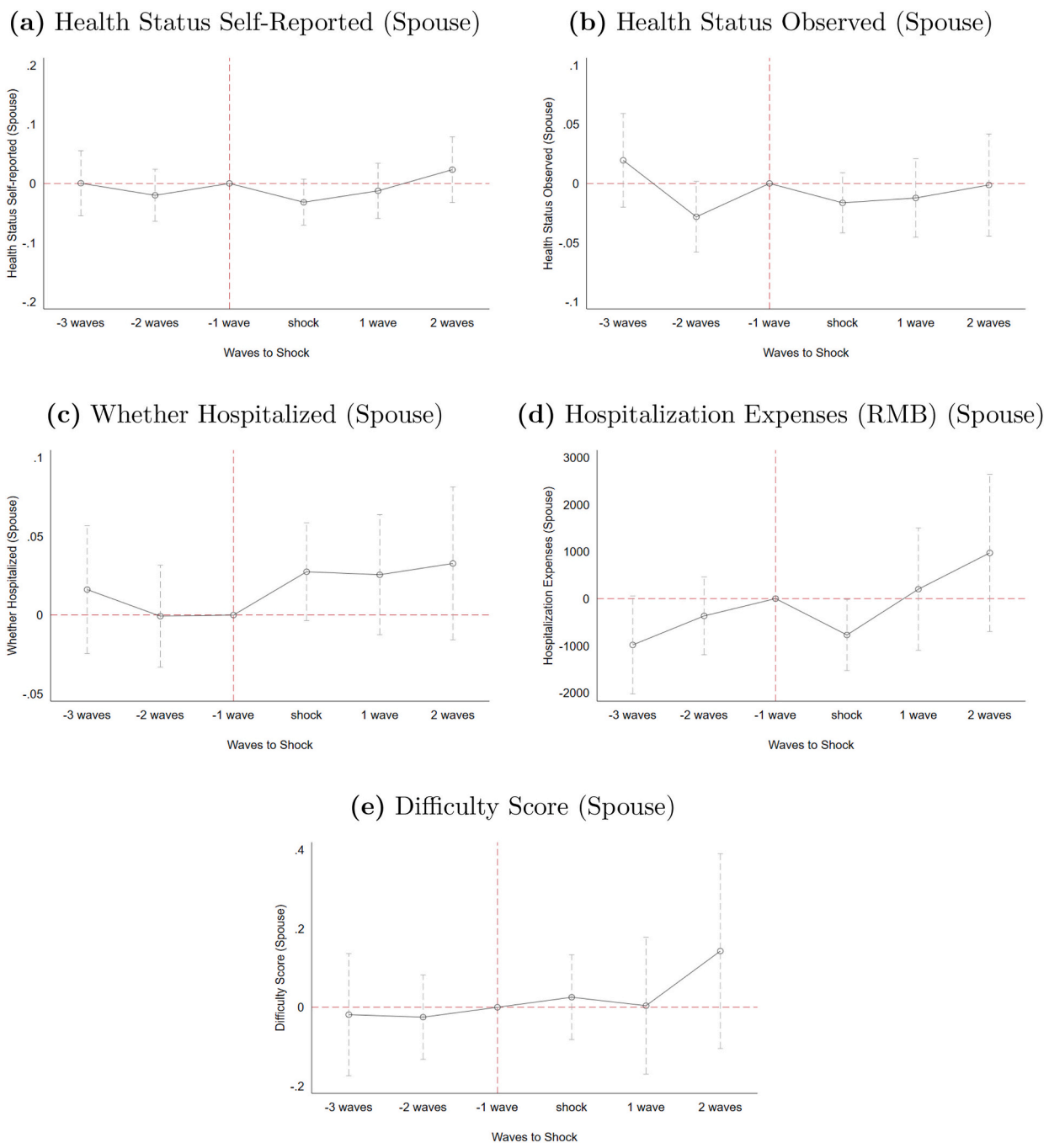

Fig. B3. Event-study estimates of the effects of health shocks on measures of spouse's physical health.
Notes: This figure presents the dynamic effects of health shocks on different measures of spouse's physical health. The regression specification is specified in Eq. 2 and discussed in details in Section 4.2. We plot the estimated coefficients of time-to-treatment dummies (β^ks in Eq. 2) together with the corresponding 90% confidence intervals in the figure.

