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Estimates of multidimensional poverty and its determinants among older people in rural China: evidence from a multicenter cross-sectional survey

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Abstract

Background In 2020, China declared that the absolute poverty in the country had been eradicated, but older people in rural areas are deprived in multiple domains. Poverty is multidimensional and involves deprivations in health, social welfare, living standards, and income. This study focused on assessing the poverty status of rural older persons and providing a basis for decision-making at all levels of government in China.

Methods A multicenter cross-sectional survey was conducted in four rural areas of China. Individuals aged 60 years and older were selected through stratified sampling. People with aphasia and severe cognitive impairment were excluded. An electronic questionnaire was used to collect older people's information, including basic demographics, major illnesses, disabilities, chronic diseases, functional disorders, and ability to perform activities of daily living. It also asked about the medical, financial, and social security assistance that respondents received, food and clothing standards, safe housing, clean energy, safe drinking water, and reliable electricity. Specific questions were asked regarding income sufficiency, financial support from children, and pension income. Multidimensional poverty measurements were used to compare regional disparities and indicators differences. Logistic regression was used to identify the risk factors influencing poverty.

Results A total of 1272 older people were analyzed. Of them, 704 (55.35%) were women and 652 (51.26%) were aged between 60 and 69 years. The most frequently mentioned causes of poverty were illness, a lack of employment, inadequate technology, and poor transportation. We found that as multidimensional poverty indicators increased (from 6 to 10), the number of poor older people decreased (from 1218 to 437), as did the poverty incidence (from 95.75 to 34.36%) and multifaceted poverty index (from 53.41 to 25.06%). Xuanwei had the highest incidence of poverty (66.61%) and multidimensional poverty index (0.66) among the four provinces studied. Regarding the contribution of indicators, financial alleviation made the greatest contribution to multidimensional poverty among

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rural older adults (up to 70.51%). Age, marital status, education level, awareness of poverty alleviation policies, and region were significant predictors of multidimensional poverty among older rural residents ($P < 0.05$).

Conclusions China's subsidy system and financial support must be enhanced. Particular attention should be given to the re-education of rural older individuals, basic vocational education should be strengthened in rural areas, and social participation should be encouraged.

Keywords Older people, Rural area, Influencing factor, Targeted poverty alleviation, Multidimensional poverty

Background

China has undergone rapid economic development over the past 40 years, providing a solid foundation for reducing poverty [1]. China has been implementing large-scale poverty alleviation and development programs since the 1980s, which have helped reduce the poverty rate from 97.5% in 1978 to 1.7% by the end of 2018. China considers poverty alleviation and development as a top priority and has significantly emphasized targeted poverty alleviation to lift all 99 million impoverished people, 832 poor counties, and 128,000 poor villages in rural China. The task of eradicating absolute poverty, once considered daunting, has now been accomplished [2].

Poverty is defined as a condition in which an individual's or family's income is insufficient to meet their basic needs. However, defining poverty solely in terms of income or consumption is now considered unbalanced because it inappropriately separates people based on their economic status and social background [3]. The World Bank has adopted a multidimensional definition that encompasses various aspects of poverty. In 2015, the World Bank published *Voices of the Poor*, which provided new insights into poverty issues from the perspectives of governments, households, and social organizations. The meaning of poverty has now expanded beyond economic considerations to include other aspects of life, such as health, longevity, and literacy [4].

Poverty among older people is a significant aspect of the poverty problem [5, 6]. Physiological considerations render this a special problem, and population aging worldwide is a growing concern related to the poverty of older people. According to the United Nations, a country is classified as aging if more than 10% of its population is over 60 years old or more than 7% is over 65 years old [7]. China became an aging society in 2001, with a population of individuals over 65 years old reaching 90.62 million, accounting for 7.1% of the total population. By the end of 2017, China's population aged 65 years and older reached nearly 160 million, accounting for 11.4% of the total population [8]. The United Nations projects that by 2050, this proportion will reach 27.6% [7].

In China, poverty among older adults has always been treated as absolute. A certain level was applied to determine whether a person's standard of living was defined as impoverishment [9]. The national poverty alleviation

standard for farmers was ¥2,300 per year in 2011 [10]. This number had increased to ¥3,535 per year by 2018. However, factors such as the ability to work and health status were not considered [9, 11]. Recently, Chinese scholars have shifted from using a single indicator to a more multidimensional evaluation of poverty among older adults using ten indicators, including health, education, and living standards [12, 13]. The United Nations' 2019 *Human Development Report* referred to this method as the Multidimensional Poverty Index (MPI) [14].

Although China has made remarkable progress in poverty alleviation and development, factors such as unbalanced urban and rural development and intergenerational transmission of poverty are becoming increasingly difficult to progress further. Individuals' ability to achieve self-development is the foundation upon which they can escape poverty and become prosperous [15]. Therefore, when discussing poverty among rural older adults, it is necessary to consider their ability. In this study, we adopted a multidimensional definition of poverty to explore the applicability of *Amartya Sen's 'ability' theory* [16] to poverty among China's rural older people. Specific techniques for measuring multidimensional poverty among older adults in rural China were explored. We also assessed particularity, complexity, and regional differences.

