

Identifying vulnerability to poverty and its determinants among older adults in empty-nest households: an empirical analysis from rural Shandong Province, China

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Abstract

Although extreme poverty has been eradicated in China, older adults in empty-nest households may risk falling into or returning to poverty in the future. Previous studies on poverty alleviation had focused on the measurement of ex-post poverty at a particular time. Few studies have assessed households' vulnerability to poverty from a forward-looking perspective. This study aims to identify the vulnerability to poverty and its determinants among rural empty-nest households with older adults. A total of 1951 rural empty-nest households with older adults followed for 1 year were included in the analysis. The three-stage Feasible Generalized Least Square method was used to estimate the vulnerability to poverty in 2019 and 2020. A regression model was used to explore the effect of different factors on vulnerability to poverty, and Shapley values were used to decompose each factor's contribution and the attributable percentage. With the increase of the poverty threshold, the success rate of predicting poverty status in 2020 based on poverty vulnerability in 2019 increased from 33.00% to 63.71%. Regardless of the poverty threshold, the vulnerability to poverty incidence decreased from 2019 to 2020. For example, under the Shandong province poverty line, the estimated proportion of rural empty-nest households with older adults vulnerable to poverty had decreased from 15.63% in 2019 to 11.17% in 2020. The Shapley decomposition results suggested that the number of the household labour force, the interviewees' education and age and household size were the four most influential factors that contributed significantly to the poverty vulnerability. This study reveals that a portion of rural empty-nest households with older adults are still vulnerable to poverty. The formulation of future anti-poverty policies should prioritize these groups and adopt targeted poverty prevention and poverty alleviation measures based on the driving factors of poverty vulnerability among rural empty-nest households with older adults.

Keywords: Vulnerable to poverty, empty-nest households with older adults, panel data, Shapley decomposition, China

Key messages

- A portion of rural empty-nest households with older adults are still vulnerable to poverty.
- The number of the household labour force, the interviewees' education and age and household size were the four most influential factors that contributed significantly to the vulnerability to poverty among rural empty-nest households with older adults.
- In developing future anti-poverty policies after poverty eradication, we can use the vulnerability to poverty indicators to identify groups that may fall into poverty to adopt targeted ex-ante poverty reduction interventions to eliminate poverty fundamentally.

Introduction

Eliminating poverty is one of the world's greatest challenges (Liu *et al.*, 2020). The first goal of the 17 Sustainable Development Goals set by the United Nations is to end poverty in all its forms from everywhere by 2030. As a developing country that once had the largest rural poor population globally, poverty is of particular concern in China (Liu *et al.*, 2018). Since the reform and opening-up policies in 1978, China has made great strides in poverty alleviation, lifting more than 700 million people out of poverty, and becoming the first developing country to achieve the Millennium Development Goal for poverty reduction in 2015, making a great contribution (more than 70%) to the global poverty alleviation (Wang and Zhou, 2020). China's success in poverty reduction is largely due to the implementation of large-scale anti-poverty programmes,

which have been divided into four stages, including relief-type poverty alleviation (1978–85); development-oriented poverty alleviation (1986–2000); consolidation-oriented comprehensive poverty alleviation (2001–12) and targeted poverty alleviation (TPA, 2013–20) (Guo *et al.*, 2019). Among them, the implementation of the fourth stage TPA programmes has reduced the number of rural poor people from 98.99 million in 2013 to zero in 2020, and all transitioned 832 poverty-stricken counties and 128 000 impoverished villages got rid of poverty (Zhang, 2021; Nong *et al.*, 2021). By the end of 2020, China has achieved the goal of completely eradicating extreme poverty the current poverty.

Although poverty has been eradicated in China, poverty is dynamic, and the current non-poor status does not mean that it will sustain itself in the future. Some non-poor households/individuals may slip into poverty due to job losses, health problems and other unexpected shocks (Zhang and Wan, 2008). In Spain, a study revealed that around a quarter of households who managed to lift themselves out of poverty returned to poverty within 3–6 months (Cantó, 2002). Using data from 1968 to 2003, Stevens found that 36% of individuals who had grown out of poverty in the USA returned to poverty within 4 years (Stevens, 2012). A recent study conducted in China showed that, due to the COVID-19 pandemic, 23% of households who had been lifted out of poverty since 2013 reported that they are possible to fall back into poverty, and 7.1% of households who have never been poor reported that they would possibly slip into poverty (Luo *et al.*, 2020).

With the increasing ageing population in China, empty-nest older adults are on the rise, which are expected to account for around 90% of the total older adults population by 2030, and the vast majority of them live in rural areas (Zhang *et al.*, 2019). Rural empty-nest older adults are defined as rural older adults aged ≥ 60 years who have no children or whose children have already left home for over a half year in this study (Zhou *et al.*, 2015). As a vulnerable group, rural empty-nest older adults have lower economic status, limited sources of income and a higher prevalence of chronic illness than their counterparts (Jing *et al.*, 2021; Liu and Guo, 2008), which makes this subpopulation risk falling into poverty or returning to poverty in the future. However, previous poverty alleviation studies on empty-nest older adults mainly focused on measuring ex-post poverty at a particular time, few studies have considered the future welfare of households and predicated ex-ante poverty (Abebe, 2016; Haq, 2015).

To sustain the accomplishments in poverty alleviation and prevent rural empty-nest households with older adults from falling into poverty in China, it is necessary to assess households' vulnerability to poverty and further explore the main determinants of vulnerability to poverty from the forward-looking perspective. Poverty vulnerability was firstly proposed by the World Bank, which was defined as the probability of a household becoming poor or poorer in the future (World Bank, 2000). Measuring vulnerability to poverty and exploring its determinants is of great relevance for formulating anti-poverty policies and reducing the cost of poverty reduction. Thus, this study addresses the following two research questions: (a) what is the current status of poverty vulnerability among rural empty-nest households with older adults? (b) What are the most

influential factors in livelihood capital contributing significantly to poverty vulnerability among rural empty-nest households with older adults?