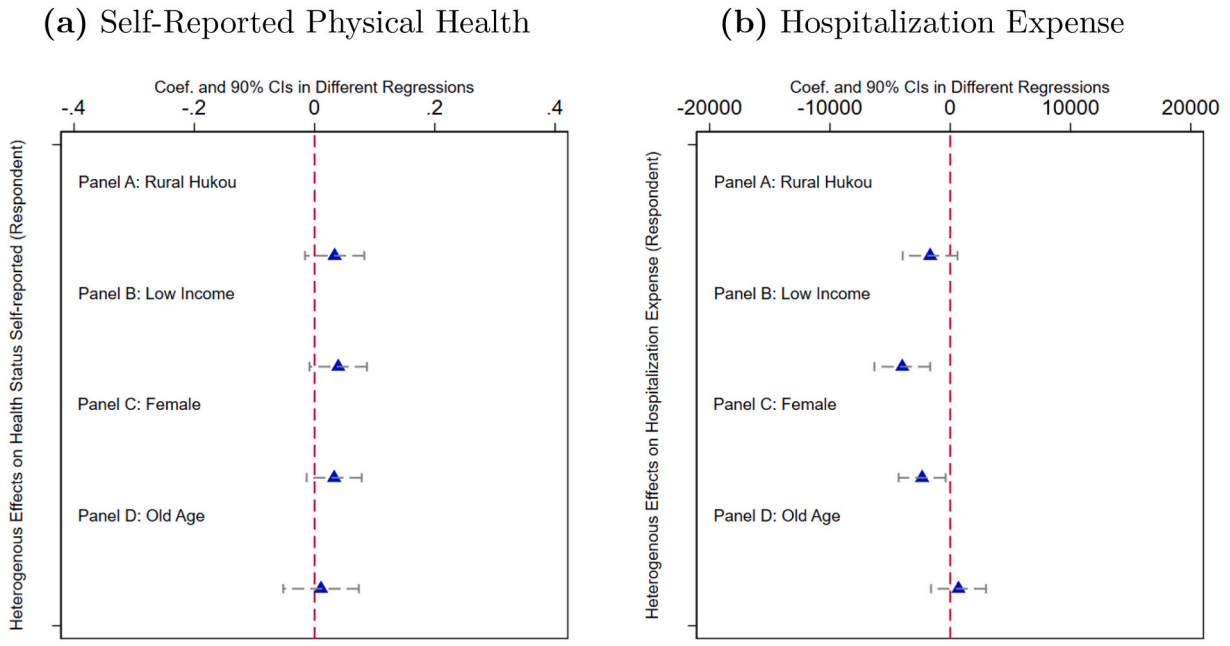

Fig. B4. Heterogeneous effects of the health shock on physical health and medical expenses.
Notes: *This* figure presents the differences on the effects of health shocks on variouse kinds of outcomes between households with different characteristics. Regression equation is specified in Eq. 3 and the sample is the same as in baseline Table 3. For each dimension of heterogeneity, we plot the coefficient estimate of β_2 in Eq. 3 and its 90% confidence interval. Low income dummy is defined as one of pre-shock household income per capita is below the sample mean. Retirement age is set as 65 for male and 60 for female for the urban households. Old age dummy is defined as one if pre-shock age of the respondent is over 60.