Methods

Study design, setting and participants

This study was conducted based on a primary survey among the older populations in the rural districts of Lianping, Kashgar, Xuanwei, and Longsheng, located in Guangdong, Xinjiang, Yunnan, and Guangxi Provinces of China, separately. The respondents were selected by stratified sampling. Firstly, two or three villages were randomly selected from each district based on population size; then, 250 to 500 villagers aged over 60 years were conveniently selected in each village. Aphasia and severe cognitive impairment were considered as an exclusion criterion. This study was conducted according to the STROBE guidelines (<https://www.strobe-statement.org>), and the survey was administered in accordance with relevant guidelines and regulations, including the Declaration of Helsinki.

Instruments

The Chinese Academy of Sciences developed the concept of ‘*Precision Poverty Alleviation Effectiveness Evaluation Technology and Methods*,’ which was applied in this study. Their highly reliable and valid questionnaire has been used for large-scale evaluations across China.

The questionnaire covers basic information about respondents, including their gender, age, marital status, education level, and Body Mass Index (BMI). In our study, the height and weight of some subjects could not be measured, and general averages were used. The Academy of Sciences questionnaire also asks about the respondent’s health status, including major diseases causing disability, chronic diseases, functional impairment, and the ability to perform activities of daily living. We used Longshi Scale (Supplementary Fig. 1) [17, 18] to evaluate the ability of older people to perform activities of daily living and social participation.

The questionnaire asks about income and whether the respondent feels their income is sufficient. It seeks a record of their income when such information is available. It also inquires regarding the reasons for poverty and respondents’ awareness of poverty alleviation policies, such as knowledge of poverty alleviation policies, how to apply for a poverty assessment, poor household assessment standards, the poverty identification process, and an understanding of the results of poor household assessment. It asks about the social benefits respondents receive, such as whether they have received disability social security payments, land and breeding industry poverty alleviation support, other poverty alleviation payments, or any kind of disaster relief. It also covers living standards, such as whether the respondent has sufficient food and clothing, safe housing, clean energy at home, safe drinking water, and reliable electricity.

Multidimensional poverty index

Poverty is reported by the single headline measure of multidimensional poverty index (MPI), or the adjusted headcount ratio ($MPI = H \times A$), composed of the incidence or headcount ratio (H), the proportion of people identified as multidimensionally poor, and the intensity or average deprivation share (A), that is the average share of (weighted) deprivations faced by multidimensionally poor people. In this study, by incorporating the intensity of poverty, the MPI goes beyond the simple headcount ratio used by monetary measures to consider gains among the poorest of the poor who have not yet exited poverty.

Quality control

The survey was conducted by 24 trained investigators who were village doctors, community doctors, and medical students. The questionnaires were interviewed by face

to face and recorded on mobile phones. To ensure the quality of the responses, the investigators received study-specific pre-survey training to explain the purpose and significance of the survey. This helped them explain the survey to the respondents and encouraged respondents to provide accurate and truthful answers. We also conducted a quasi-experiment prior to the formal investigation and used mobile phone network questionnaires to collect data. The data were automatically entered into the database as they were collected in real time.

Data analysis

We applied multidimensional poverty measurements to investigate regional disparities and differences in various indicators among rural older people in Lianping, Kashgar, Xuanwei, and Longsheng. We also analyzed the causes and contributions of poverty. Multidimensional poverty was categorized into 6 to 10 dimensions. Logistic regression was used to identify the principal factors predicting poverty among rural older people. A statistically significant difference was defined as $P < 0.05$.

Results

Demographics

A total of 1,284 respondents agreed to participate, and after 12 were excluded because they were less than 60 years old, the final analysis involved 1272 older respondents. Among them, 522 (41.03%) were from Lianping (Guangdong), 257 (20.21%) were from Kashgar (Xinjiang), 302 (23.74%) were from Xuanwei (Yunnan), and 191 (15.02%) were from Longsheng (Guangxi). Please refer to Table 1. Additionally, 704 (55.35%) were women and 652 (51.26%) were aged between 60 and 69 years. More than half (58.41%) of participants had a BMI between 18.5 and 24.9. Married and widowed older individuals accounted for 67.45% and 30.66%, respectively, and 82.47% had primary school education or lower.

Causes of poverty

The five reasons for their poverty most frequently cited by respondents were illness, lack of employment, lack of funds, lack of technology, and poor transportation (Fig. 1). These reasons accounted for between 30% and 85% of the reasons cited in the different districts (Fig. 2). Illness was the cause most often cited, except in Longsheng, where a lack of employment appeared more often (Fig. 3).