Theoretical analysis

Poverty vulnerability in rural empty-nest households with older adults will be influenced by a variety of uncertain factors, and the Sustainable Livelihoods Approach (SLA) framework is used to identify the external and internal factors that affect household socio-economic survival (Sricharoen, 2019). The most typical SLA framework was proposed by the UK Department for International Development (DFID) (DfID, 1999). The core component of the SLA framework is livelihood capital, which reflects the livelihood resources available to the family from multiple dimensions and more comprehensively reflects the ability of farmers to cope with risks. Under the SLA framework, the livelihood capital is divided into five dimensions: natural capital, physical capital, financial capital, social capital and human capital. Previous studies have found that some livelihood capital indicators can increase the poverty vulnerability while others can reduce the poverty vulnerability. Thus, to answer the above questions, this study is based on the SLA framework to examine what are the most influential factors in livelihood capital contributing significantly to poverty vulnerability among rural empty-nest households with older adults.

Methods

Study design and sample

This study used the data from the 2019 and 2020 Shandong Rural Elderly Health Cohort survey, a representative survey of rural older adults aged ≥ 60 years. The selection of respondents in the baseline survey conducted in May 2019 was based on the multistage stratified random sample method. To be specific, first, three counties (one above the medium economic level, one at the medium economic level and one below the medium economic level) were randomly selected from all counties in Shandong province, based on the Gross Domestic Product per capita in 2018; second, we randomly selected five townships from each sample rural county; third, we randomly selected four villages from each sample township and then randomly selected the respondents from rural older adults aged or over 60 years old by using village resident registry (including the residents' contacts in each village). More details about data collection are described elsewhere (Jing *et al.*, 2020; Wang *et al.*, 2021). A total of 3 rural counties, 15 towns, 60 villages and 3600 rural older adults were recruited in the baseline survey, of which 3243 rural older adults had complete and valid data. In total, 2785 rural older adults from the baseline survey were follow-up in August 2020, of which 2288 were rural empty-nest older adults. Our analysis in this study mainly focuses on the rural empty-nest households with older adults. Thus we first excluded 93 respondents whose empty-nest status was inconsistent between the two surveys, then excluded 244 respondents who belonged to the same households. Finally, 1951 rural empty-nest households were included in the analysis.

All respondents in both surveys were interviewed face-to-face by trained interviewers using a standardized questionnaire. To ensure data quality, a coordinator was designated

in each sampled county to monitor the investigation process. After completing the daily investigation process, the logic, completeness and accuracy of the questionnaire underwent a thorough review by the coordinators.

Measurement

Vulnerability to poverty

Through summarizing the previous literature, it is found that there are three principal methods for measuring vulnerability to poverty, namely: vulnerability as uninsured exposure to risk (VER), vulnerability as low expected utility (VEU) and vulnerability as expected poverty (VEP). Unlike the VEU and VEP methods, VER is an ex-post assessment of the extent of welfare loss caused by a negative shock, rather than a predictive tool of future poverty. Unlike the VEP methods, the VEU method is difficult to calculate and requires panel data with sufficient length. As the most commonly used method, the VEP method has good applicability to cross-sectional and short panel data and conducts an ex-ante assessment of future poverty. To be consistent with the purpose of this study, we adopted the VEP method.

Based on VEP, the vulnerability of a household at time t is defined as the probability of a household's consumption level being below the poverty line z at time $t + 1$ (Chaudhuri, 2003). It was written as follows:

$$v_{ht} = \Pr(\ln C_{h,t+1} < \ln z)$$

where z is the poverty line, under which a household is considered poor.

The method assumes that a household's consumption is determined by household characteristics, it was given as follows:

$$\ln C_{ht} = X_h \beta + \varepsilon_h$$

where $\ln C_{ht}$ is the logarithm of per capita household consumption, X_h is a vector of household characteristics and householder characteristics and ε_h is the error term with zero mean. Also, C_{ht} is assumed to have a lognormal distribution. It is also assumed that the variance of the disturbance is written as follows:

$$\sigma_{\varepsilon,h}^2 = X_h \theta$$

To solve the heteroscedasticity of the cross-sectional data, we further use the three-stage Feasible Generalized Least Square (FGLS) method proposed by Amemiya to estimate β and θ (Amemiya, 1977).

Based on the β and θ , we can estimate the expected log consumption and the variance of log consumption for each household, it was given as follows:

$$\hat{E}[\ln C_h | X_h] = X_h \hat{\beta}$$

$$\hat{V}[\ln C_h | X_h] = X_h \hat{\theta}$$

Assuming that the consumption is normally distributed and $\Phi(\cdot)$ represents the cumulative density function of the

standard normal distribution; the estimated vulnerability to poverty is given as follows:

$$\widehat{V}_{ht} = \hat{Pr}\left(\ln C_h < \frac{\ln z}{X_i}\right) = \Phi\left(\frac{\ln z - X_h \hat{\beta}}{\sqrt{X_h \hat{\theta}}}\right)$$

In particular, we selected the log per capita household income rather than log per capita household consumption to estimate the vulnerability to poverty, the reason lies in two facets: one is that household income data in our survey is more detailed and reliable than consumption data and the other is that previous studies on poverty in China mainly focused on income poverty (Imai *et al.*, 2010).