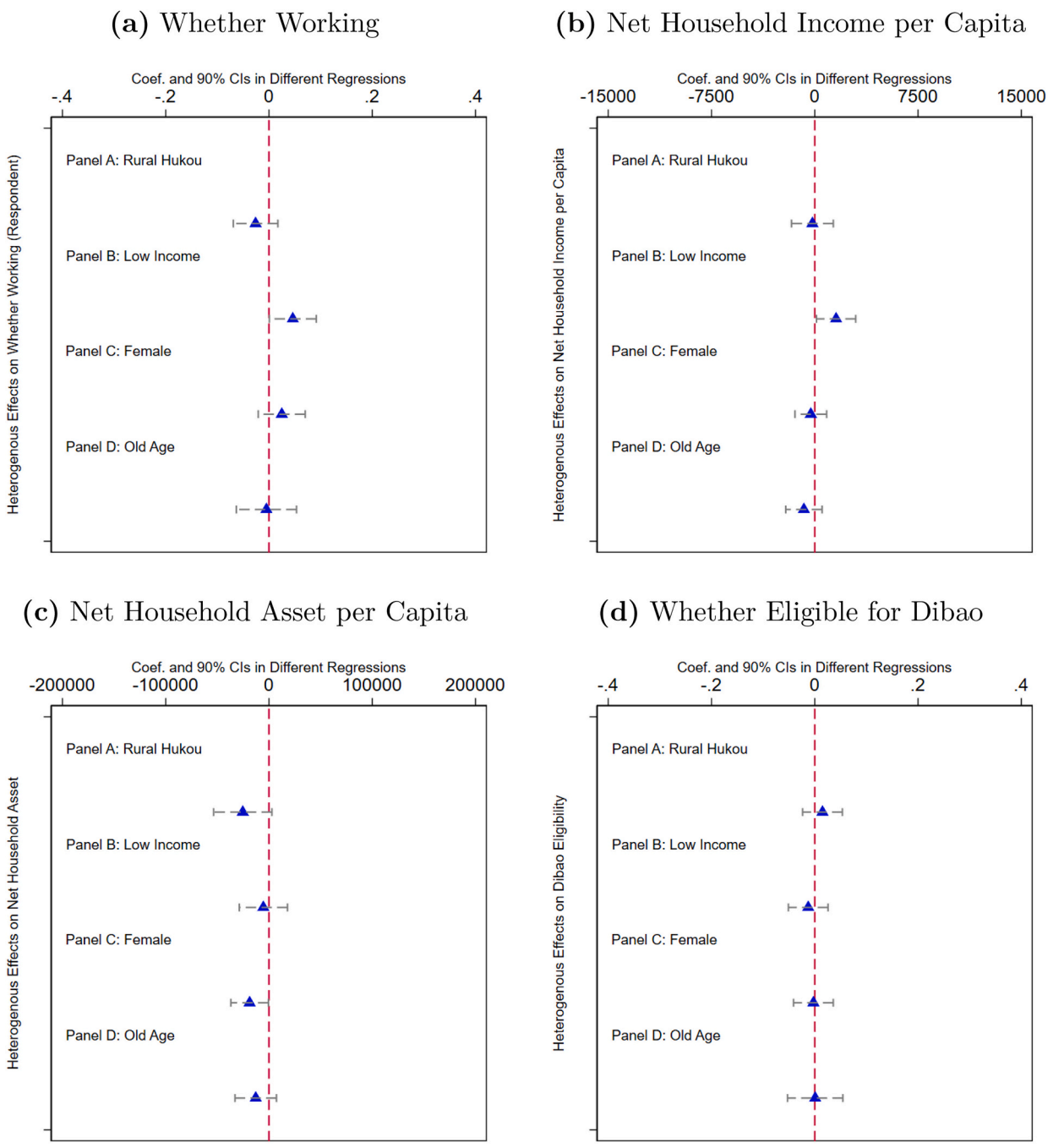

Fig. B5. Heterogeneous effects of the health shock on income, asset, and poverty status.

Notes: This figure presents the differences on the effects of health shocks on variouse kinds of outcomes between households with different characteristics. Regression equation is specified in Eq. 3 and the sample is the same as in baseline Table 3. For each dimension of heterogeneity, we plot the coefficient estimate of β_2 in Eq. 3 and its 90% confidence interval. Low income dummy is defined as one of pre-shock household income per capita is below the sample mean. Retirement age is set as 65 for male and 60 for female for the urban households. Old age dummy is defined as one if pre-shock age of the respondent is over 60.