Multidimensional poverty indicator system and deprivation thresholds

In its 2010 *Human Development Report* [19], the United Nations Development Program published multidimensional poverty indices based on the work by Alkire on 104 developing countries. The 2011 *Human Development*

Table 1 Description of socio-demographic characteristics of older people in Lianping, Kashgar, Xuanwei, and Longsheng of China

Items		Lianping		Kashgar		Xuanwei		Longsheng		Total	Percentage (%)
		N	%	N	%	N	%	N	%		
Sex	Male	225	43.10	106	41.25	142	47.02	95	49.74	568	44.65
	Female	297	56.90	151	58.75	160	52.98	96	50.26	704	55.35
Age	60–69	276	52.87	156	60.70	110	36.42	110	7.59	652	51.26
	70–79	144	27.59	77	29.96	113	37.42	59	30.89	393	30.90
	≥ 80	102	19.54	24	9.34	79	26.16	22	11.52	227	17.85
BMI(kg/m ²) ¹	< 18.5 (Thin)	87	16.67	7	2.72	78	25.83	28	14.56	200	15.72
	18.5–24.9 (Normal)	316	60.54	107	41.63	193	63.91	127	66.49	743	58.41
	≥ 25.0 (Overweight and obesity)	119	22.79	143	55.64	31	10.26	36	18.85	329	25.86
Marriage	Married	347	66.48	177	68.87	188	62.25	146	76.44	858	67.45
	Widow	163	31.23	76	29.57	108	35.76	43	22.51	390	30.66
	Unmarried and Divorce	12	2.30	4	1.56	6	1.98	2	1.04	24	1.89
Education	Illiteracy	122	23.37	41	15.95	210	6.54	75	39.27	448	35.22
	Primary school	279	53.45	163	63.42	69	22.85	90	47.12	601	47.25
	Middle school	96	18.39	38	14.79	21	6.95	20	10.47	175	13.76
	High school and above	25	4.79	15	5.22	2	0.66	6	2.25	48	3.77

¹ BMI, body mass index, whose calculation method is weight divided by the square of height, in kilograms per square meter

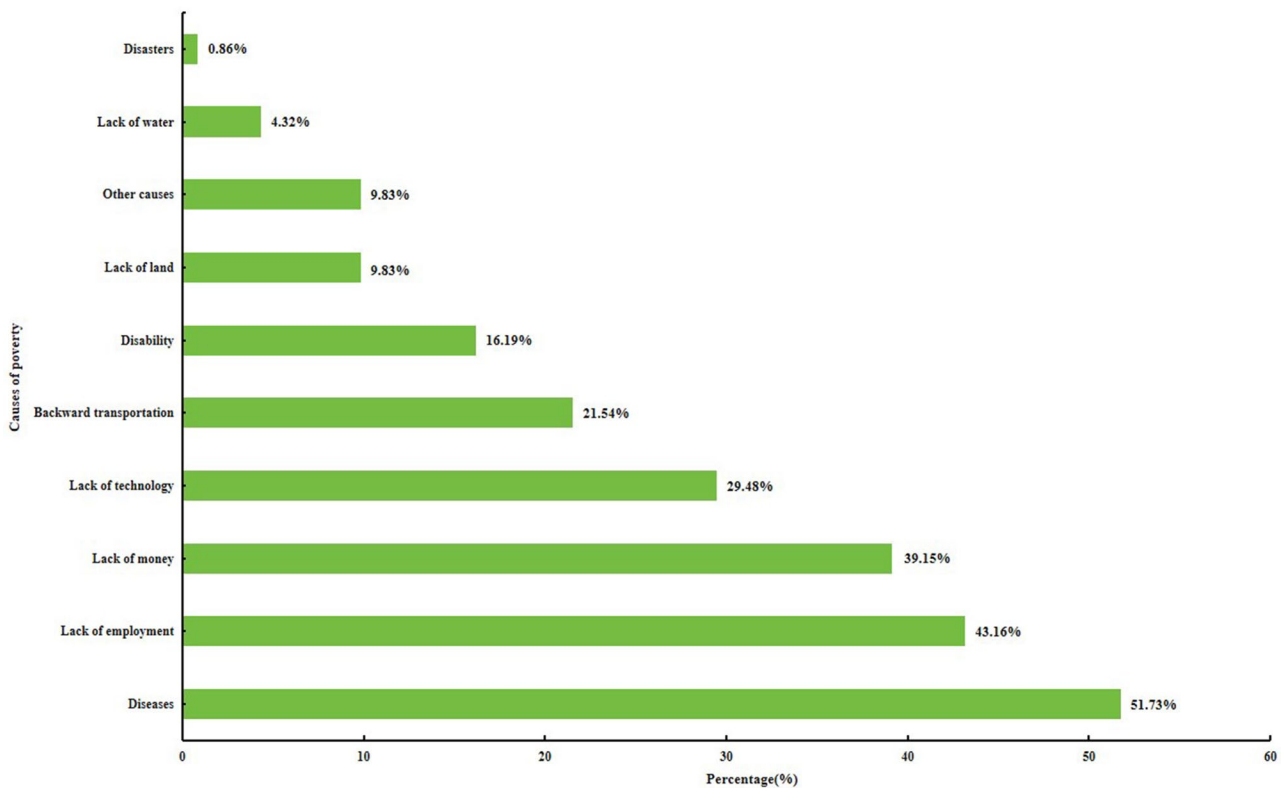


Fig. 1 Percentage of older people multidimensionally poor in Lianping, Kashgar, Xuanwei, and Longsheng of China

Report [20] extended these indices to 109 countries. Their multidimensional poverty index has three dimensions of education, health, and living standards with ten indicators. It is designed to reflect multiple dimensions of deprivation that exist simultaneously for individuals or families. We drew on the published results of domestic and foreign scholars when designing our own indices.