The selection of the poverty line and vulnerability to poverty threshold can influence the accuracy of poverty vulnerability prediction. Regarding the poverty line, for the robustness of the results, we selected three poverty lines: the US\$1.9 per person per day international poverty line, the US\$2.4 per person per day Shandong Province poverty line and the US\$3.2 per person per day international poverty line. For easy presentation and interpretation of the results, we label US\$1.9 per capita per day, US\$2.4 per capita per day (Shandong poverty line) and US\$3 per capita per day as poverty line 1, poverty line 2 and poverty line 3, respectively. For the threshold of vulnerability to poverty, a household is considered vulnerable when its probability of falling into poverty in the future is higher than the set vulnerability to the poverty threshold. A vulnerability to poverty threshold of 0.5 has been used as a reasonable threshold with reliable prediction in previous studies (Zhang and Wan, 2006; 2008), and the advantage of this threshold is that if a household with a current consumption/income level is equal to the poverty line and faces a zero-average shock, then it has a vulnerability to poverty of 0.5, thus we adopted this threshold.

Main variables

Based on the SLA framework, combined with the questionnaire used in the survey, the livelihood capital in this study was measured from the dimensions of physical capital, financial capital, social capital and human capital. Among these, physical capital was measured by cooking fuels, toilets and housing areas. Social capital was measured by the time since being empty-nest; living arrangement and the number of children. Financial capital was measured by registered poor households. Human capital was measured by household size, the number of the household labour force, the number of chronic disease patients, education of the interviewee, age of the interviewee; inpatient service utilization of the interviewee and catastrophic health expenditure. [Supplementary Table 1](#) shows the definition of main variables.

Statistical analysis

First, we describe the basic characteristics of older adults in rural empty-nest households with mean values (standard deviation) or frequencies (percentage). Second, following the VEP method mentioned above, a three-stage FGLS model was used to estimate the vulnerability to poverty of rural empty-nest households with older adults in 2019 and 2020. Meanwhile, a poverty transition matrix was used to test the accuracy of poverty vulnerability prediction by comparing poverty vulnerability incidence in 2019 with the actual poverty incidence

in 2020. Third, based on the application of the Shapley decomposition method in previous poverty studies (Fang and Zhang, 2021; Xiang *et al.*, 2021), this study adopted this method to decompose the contributions of livelihood capital factors to vulnerability to poverty. The Shapley values can be used to decompose the indicator based on the regression model, which can not only investigate which factors influence the dependent variable but also quantify the contribution of these factors to the dependent variable. In this study, Shapley decomposition mainly included two steps: (1) Ordinary Least Square (OLS) regression model was used to explore the effect of different factors on vulnerability to poverty; (2) based on the OLS regression model results, we used the Shapley2 command in Stata software (Wendelspiess Chávez Juárez, 2015) to decompose the contribution and contribution rate of influencing factors to vulnerability to poverty among the rural empty-nest household with older adults. Stata 14.2 (Stata Corp, College Station, TX, USA) was used for all statistical analyses.

Results

The basic characteristics of rural empty-nest households with older adults

Table 1 shows the characteristics of the respondents' households. Among the 1951 rural empty-nest households with older adults, in 2020, 38.8% of the respondents were illiterate, with a mean age of 71.3 years. About 57.0% of the respondents used firewood for cooking, 56.2% used sanitary toilets, with a typical respondent living in a home of more than 90 square metres. On average, a rural empty-nest household with older adults includes 2.5 children, 1.8 household members and 1 adult labourer. Some variables have changed during the two waves of data collection. From 2019 to 2020, the percentage of living alone increased from 25.2% to 25.7%; the percentage of households in poverty increased from 6.3% to 7.8%; the percentage of patients having chronic disease increased from 89.5% to 95.7% and the percentage of respondents who have used inpatient service reduced from 20.2% to 15.9%.

Vulnerability to poverty among rural empty-nest households with older adults and its prediction accuracy

We estimated the variance of the error term based on the logarithm of household income per capita using VEP and FGLS methods (Results shown in Supplementary Table 2). The first three columns of Table 2 present the vulnerability to poverty incidence in 2019 and 2020. The incidence rate of vulnerability to poverty among rural empty-nest households decreased over time and increased as we increase the poverty threshold. Specifically, from 2019 to 2020, the vulnerability to poverty incidence decreased from 3.18% to 1.90% with poverty line 1; from 15.63% to 11.17% with poverty line 2 and from 43.11% to 39.98% with poverty line 3. Furthermore, to assess the accuracy of the vulnerability to poverty prediction, we compare the estimated poverty vulnerability in 2019 with the accurate poverty in 2020. The last three columns of Table 2 present the success rate of predicting poverty status in 2020 based on poverty vulnerability in 2019. Under poverty lines 1, 2 and 3, the success rate was 33.00%, 53.11% and 63.71%, respectively.

Table 1. Basic characteristics of the empty-nest elderly household in rural Shandong, China in 2019 and 2020

Characteristics	2019, N (%)	2020, N (%)
Types of cooking fuels		
Gas	481(24.6)	480(25.1)
Electricity	347(17.8)	349(17.9)
Firewood	1123(57.6)	1113(57.0)
Types of toilets		
No toilet	18(0.9)	18(0.9)
Sanitary toilet	1090(55.9)	1097(56.2)
Dry latrine	843(43.2)	836(42.9)
Housing area (m ²), Mean \pm SD	94.9 \pm 49.1	94.7 \pm 50.1
Time since being empty-nest (Years), Mean \pm SD	16.8 \pm 9.9	18.5 \pm 10.3
Living arrangement		
Living alone	491(25.2)	502(25.7)
Living with spouse	1324(67.8)	1309(67.1)
Living with others	136(7.0)	140(7.2)
The number of children, Mean \pm SD	2.5 \pm 1.11	2.5 \pm 1.11
Registered poor household		
Yes	123(6.3)	152(7.8)
No	1828(93.7)	1799(92.2)
Household size, Mean \pm SD	1.8 \pm 0.6	1.8 \pm 0.6
The number of the household labour force, Mean \pm SD	1.1 \pm 0.9	1.0 \pm 0.9
Number of chronic disease patients		
0	205(10.5)	83(4.3)
1	1075(55.1)	1109(56.8)
≥ 2	671(34.4)	759(38.9)
Education attainment of the interviewee		
Illiteracy	757(38.8)	757(38.8)
Primary school	786(40.3)	786(40.3)
Junior school	302(15.5)	302(15.5)
High school and above	106(5.4)	106(5.4)
The age of the interviewee, Mean \pm SD	70.3 \pm 6.1	71.3 \pm 6.1
Inpatient service utilization of the interviewee		
Yes	393(20.2)	310(15.9)
No	1558(79.8)	1641(84.1)