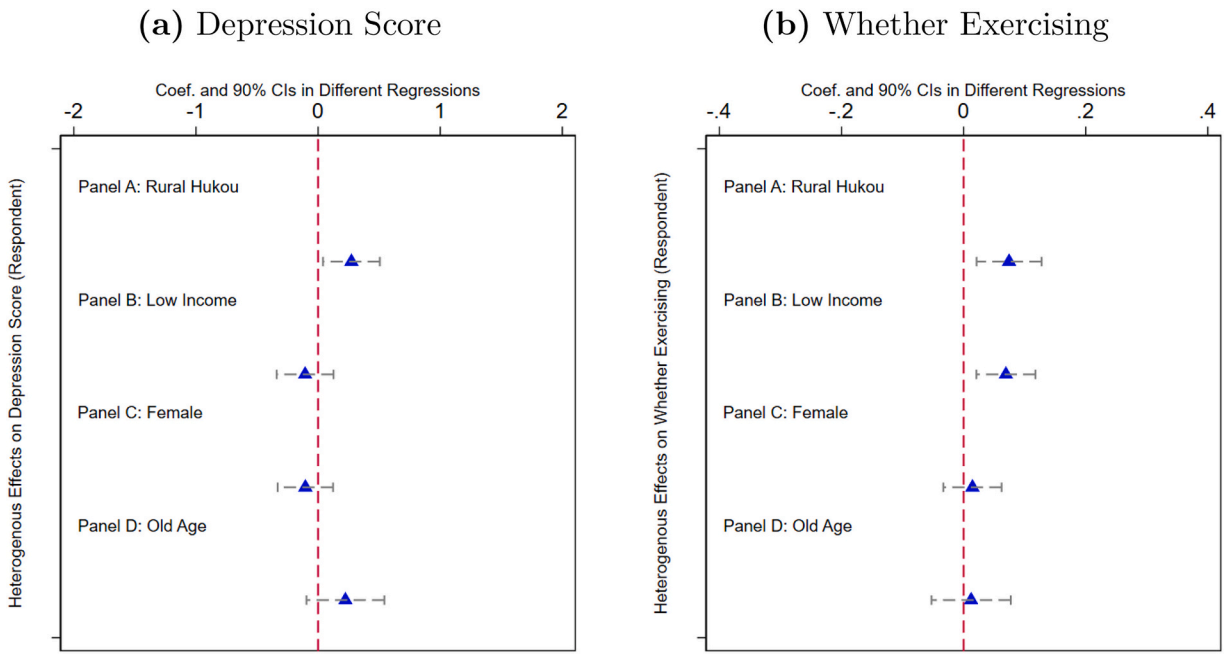

Fig. B6. Heterogeneous effects of the health shock on mental health and health behaviors.
Notes: This figure presents the differences on the effects of health shocks on variouse kinds of outcomes between households with different characteristics. Regression equation is specified in Eq. 3 and the sample is the same as in baseline Table 3. For each dimension of heterogeneity, we plot the coefficient estimate of β_2 in Eq. 3 and its 90% confidence interval. Low income dummy is defined as one of pre-shock household income per capita is below the sample mean. Retirement age is set as 65 for male and 60 for female for the urban households. Old age dummy is defined as one if pre-shock age of the respondent is over 60.