We considered four dimensions health, living standards, social welfare, and income.

Health status measurement included serious acute illness, chronic disease, functional impairment, and daily living ability. Chinese poverty alleviation standards were adopted to measure living standards, which entail ‘having no worries about food and clothing, and having enough

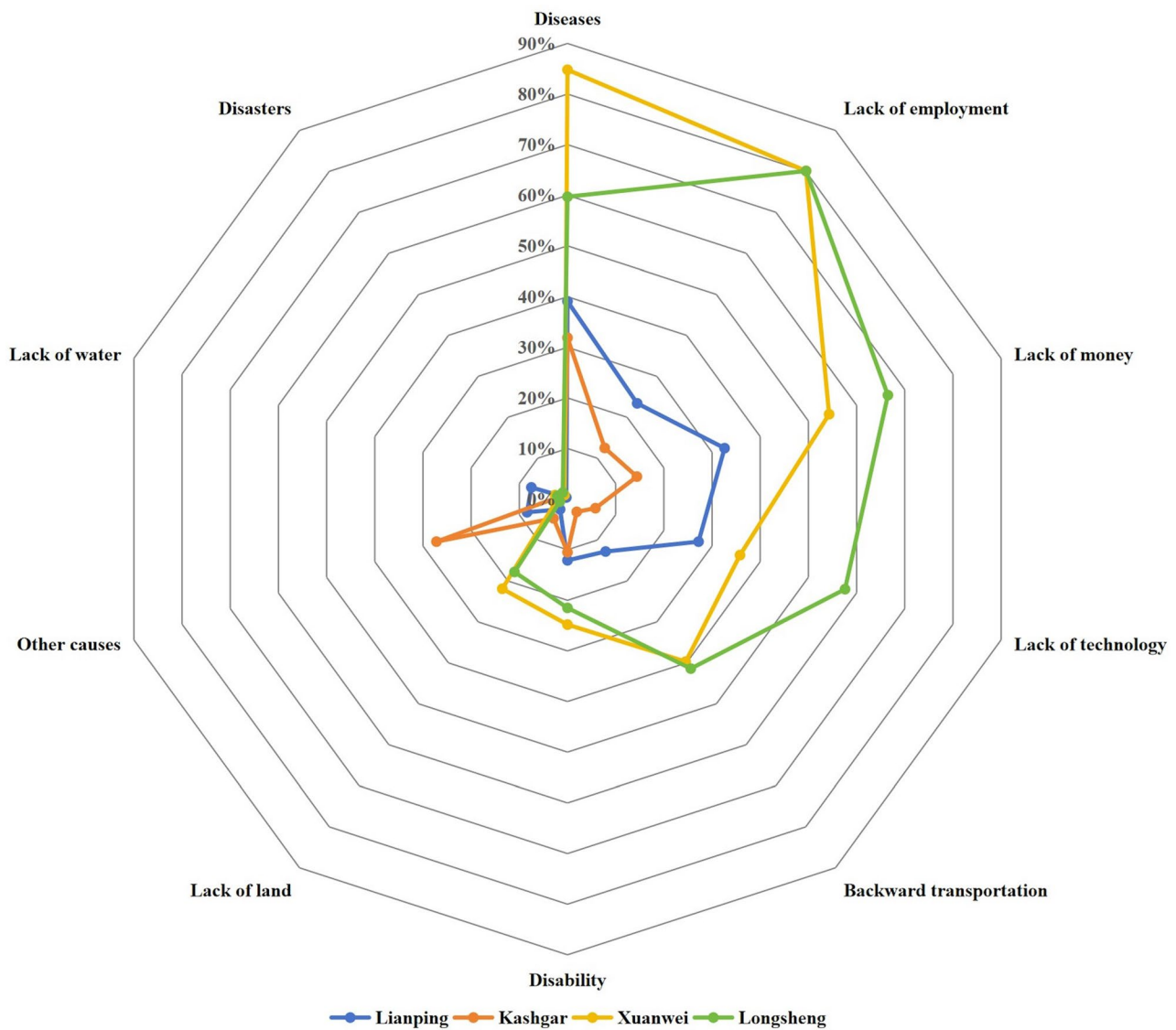


Fig. 2 Reasons for poverty in Lianping, Kashgar, Xuanwei, and Longsheng

safe housing, safe drinking water, clean energy, and daily electricity security'. Social welfare measures include medical assistance, social security payments, land and breeding industry poverty alleviation payments, and financial poverty alleviation. The income component includes direct income, financial support from children, and pension status. Please refer to Table 2 for additional details.

We adopted an equal weighting method for the indicators used in our study. Therefore, each of the 16 specific indicators was assigned a weight of 1/16. In rural areas, households with more than 1/3 of the poverty indicators are considered multidimensional poor households. Therefore, in this study, rural older people in multidimensional poverty must be poor according to at least six indicators, which means K should be greater than six. Based on the data collected, there were relatively

few older adults in multidimensional poverty when K is greater than or equal to 11. Therefore, we only discuss the current situation and factors influencing multidimensional poverty among older people with K values of 6 to 10.