Determinants of vulnerability to poverty among rural empty-nest households with older adults

The determinants of vulnerability to poverty in 2019 and 2020 are shown in Tables 3 and 4, respectively. The regression results in 2019 and 2020 show that regardless of the poverty threshold, cooking fuel types (electricity/firewood compared with gas), household size, catastrophic health expenditure and the age of the interviewee significantly increased households' vulnerability to poverty; and toilet types (sanitary toilet/dry latrine compared with no toilet), time since being empty-nest, the number of the household labour force and the number of chronic disease patients significantly decreased households' vulnerability to poverty. In addition, the non-registered poor households significantly decreased households' vulnerability to poverty with the poverty line 3.

Shapley decomposition of determinants of vulnerability to poverty

The Shapley decomposition result in Table 5 shows the differential role of different influencing factors in poverty vulnerability. Regardless of the poverty line, the number of the household labour force, the respondents' education, the respondents' age and household size are the main contributing factors in 2019 and 2020. For example, under the poverty line

Table 2. The vulnerability to poverty incidence among rural empty-nest elderly households and its comparison with the actual poverty incidence

Poverty line	2019	2020	2019	2020	
				Poor ^a	Non-poor ^b
Poverty line 1	3.18%	1.90%	Vulnerability	33.00%	67.00%
			Non-vulnerability	29.44%	70.56%
Poverty line 2	15.63%	11.17%	Vulnerability	53.11%	46.89%
			Non-vulnerability	29.77%	70.23%
Poverty line 3	43.11%	39.98%	Vulnerability	63.71%	36.29%
			Non-vulnerability	37.22%	62.78%

Note: ^aThe household is regarded as poor if their income is lower than the set poverty line.

^bThe household is regarded as non-poor if their income is higher than the set poverty line.

Table 3. The determinants of vulnerability to poverty among empty-nest elderly household in rural Shandong, China, 2019

Characteristics	Poverty line 1		Poverty line 2		Poverty line 3	
	Coefficient	SD	Coefficient	SD	Coefficient	SD
Types of cooking fuels	0.022***	0.001	0.035***	0.001	0.042***	0.001
Types of toilets	-0.035***	0.003	-0.067***	0.003	-0.101***	0.002
Housing area	-0.0002***	0.00003	-0.0002***	0.00003	-0.00001**	0.00003
Time since being empty-nest	-0.027***	0.002	-0.033***	0.002	-0.030***	0.002
Living arrangement	-0.007	0.007	-0.011	0.008	-0.027***	0.006
The number of children	0.004***	0.001	0.015***	0.002	0.024***	0.001
Non-registered poor household	0.019***	0.002	0.014***	0.002	-0.011**	0.002
Household size	0.153***	0.006	0.192***	0.006	0.197***	0.005
The number of the household labour force	-0.083***	0.002	-0.113***	0.002	-0.117***	0.002
Number of chronic disease patients	-0.031***	0.002	-0.041***	0.003	-0.038***	0.002
Catastrophic health expenditure	0.028***	0.003	0.048***	0.003	0.061***	0.003
Education of the interviewee	-0.045***	0.001	-0.078***	0.001	-0.107***	0.001
The age of the interviewee	0.097***	0.003	0.149***	0.003	0.182***	0.003
Inpatient service utilization of the interviewee	-0.087**	0.004	-0.020**	0.004	-0.033***	0.003

Note: **significant at 5%;

***significant at 1%.

1, the number of the household labour force, education, age and household size contributes 0.2449, 0.1484, 0.1471 and 0.0938 to the vulnerability to poverty, which accounted for 30.1%, 18.3%, 18.3% and 11.5% of vulnerability to poverty in 2020. In addition, the education of the respondent is much more important as a determinant of vulnerability for poverty line 3 than for poverty lines 1 and 2, whereas household size has a much weaker role for poverty lines 2 and 3 than for poverty line 1.

Discussion

Although China has eradicated extreme poverty, vulnerability to poverty, as a predictor of future poverty, provides critical new insight into the consolidation and expansion of the poverty alleviation accomplishments. To our knowledge, this study is the first to analyse vulnerability to poverty among rural empty-nest households with older adults in China. We found that, with increasing poverty threshold, the success rate of predicting poverty status in 2020 based on poverty vulnerability in 2019 increased from 33.00% to 63.71%. This finding provides evidence of the predictive power of the poverty vulnerability indicator for future poverty status among rural empty-nest families with older adults. In developing future anti-poverty policies after poverty eradication, we can use the vulnerability to poverty indicators to identify groups that may fall into poverty to adopt targeted

ex-ante poverty reduction interventions to eliminate poverty fundamentally.