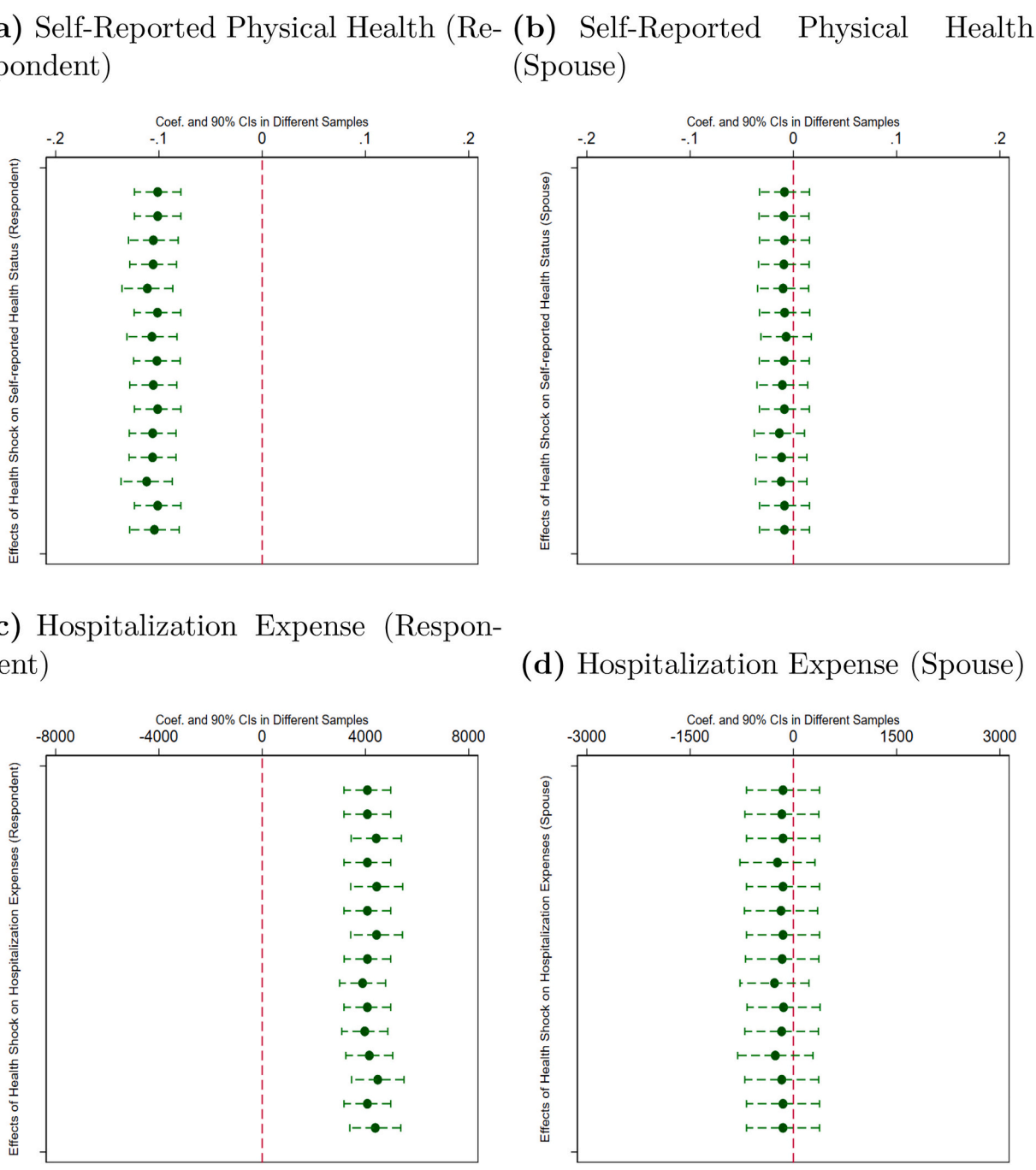

Fig. B7. Robustness checks on exclusions of missing values.

Notes: This *figure* presents estimated coefficient of interest in Eq. 1 by restricting the estimation sample to a balanced panel for each dependent variable. The estimations are based on the baseline sample and 14 alternative samples: including (1) sample with respondent's self-reported health status nonmissing, (2) sample with spouse's self-reported health status nonmissing, (3) sample with respondent's hospitalization expenses nonmissing, (4) sample with spouse's hospitalization expenses nonmissing, (5) sample with respondent's labor market participation nonmissing, (6) sample with spouse's labor market participation nonmissing, (7) sample with net household income per capita nonmissing, (8) sample with net household asset per capita nonmissing, (9) sample with whether having dibao nonmissing, (10) sample with whether eligible for dibao nonmissing. (11) sample with respondent's depression score nonmissing, (12) sample with spouse's depression score nonmissing, (13) sample with respondent's exercise dummy nonmissing, (14) sample with spouse's exercise dummy nonmissing. For each estimation, we plot the coefficient estimate of β_1 in Eq. 1 and its 90% confidence interval.