Poverty in the four regions

The number and percentage of older adults in multidimensional poverty decreased as the number of dimensions increased. With the indicators equally weighted, the number of rural older people (n), poverty incidence (H), average share of deprivation (A), and the overall multidimensional poverty index (M_0) decreased as the number of factors (K) increased.

Lianping in Guangdong Province had the largest sample. Therefore, the largest number of rural older

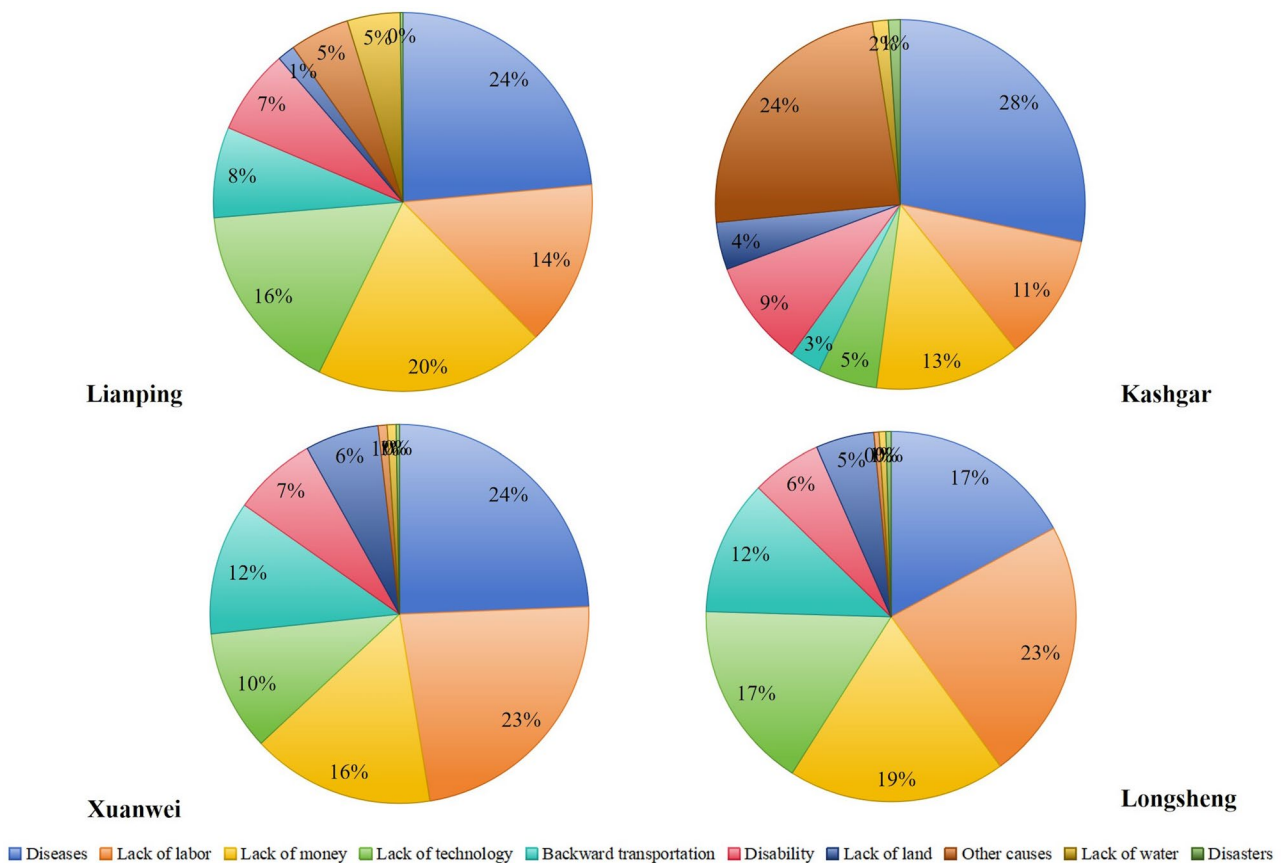


Fig. 3 Percentage distribution of causes for poverty older people in Lianping, Kashgar, Xuanwei, and Longsheng

individuals were rated as impoverished. Xuanwei in Yunnan had the highest incidence of poverty and multidimensional poverty index among the four districts surveyed, indicating that poverty was the most severe.

For $K=6, 7, \text{ and } 8$, Kashgar in Xinjiang had a higher poverty incidence and multidimensional poverty index than Longsheng, Guangxi. However, for $K=10$, Longsheng's poverty incidence and multidimensional poverty index were higher than those of Kashgar (Table 3).

Contributions of different poverty dimensions

Table 4 shows that, except for in Lianping, lack of financial support is the main indicator of multidimensional poverty among rural older people. Even when $K=7, 8, 9, \text{ and } 10$, financial poverty alleviation remains the most important factor, with land and breeding industry support in second place.