This study showed that regardless of the poverty threshold, the vulnerability to poverty incidence decreased over time. For example, under the poverty line 2, the estimated proportion of rural empty-nest households with older adults vulnerable to poverty had decreased from 15.63% in 2019 to 11.17% in 2020. Under the poverty line 1, the vulnerability to poverty incidence (3.18%) in this study was much lower than the 16.57% of rural households in a study based on the data from the 2013 China Household Income Survey (Li, 2020) or the 10.5% of farmer households in the 2015 China Household Finance Survey data (Sun *et al.*, 2020). Also, the vulnerability to poverty incidence under any poverty threshold in the present study was lower than 56% of households in Ghana (Novignon *et al.*, 2012). The low vulnerability to poverty incidence in this study compared with other studies and its decreasing trends may be related to implementing a series of poverty reduction strategies in China. In particular, the TPA strategy implemented in 2013 has enabled the scale of poverty reduction to reach an average of more than 10 million persons per year, accelerating the global poverty reduction. To be specific, the TPA strategy built up electronic archives for each poor household to record their progress in poverty reduction and adopted, categorized and targeted anti-poverty measures to help them get out of poverty, such as supporting the poor households who have the ability to work to develop

Table 4. The determinants of vulnerability to poverty among empty-nest elderly household in rural Shandong, China, 2020

Characteristics	Poverty line 1		Poverty line 2		Poverty line 3	
	Coefficient	SD	Coefficient	SD	Coefficient	SD
Types of cooking fuels	0.020***	0.001	0.032***	0.001	0.039***	0.001
Types of toilets	-0.014***	0.003	-0.035***	0.003	-0.063***	0.002
Housing area	0.0003***	0.00003	0.0005***	0.00003	0.0007***	0.00002
Time since being empty-nest	-0.028***	0.002	-0.040***	0.002	-0.045***	0.002
Living arrangement	-0.038***	0.006	-0.041***	0.007	-0.038***	0.005
The number of children	-0.006***	0.001	-0.0008	0.001	0.009***	0.001
Non-registered poor household	-0.002	0.002	-0.014***	0.002	-0.032***	0.001
Household size	-0.152***	0.005	0.198***	0.006	0.207***	0.004
The number of the household labour force	-0.078***	0.002	-0.115***	0.002	-0.134***	0.001
Number of chronic disease patients	-0.038***	0.001	-0.050***	0.003	-0.060***	0.002
Catastrophic health expenditure	0.039***	0.003	0.051***	0.003	0.060***	0.002
Education of the interviewee	-0.038***	0.001	-0.066***	0.001	-0.096***	0.001
The age of the interviewee	0.104***	0.003	0.158***	0.003	0.190***	0.002
Inpatient service utilization of the interviewee	0.037***	0.004	0.047***	0.004	0.059***	0.003

Note: **significant at 5%;

***significant at 1%.

their industries to increase household income (e.g. the implementation of large-scale solar photovoltaic poverty alleviation project implemented in Shandong province has provided job and income-generating opportunities for poor households to alleviate poverty, benefiting 326 000 poor households during the 13th Five-Year Plan); improve financial risk protection for rural households by reducing the out-of-pocket medical expenditure and helping the physically disabled and social groups with special difficulties out of poverty through the guarantee of social security. Implementing these poverty alleviation strategies has improved the ability to grow economically and prepare for risk shocks among poor rural households. It thus not only reduces the incidence of poverty but also the likelihood of falling into poverty in the future.

Nonetheless, China's accomplishments in poverty eradication do not mean the elimination of poverty risk. Notably, we found that 11.17% (Shandong Province poverty line) of rural empty-nest households with older adults may fall into poverty in 2021. This is because rural empty-nest older adults face the multiple challenges of increased disease risk, diminished income and reduced family support (Wang and Zhao, 2011; Zhang *et al.*, 2020), thus lack the ability to weather through risk shocks and are more vulnerable to poverty.

The Shapley decomposition suggested that the number of the household labour force, the education and age of the interviewee and household size were the four most influential factors contributing significantly to the vulnerability to poverty among rural empty-nest households with older adults. For family characteristics, we found the number of the household labour force significantly decreased the vulnerability to poverty among rural empty-nest households with older adults. Previous studies have indicated that labour force participation positively affects improving welfare and reducing poverty (Saifuloh *et al.*, 2019). More household labour force means more income and more savings generated, which enhances the household's ability to resist risk shocks and reduces the likelihood of poverty vulnerability. Another plausible explanation was the 'healthy worker effect,' i.e. the healthy rural empty-nest older adults were more likely to be employed (Thygesen *et al.*, 2011). The large household size significantly

increased the vulnerability to poverty of the households. Similar results have been found in some developing countries such as Ghana, Congo and Nigeria (Agbaje *et al.*, 2013; Novignon *et al.*, 2012; Ouadika and Blanchard, 2020). This finding can be attributed to the negative effect of household size on household consumption and welfare. As previous studies have demonstrated that there was a positive relationship between household size and poverty (Anyanwu, 2014; Rahman, 2013), a large household size dilutes the per capita consumption of the household and increases the possibility of the household being poor (Khan *et al.*, 2015).

Furthermore, we found that the high level of education of the interviewee reduced the vulnerability to poverty of the households, which was consistent with previous studies (Ouadika and Blanchard, 2020). This finding can be attributed to the important role of education in increasing income and coping with shocks (Demissie and Kasie, 2017). On the one hand, education not only provides people with the necessary skill base to increase the value and efficiency of the labour force, ultimately enabling people to engage in more remunerative jobs (Atake, 2018); on the other hand, education plays an important role in developing the knowledge and values that enable people to better cope with risks and unexpected shocks (Li, 2020). Our study also found that the education of the respondent is much more important and household size is much weaker as a determinant of vulnerability for poverty line 3 than for poverty lines 1 and 2. To our knowledge, few studies have examined whether the effect of education/household size on poverty vulnerability varies with the poverty line, and one study using China Family Panel Studies data found that the poverty reduction effect of education was moderated by regional economic status, and the higher the regional economic level, the greater the poverty reduction effect of education (Gao and Wang, 2016). Thus, we speculated that this may be because the marginal effect of education in reducing poverty is larger at high poverty lines, while the opposite is true for household size.