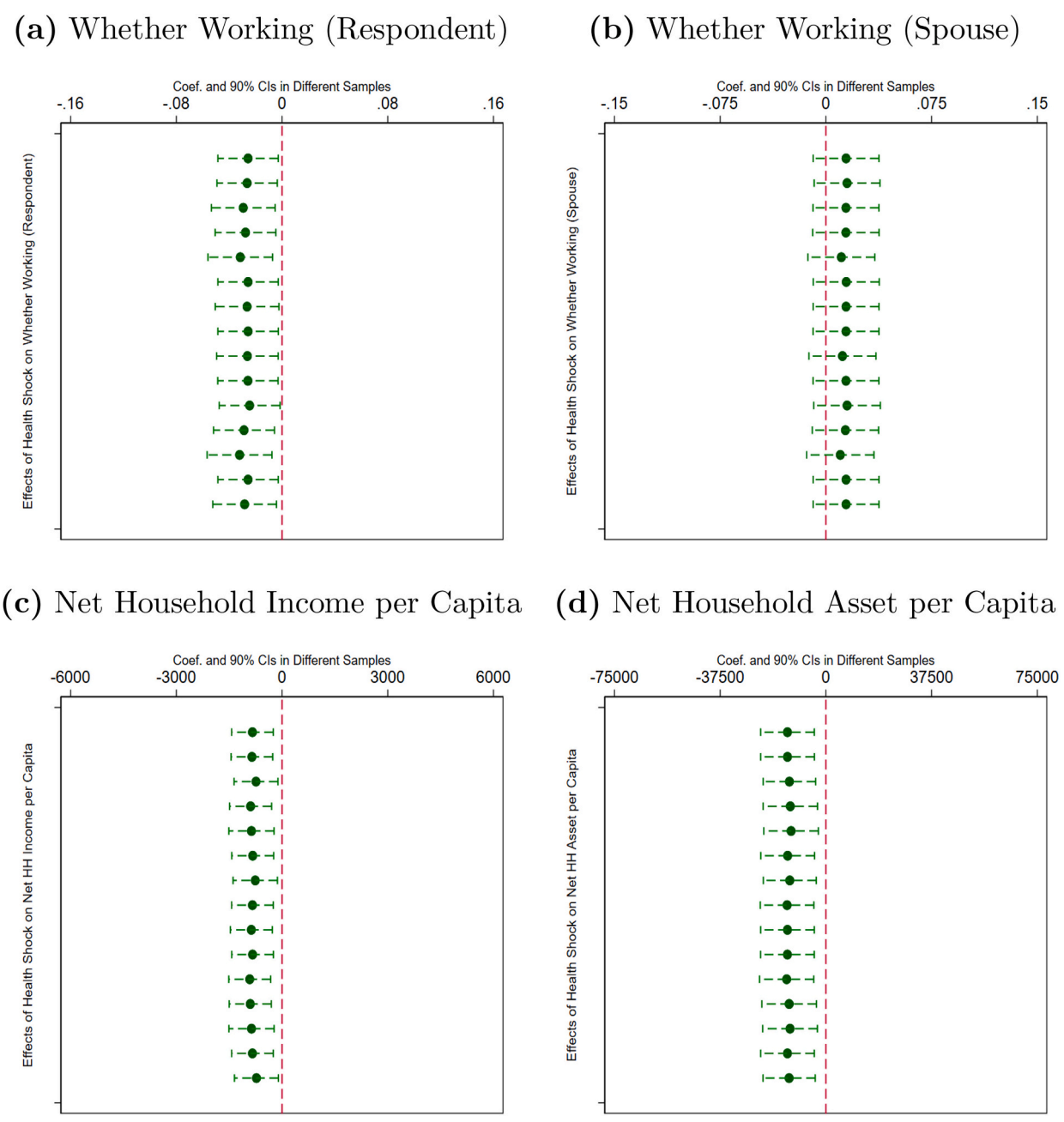

Fig. B8. Robustness checks on exclusions of missing values (cont.)

Notes: This *figure* presents estimated coefficient of interest in Eq. 1 by restricting the estimation sample to a balanced panel for each dependent variable. The estimations are based on the baseline sample and 14 alternative samples. See figure notes in Appendix Fig. B7 for the construction of alternative samples. For each estimation, we plot the coefficient estimate of β_1 in Eq. 1 and its 90% confidence interval.