Influencing factors of multidimensional poverty in four regions

Table 5 presents the coefficients of the binary logistic regression models based on data for $K=6$ to 10. Knowledge of poverty alleviation policies, how to apply for a poverty assessment, poor household assessment

standards, the poverty identification process, and an understanding of the results of poor household assessment were also included as predictors. The head of the household was also included as an independent variable in the regression models.

As shown in Table 5, age, marital status, education level, awareness of poverty alleviation policies, and region are all significant predictors. Older people (≥ 80 years old) are less likely to experience multidimensional poverty than those 60 to 69 years. The risks of multidimensional poverty for people aged 70 to 79 years and 60 to 69 years are 4.628 and 2.776 times higher than for people aged 80 years and older in Model I. However, this effect gradually weakens as the K value increases, as shown in Models II-V when $K \geq 10$, the impact of age on poverty disappears in all models.

According to a recent study, marital status is significantly related to the likelihood of experiencing multidimensional poverty in old age. The reported data indicate that the risk of multidimensional poverty for widowed, unmarried, or divorced older people is 5.581 and 5.209 times higher than that for married older individuals in Model I. However, this effect disappears when $K \geq 7$ in Models II-V. This indicates that the influence of

Table 2 Dimensions and indicators used in the estimation of multidimensional poverty in four regions of China

Dimensions	Indicators	Criticality and assignment
Health status	Had a serious illness in the past two years ¹	0 = No; 1 = Yes
	Had a chronic disease ²	0 = No; 1 = Yes
	Had a functional disorder ³	0 = No; 1 = Yes
	Activity of daily living ⁴	0 = Self-care for small parts of life (Longshi Scale ⁹ was grade 3 or lower); 1 = Self-care for most parts of life (Longshi Scale was grade 4 or higher)
Social Welfare	Had received medical assistance ⁵	0 = No; 1 = Yes
	Had received social Security ⁶	0 = No; 1 = Yes
	Had received poverty alleviation through land and breeding industries ⁷	0 = No; 1 = Yes
	Had received financial poverty alleviation ⁸	0 = No; 1 = Yes
Living standard	Had no worries about food and clothing	0 = No; 1 = Yes
	Had safe housing	0 = No; 1 = Yes
	Had clean energy at home	0 = No; 1 = Yes
	Had safe drinking water	0 = No; 1 = Yes
	Whether daily electricity is guaranteed	0 = No; 1 = Yes
Economic Condition/ Well-being	Whether household income is sufficient	0 = No; 1 = Yes
	Had financial support from children	0 = No; 1 = Yes
	Had a pension	0 = No; 1 = Yes

¹ Serious illness means requiring hospitalization or being bedridden at home, such as cerebral infarction, cerebral hemorrhage, brain trauma, tumor, spinal cord injury, fracture, Alzheimer's disease, etc

² Chronic diseases refer to non-communicable diseases accumulated over a long period of time, including hypertension, heart disease, diabetes, hyperlipidemia, hyperuricemia, chronic obstructive pulmonary disease, chronic renal insufficiency, Parkinson's, Alzheimer's disease, anxiety, depression, etc

³ Functional disorders refer to abnormalities in the functions of certain organs or systems of the human body, including movement disorders, sensory disorders, defecation disorders, speech disorders, swallowing disorders, cognitive disorders, cardiopulmonary disorders, mental disorders, sleep disorders, etc

⁴ Ability of daily living, referred to as ADL, is an important indicator of the health status of the elderly, including bowel and bladder control, eating, personal cleaning, toileting, housework, entertainment, community exercise, shopping, and participation in community activities

⁵ Medical assistance includes basic medical insurance for urban and rural residents, new rural cooperative medical insurance, serious illness medical insurance, outpatient assistance, hospitalization assistance, etc

⁶ Social security includes rural subsistence allowances, poverty relief, student aid for poor children, subsistence allowances, renovation of dilapidated houses, etc

⁷ Land and breeding poverty alleviation includes the distribution of subsidies for poultry, vegetables, seeds, cultivated land, forestland, etc

⁸ Financial poverty alleviation includes providing loans or subsidies for housing construction, student aid, entrepreneurship, etc

⁹ Longshi Scale is a 6-level scale, which used to evaluate ability in the activities of daily living and the social participation ability

marital status on elderly poverty weakens as the evaluation dimension increases.

The predictive power of the level of education may be influenced by awareness of poverty alleviation policies. Educational level is a significant factor affecting multidimensional poverty in older people before adjusting for awareness of poverty ($P < 0.05$). However, after adjusting for factors such as whether the older people knew about poverty alleviation policies, had applied for poverty assessment, knew the standards for assessing poor households, knew the poverty identification process, knew the results of poor households, and knew about assistance, education level was no longer significant ($P > 0.05$).

In the assessment regions, the risks of multidimensional poverty for Kashgar, Xuanwei, and Longsheng are 3.413, 2.426, and 17.318 times greater, respectively, than that of Lianping in Models I to IV. This indicates that the level of prosperity in the Lianping area is higher than in the other three areas.