Consistent with previous studies (Demissie and Kasie, 2017), we found that the older the interviewee, the higher the vulnerability to poverty. The possible explanation for this finding is that the physical function of rural empty-nest

Table 5. Decomposition of the determinants of poverty vulnerability among rural empty-nest elderly households in 2019 and 2020

Characteristics	Poverty line 1			Poverty line 2			Poverty line 3		
	2019	2020	Average ^a	2019	2020	Average ^a	2019	2020	Average ^a
Types of cooking fuels	0.0319 (3.9)	0.0302 (3.7)	(3.8)	0.0369 (4.1)	0.0329 (3.6)	(3.9)	0.0358 (3.8)	0.0309 (3.2)	(3.5)
Type of toilets	0.0203 (2.5)	0.0037 (0.5)	(1.5)	0.0343 (3.8)	0.0095 (1.0)	(2.4)	0.0531 (2.6)	0.0200 (2.1)	(2.4)
Housing area	0.0044 (0.5)	0.0165 (2.0)	(1.2)	0.0017 (0.2)	0.0176 (2.0)	(1.1)	0.0003 (0.1)	0.0190 (2.0)	(1.0)
Time since being empty-nest	0.0118 (1.4)	0.0094 (1.2)	(1.3)	0.0071 (0.8)	0.0086 (1.0)	(0.9)	0.0036 (0.4)	0.0068 (0.7)	(0.5)
Living arrangement	0.0639 (7.7)	0.0393 (4.5)	(6.1)	0.0404 (4.5)	0.0301 (3.3)	(3.9)	0.0238 (2.5)	0.0220 (2.3)	(2.4)
The number of children	0.0405 (6.6)	0.0199 (2.5)	(4.6)	0.0602 (6.8)	0.0313 (2.5)	(4.6)	0.0717 (6.1)	0.0433 (2.6)	(4.4)
Registered poor household	0.0077 (0.9)	0.0042 (0.5)	(0.7)	0.0024 (0.3)	0.0104 (1.2)	(0.8)	0.0036 (0.4)	0.0204 (2.1)	(1.2)
Household size	0.1163 (14.0)	0.0938 (11.5)	(12.6)	0.0765 (8.6)	0.0694 (7.7)	(8.2)	0.0469 (5.9)	0.0478 (5.0)	(5.5)
The number of the household labour force	0.0203 (23.9)	0.2449 (30.1)	(27.0)	0.1997 (22.4)	0.2634 (29.2)	(25.8)	0.1788 (20.8)	0.2544 (26.4)	(23.6)
Number of chronic disease patients	0.0107 (1.3)	0.0085 (1.0)	(1.2)	0.0091 (1.0)	0.0092 (1.0)	(1.0)	0.0065 (0.7)	0.0097 (1.0)	(0.8)
Catastrophic health expenditure	0.0142 (1.7)	0.0320 (3.8)	(2.8)	0.0211 (2.4)	0.0336 (3.7)	(3.0)	0.0254 (2.7)	0.0327 (3.4)	(3.0)
Education of the interviewee	0.17261 (20.9)	0.1484 (18.3)	(19.6)	0.2518 (28.2)	0.2110 (23.4)	(25.8)	0.3444 (36.2)	0.2926 (30.3)	(33.3)
Age of the interviewee	0.1201 (14.5)	0.1471 (18.3)	(16.4)	0.1495 (16.7)	0.1693 (18.8)	(17.7)	0.1664 (17.5)	0.1720 (17.8)	(17.7)
Inpatient service utilization of the interviewee	0.0013 (0.2)	0.0172 (2.1)	(1.2)	0.0021 (0.2)	0.0143 (1.6)	(0.9)	0.0032 (0.3)	0.0110 (1.1)	(0.7)

Note: Shapley contribution % in parentheses.

^aThe average of Shapley contribution rate (%) in 2019 and 2020.

older adults gradually declines with age, accompanied by various health problems (e.g. high prevalence of chronic illness, frailty and disability) (Chen *et al.*, 2014; Duba *et al.*, 2012; Prasad *et al.*, 2012), which may lead to a reduction in ability and opportunity to earn income, ultimately increasing the household probability of falling into poverty in the future.

Contrary to our expectations, the more chronic disease patients in rural empty-nest households with older adults, the less vulnerable the household was to poverty. We speculated that chronic patients might not seek treatment due to the lower economic status of their household, thus reducing the household consumption expenditure. As Zhou *et al.* suggested, compared with non-empty-nest older adults, empty-nest older adults had a higher non-use rate of healthcare service, and financial difficulties were the main reason they did not use healthcare services (Zhou *et al.*, 2015), which also confirms our speculation. Our results also indicated that the long time since being empty-nest significantly reduced the vulnerability to poverty, which may be because the economic resources and risk-resilience of older adults in rural empty-nest households tend to stabilize with the increase in the duration of the empty nest.

China's rural minimum living standard guarantee (Dibao) programme is one of the largest social safety-net programme in the world, which provided cash supplements to registered poor households (Golan *et al.*, 2017). However, this study found that registered poor household has a limited effect on poverty vulnerability. Not surprisingly, previous studies have shown similar findings that the Dibao programme did not reduce the poverty vulnerability of rural households but instead may increase the poverty vulnerability of rural households currently in poverty (Sun and Duan, 2020; Xu and Li 2018). This finding might be due to two aspects of reasons. One is the targeting errors in the implementation of the policy, where some households below the poverty line (non-poor households) were beneficiaries of the Dibao programme and vice versa. The other is the Dibao programme may increase beneficiaries' dependence on government cash transfer and reduce labour force participation, thereby causing persistent poverty.