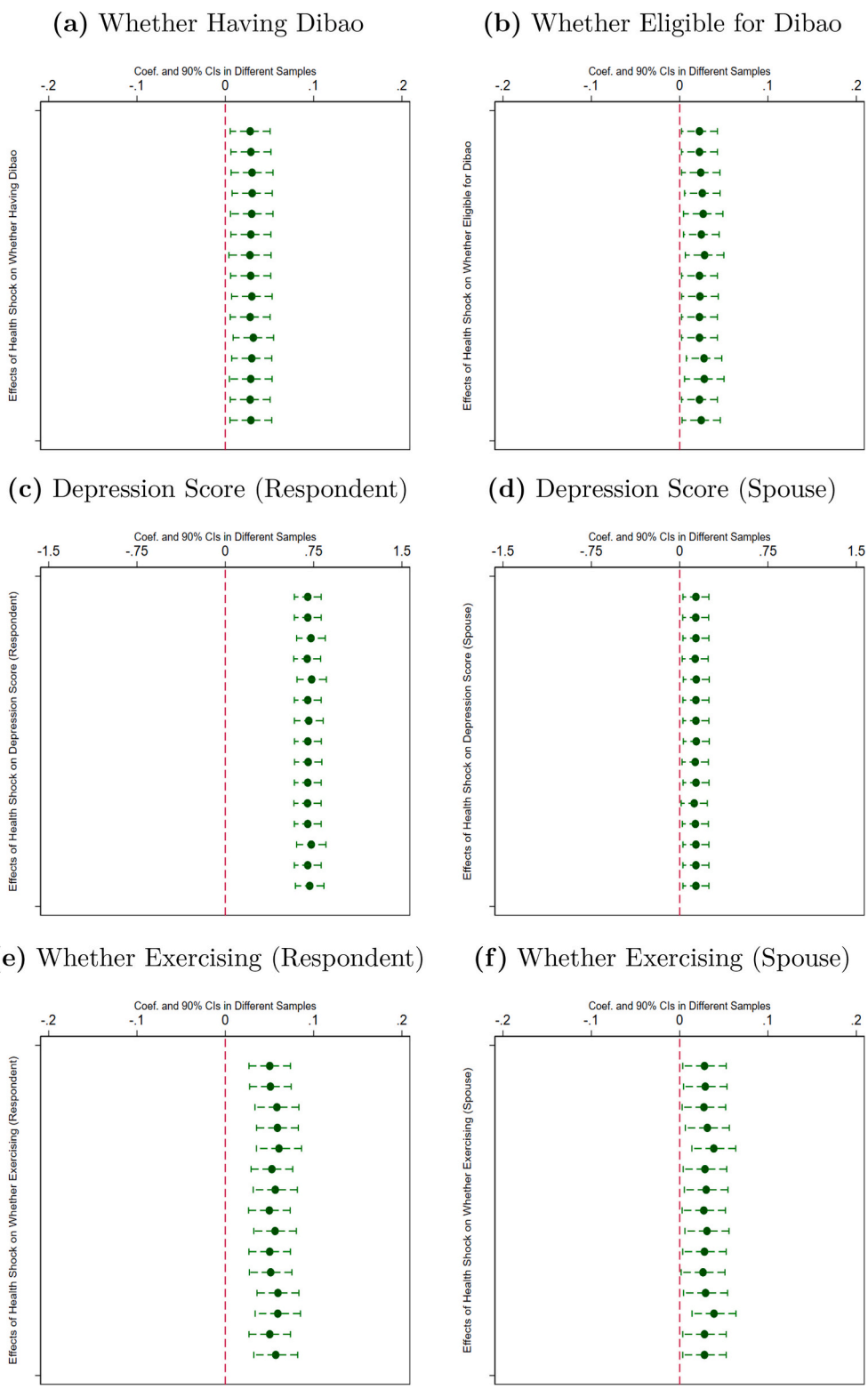

Fig. B9. Robustness checks on exclusions of missing values (cont.)
Notes: This figure presents estimated coefficient of interest in Eq. 1 by restricting the estimation sample to a balanced panel for each dependent variable. The estimations are based on the baseline sample and 14 alternative samples. See figure notes in Appendix Fig. B7 for the construction of alternative samples. For each estimation, we plot the coefficient estimate of β_1 in Eq. 1 and its 90% confidence interval.

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