Additionally, awareness of poverty influences multidimensional poverty. The risk of multidimensional poverty for older people aware of poverty alleviation policies is 2.211 times higher than that for unaware older individuals when $K = 10$. The risk of multidimensional poverty for older adults who applied for poverty assessment is 2.429 times higher than that for older adults when $K = 6$. We found that people who know poverty household assessment standards are less likely to experience multidimensional poverty than those unaware of such standards ($OR = 0.193 - 0.0450$, $P < 0.05$) in Models III to V. The results of logistic regression analysis of influencing factors on different dimensional poverty in older people are presented in Supplementary Tables 1 to 5.

Discussion

This study conducted a multicenter cross-sectional survey to evaluate the multidimensional poverty and its determinants among older people in four rural areas of

Table 3 Incidence of poverty, intensity of poverty, and multidimensional poverty index in different dimensions among older people in four regions of China

K ¹	Regions ²	Total number of older people (n)	Number of poor older people (q)	Poverty incidence (H, %) ³	Average share of deprivation (A, %) ⁴	Multidimensional poverty index(MPI) ⁵
6	Lianping	522	502	96.17	56.61	0.5444
	Kashgar	257	246	95.72	51.55	0.4934
	Xuanwei	302	298	98.68	66.61	0.6573
	Longsheng	191	172	90.05	49.02	0.4414
7	Lianping	522	443	84.87	59.16	0.5020
	Kashgar	257	221	85.99	53.14	0.4570
	Xuanwei	302	291	96.36	67.31	0.6486
	Longsheng	191	141	73.82	51.55	0.3806
8	Lianping	522	371	71.07	62.15	0.4417
	Kashgar	257	177	68.87	55.47	0.3821
	Xuanwei	302	259	85.76	70.22	0.6022
	Longsheng	191	91	47.64	55.84	0.2660
9	Lianping	522	281	53.83	66.04	0.3555
	Kashgar	257	96	37.35	60.09	0.2245
	Xuanwei	302	229	75.83	72.87	0.5526
	Longsheng	191	52	27.23	97.72	0.2660
10	Lianping	522	176	33.72	71.88	0.2423
	Kashgar	257	33	12.84	67.42	0.0866
	Xuanwei	302	206	68.21	74.73	0.5097
	Longsheng	191	22	11.52	142.33	0.1639

¹ K represents the number of poverty indicators. Poverty indicators include serious illness, chronic disease, functional disorder, activity of daily living, medical assistance, social security, poverty alleviation through land and breeding industries, financial poverty alleviation, food and clothing, housing, clean energy, drinking water, electricity, household income, financial support from children and pension

² A total of 1272 older people were conducted, with 522, 257, 302 and 191 in Lianping, Kashgar, Xuanwei, and Longsheng, respectively

³ H is the incidence or headcount ratio of older people in different indicators, which represents the proportion of people identified as multidimensional poverty. The calculation formula is $H = q/n \times 100\%$

⁴ A, average deprivation share, is the average share of (weighted) deprivations faced by multidimensionally impoverished people

⁵ MPI, multidimensional poverty index, the calculation formula is $MPI = H \times A$

China, aiming to develop targeted poverty alleviation policies and improve their poverty situation. In this study, the concept of multidimensional poverty stemmed from *Sen's basic capabilities approach* [21], which is not simply a shortage of income but also an inability to obtain essential services such as education, sanitation, and drinking water. This perspective has encouraged scholars to explore advanced techniques for quantifying poverty among older adults. The multidimensional poverty index is one such technique. This index has ten dimensions reflecting health, education, living standards, and income level [22]. Its multidimensional indicators are based on the characteristics of the older population in China.

In this study, we found that the five most prevalent causes of poverty were illness, lack of employment, funds, technology, and poor transportation. In Lianping, Kashgar, and Xuanwei, illness was the primary cause. China's National Health Commission has indicated [23] that most people suffering from illness-related poverty in the country are aged 60 years and above. Older people tend to have medical expenses three to five times higher

than those of other age groups [24, 25]. This supports the findings of our survey on poverty due to illness. Demographic characteristics and types of disease can increase an individual's risk of poverty. Therefore, it is important to establish a permanent mechanism that prevents older people from falling into poverty due to illness and helps them return to normal lives. That would not only help consolidate and expand the results of health-related poverty alleviation but also connect it with village revitalization.

In Longsheng, a lack of employment was the most common complaint. Lack of employment had many causes [26] and tends to coincide with a lack of technology and capital investment [27, 28]. Therefore, when targeting impoverished elderly families lacking employment, attention should also be paid to assisting other poor families through measures such as education on poverty alleviation. Employment poverty alleviation can also help solve labor shortages.