This study has two strengths. First, the use of follow-up data in 2020 can evaluate the success rate of vulnerability to poverty prediction. Another strength is the use of a population-based dataset that provides a sufficient sample size and statistical power to explore the determinant of vulnerability to poverty. Nevertheless, three limitations of our study should be noted. First, the household income/expenditure was self-reported, with the possibility of a recall bias. Second, we only use the two waves of data and cannot fully explore the long-term patterns of the occurrence and dynamic change of vulnerability to poverty. Future studies are needed to analyse the vulnerability to poverty among rural empty-nest households with older adults using data with a sufficient number of waves. Third, the sample of this study was selected from a province, so the main results of this study may not be generalized to other provinces, as there are great differences in economic levels and anti-poverty strategies among provinces.

Policy implications

With the backdrop of population ageing and intense urbanization, empty-nest households with older adults have become a common sight in rural China. Although extreme poverty

has been eradicated in China, our analysis shows that a portion of rural empty-nest households with older adults are still vulnerable to poverty, and therefore, the formulation of future anti-poverty and welfare policies should prioritize these vulnerable groups and adopt targeted poverty prevention and poverty alleviation measures based on the driving factors of poverty vulnerability among rural empty-nest households with older adults. In the short term, first, the government should take diversified measures to increase the obtaining income opportunities for older adults in empty-nest households. Second, policymakers should redesign and optimize the medical insurance system and social safety net assistance programmes, expand their coverage and increase their effectiveness, so as to reduce the economic burden of rural empty-nest households with older adults. In long term, education is the key to poverty reduction, on one hand, the government should provide free educational opportunities for rural older adults. On the other hand, the government should improve the educational attainment and quality of the young generation to promote the accumulation of human capital and reduce the intergeneration transmission of poverty.

Conclusions

This study reveals that a portion of rural empty-nest households with older adults are still vulnerable to poverty. The number of the household labour force, the interviewees' education and age and household size are the four most influential factors contributing significantly to the vulnerability to poverty among rural empty-nest households with older adults. To sustain the poverty alleviation accomplishments and prevent rural empty-nest households with older adults from falling into poverty in China, anti-poverty policies should focus on these groups and use targeted poverty prevention and poverty alleviation measures based on the driving factors of poverty vulnerability among rural empty-nest households with older adults.

Supplementary data

[Supplementary data](#) are available at *Health Policy and Planning* online.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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Author contributions

Study concept and design: C.Z. Data collection: Z.J., J.L., T.G. and Y.W.. Data analysis and interpretation: Z.J. and Y.W.. Drafting the article: Z.J.. Critical revision of the article: C.Z. and Z.C.. All authors read and approved the final manuscript.

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References

- Abebe FE. 2016. Determinants of rural households' vulnerability to poverty in Chench and Abaya districts, Southern Ethiopia (Microeconometric Analysis). *Journal of economics and sustainable development* 7: 41–56.
- Agbaje MA, Okunmadewa FY, Omomona BT, Oni OA. 2013. An assessment of vulnerability to poverty in rural Nigeria. *ARNP Journal of Agricultural and Biological Science* 8: 60–75.
- Amemiya T. 1977. The maximum likelihood and the nonlinear three-stage least squares estimator in the general nonlinear simultaneous equation model. *Econometrica: Journal of the Econometric Society* 45: 955–68.
- Anyanwu JC. 2014. Marital status, household size and poverty in Nigeria: evidence from the 2009/2010 survey data. *African Development Review* 26: 118–37.
- Atake E-H. 2018. Health shocks in Sub-Saharan Africa: are the poor and uninsured households more vulnerable? *Health Economics Review* 8: 1–13.
- Cantó O. 2002. Climbing out of poverty, falling back in: low income stability in Spain. *Applied Economics* 34: 1903–16.
- Chaudhuri S. 2003. *Assessing Vulnerability to Poverty: Concepts, Empirical Methods and Illustrative Examples*. New York: Department of Economics, Columbia University, 56.
- Chen L-J, Chen C-Y, Lue B-H, Tseng M-Y, Wu S-C. 2014. Prevalence and associated factors of frailty among elderly people in Taiwan. *International Journal of Gerontology* 8: 114–9.
- Demissie BS, Kasie TA. 2017. Rural households' vulnerability to poverty in Ethiopia. *Journal of Poverty* 21: 528–42.
- DfID UK. 1999. *Sustainable Livelihoods Guidance Sheets*. London: DFID, 445.
- Duba AS, Rajkumar AP, Prince M, Jacob KS. 2012. Determinants of disability among the elderly population in a rural south Indian community: the need to study local issues and contexts. *International Psychogeriatrics* 24: 333–41.
- Fang Y, Zhang F. 2021. The future path to China's poverty reduction—dynamic decomposition analysis with the evolution of china's poverty reduction policies. *Social Indicators Research* 158: 507–38.
- Gao Y, Wang X. 2016. Research on the heterogeneity of education effect on poverty reduction. *Statistical Research* 33: 70–7.
- Golan J, Sicular T, Umapathi N. 2017. Unconditional cash transfers in China: who benefits from the rural minimum living standard guarantee (Dibao) program? *World Development* 93: 316–36.
- Guo Y, Zhou Y, Liu Y. 2019. Targeted poverty alleviation and its practices in rural China: a case study of Fuping county, Hebei Province. *Journal of Rural Studies*.

- Haq R. 2015. Quantifying vulnerability to poverty in a developing economy. *The Pakistan Development Review* 54: 915–29.
- Imai KS, Wang X, Kang W. 2010. Poverty and vulnerability in rural China: effects of taxation. *Journal of Chinese Economic and Business Studies* 8: 399–425.
- Jing Z, Li J, Fu P *et al.* 2021. Catastrophic health expenditure among single empty-nest elderly with multimorbidity in rural Shandong, China: the effect of co-occurrence of frailty. *International Journal for Equity in Health* 20: 1–9.
- Jing Z, Li J, Wang Y *et al.* 2020. The mediating effect of psychological distress on cognitive function and physical frailty among the elderly: evidence from rural Shandong, China. *Journal of Affective Disorders* 268: 88–94.
- Khan R, Ali E, Rehman H, Haq MAU. 2015. Determinants of rural household poverty: the role of household socioeconomic empowerment. *American-Eurasian Journal of Agricultural & Environmental Science* 15: 93–8.
- Li Q. 2020. The impact of fiscal expenditures on vulnerability to poverty of rural households and its mechanism-based on evidence from CHIP data. *International Journal of Economics, Finance and Management Sciences* 8: 20–30.
- Liu L-J, Guo Q. 2008. Life satisfaction in a sample of empty-nest elderly: a survey in the rural area of a mountainous county in China. *Quality of Life Research* 17: 823–30.
- Liu M, Feng X, Wang S, Qiu H. 2020. China's poverty alleviation over the last 40 years: successes and challenges. *Australian Journal of Agricultural and Resource Economics* 64: 209–28.
- Liu Y, Guo Y, Zhou Y. 2018. Poverty alleviation in rural China: policy changes, future challenges and policy implications. *China Agricultural Economic Review* 10: 241–59.
- Luo R-F, Liu C-F, Gao J-J *et al.* 2020. Impacts of the COVID-19 pandemic on rural poverty and policy responses in China. *Journal of Integrative Agriculture* 19: 2946–64.
- Nong H, Zhang Q, Zhu H, Zhu R. 2021. Targeted poverty alleviation and children's academic performance in China. *Review of Income and Wealth*.
- Novignon J, Nonvignon J, Mussa R, Chiwaula LS. 2012. Health and vulnerability to poverty in Ghana: evidence from the Ghana Living Standards Survey Round 5. *Health Economics Review* 2: 1–9.
- Ouadika S, Blanchard A. 2020. Health shocks and vulnerability to poverty in Congo. *Humanities and Social Sciences Communications* 7: 1–8.
- Prasad S, Sung B, Aggarwal BB. 2012. Age-associated chronic diseases require age-old medicine: role of chronic inflammation. *Preventive Medicine* 54: S29–S37.
- Rahman MA. 2013. Household characteristics and poverty: a logistic regression analysis. *The Journal of Developing* 47: 303–17.
- Saifuloh NI, Ahmad AA, Suharno S. 2019. The effect of employment aspects on poverty in Central Java Indonesia. *Eko-Regional: Jurnal Pembangunan Ekonomi Wilayah* 14: 1.
- Sricharoen T. 2019. Vulnerability to poverty of rural farm households in Thailand. *Asian Review* 32: 3–38.
- Stevens AH. 2012. Transitions into and out of poverty in the United States.
- Sun B, Duan Z. 2020. Research on the effect of the rural minimum living security system -evidence from the perspective of poverty vulnerability. *Public Finance Research* 02: 113–28.
- Sun H, Li X, Li W. 2020. The Nexus between credit channels and farm household vulnerability to poverty: evidence from rural China. *Sustainability* 12: 3019.
- Thygesen LC, Hvidtfeldt UA, Mikkelsen S, Henrik B-H. 2011. Quantification of the healthy worker effect: a nationwide cohort study among electricians in Denmark. *BMC Public Health* 11: 1–11.
- Wang J, Zhao X. 2011. Empty nest syndrome in China. *The International Journal of Social Psychiatry* 58: 110.
- Wang Y, Fu P, Jie L *et al.* 2021. Changes in psychological distress before and during the COVID-19 pandemic among older adults: the contribution of frailty transitions and multimorbidity. *Age and Ageing* 50: 1011–18.
- Wang Y, Zhou X. 2020. The year 2020, a milestone in breaking the vicious cycle of poverty and illness in China. *Infectious Diseases of Poverty* 9: 1–8.
- Wendelspiess Chávez Juárez F. 2015. SHAPLEY2: stata module to compute additive decomposition of estimation statistics by regressors or groups of regressors.
- World Bank. 2000. World development report 2000/2001: Attacking poverty. The World Bank.
- Xiang Q, Yan C, Ying M, Liao H, Wang J. 2021. Classification and influencing factors of rural elderly's vulnerability to health-related poverty in central and western regions of China. *Global Health Journal* 5: 135–43.
- Xu C, Linmu L. 2018. Does urban and rural subsistence security system reduce future poverty? Empirical analysis based on vulnerability to poverty. *China Finance and Economic Review* 7: 86–106.
- Zhang C, Xue Y, Zhao H *et al.* 2019. Prevalence and related influencing factors of depressive symptoms among empty-nest elderly in Shanxi, China. *Journal of Affective Disorders* 245: 750–6.
- Zhang H-H, Jiang -Y-Y, Rao W-W *et al.* 2020. Prevalence of depression among empty-nest elderly in China: a meta-analysis of observational studies. *Frontiers in Psychiatry* 11: 608.
- Zhang L. 2021. An empirical study of multidimensional poverty and influencing factors in Western China. *Scientific and Social Research* 3: 183–8.
- Zhang Y, Wan G. 2006. An empirical analysis of household vulnerability in rural China. *Journal of the Asia Pacific Economy* 11: 196–212.
- Zhang Y, Wan G. 2008. Can we predict Vulnerability to Poverty? WIDER research paper.
- Zhou C, Chunmei J, Chu J *et al.* 2015. Non-use of health care service among empty-nest elderly in Shandong, China: a cross-sectional study. *BMC Health Services Research* 15: 1–10.