In this study, financial poverty alleviation was the most frequently mentioned factor. It involves providing

Table 4 Contribution of each indicator in different dimensions among the older people in the four regions (%)

K ¹	Regions ²	Serious diseases	Chronic disease	Functional impairment	ADL ³	Medical assistance	Social security	Poverty alleviation through land and breeding industry	Financial poverty alleviation	Food and clothing	Housing security	Clean energy	Safe drinking water	Electricity guaranteed	Source of living	Financial support for children	Pen-sion
6	Lianping	8.05	4.20	5.76	10.89	1.98	0.51	11.46	9.65	1.86	1.79	2.76	2.60	2.83	3.84	0.88	1.08
	Kashgar	9.86	3.15	10.35	12.12	3.55	4.48	11.93	12.37	0.95	0.39	1.54	0.67	0.67	4.99	0.59	4.07
	Xuanwei	5.92	3.49	5.26	7.56	0.16	3.18	9.45	9.45	1.23	4.86	7.30	7.38	7.28	5.71	1.72	5.54
	Longsheng	11.27	6.00	11.19	13.79	2.08	10.08	12.53	13.86	0.89	0.71	0.65	0.77	0.95	3.56	0.10	5.24
7	Lianping	8.73	4.56	6.25	11.81	2.15	0.55	12.43	10.47	2.02	1.95	3.00	2.82	3.07	4.17	0.95	1.18
	Kashgar	10.64	3.41	11.18	13.09	3.83	4.84	12.88	13.36	1.02	0.43	1.66	0.72	0.72	5.39	0.64	4.40
	Xuanwei	6.00	3.54	5.33	7.66	0.16	3.22	9.57	9.57	1.25	4.93	7.40	7.48	7.38	5.79	1.74	5.62
	Longsheng	13.07	6.96	12.98	15.99	2.41	11.69	14.53	16.08	1.03	0.83	0.76	0.89	1.10	4.13	0.11	6.08
8	Lianping	9.92	5.18	7.10	13.42	2.44	0.62	14.12	11.90	2.30	2.21	3.40	3.21	3.49	4.73	1.08	1.34
	Kashgar	12.73	4.07	13.37	15.66	4.58	5.79	15.40	15.98	1.22	0.51	1.99	0.87	0.87	6.45	0.76	5.26
	Xuanwei	6.46	3.81	5.74	8.25	0.17	3.47	10.31	10.31	1.35	5.31	7.97	8.05	7.95	6.23	1.88	6.05
	Longsheng	18.70	9.96	18.57	22.88	3.44	16.73	20.79	23.00	1.48	1.18	1.08	1.28	1.57	5.90	0.16	8.69
9	Lianping	12.33	6.43	8.82	16.67	3.03	0.77	17.55	14.79	2.86	2.75	4.23	3.99	4.34	5.88	1.35	1.66
	Kashgar	21.67	6.93	22.75	26.65	7.80	9.86	26.22	27.19	2.08	0.87	3.38	1.47	1.47	10.98	1.30	8.96
	Xuanwei	7.04	4.16	6.25	8.99	0.19	3.78	11.24	11.24	1.47	5.78	8.69	8.78	8.66	6.79	2.05	6.59
	Longsheng	18.70	9.96	18.57	22.88	3.44	16.73	20.79	23.00	1.48	1.18	1.08	1.28	1.57	5.90	0.16	8.69
10	Lianping	18.08	9.44	12.94	24.46	4.45	1.14	25.74	21.69	4.19	4.03	6.21	5.85	6.36	8.63	1.98	2.44
	Kashgar	56.18	17.98	58.99	69.10	20.22	25.56	67.98	70.51	5.39	2.25	8.76	3.82	3.82	28.46	3.37	23.22
	Xuanwei	7.63	4.51	6.78	9.74	0.20	4.10	12.18	12.18	1.59	6.27	9.42	9.52	9.39	7.36	2.22	7.15
	Longsheng	30.34	16.17	30.14	37.13	5.59	27.15	33.73	37.33	2.40	1.92	1.76	2.08	2.55	9.58	0.27	14.11

¹K represents the number of poverty indicators. Poverty indicators include serious illness, chronic disease, functional disorder, activity of daily living, medical assistance, social security, poverty alleviation through land and breeding industries, financial poverty alleviation, food and clothing, housing, clean energy, drinking water, electricity, household income, financial support from children and pension

²A total of 1272 older people were conducted, with 522, 257, 302 and 191 in Lianping, Kashgar, Xuanwei, and Longsheng, respectively

³ADL, activities of daily living

Table 5 Logistic regression analysis of influencing factors of multidimensional poverty among older people

Variables ³	K ¹ =6	K=7	K=8	K=9	K=10
	Model I ²	Model II ²	Model III ²	Model IV ²	Model V ²
Gender (Male)	0.735	0.906	1.026	1.020	0.716
Age (≥ 80)	ref.	ref.	ref.	ref.	ref.
Age (70–79)	4.628***	2.474***	1.943***	1.590**	1.405
Age (60–69)	2.776***	2.138***	1.827***	1.406*	1.102
BMI (< 18.5)	ref.	ref.	ref.	ref.	ref.
BMI (18.5–24.9)	0.965	1.130	1.048	0.985	0.944
BMI (≥ 25)	1.995	1.119	0.753	0.701*	0.564**
Marital status (Married)	ref.	ref.	ref.	ref.	ref.
Marital status (Widowed)	5.581**	2.022	2.028	1.493	1.486
Marital status (Unmarried and divorce)	5.209**	1.615	1.690	1.406	1.186
Educational level (Illiteracy)	ref.	ref.	ref.	ref.	ref.
Educational level (Primary school)	1.559	0.751	0.493*	0.602	0.480*
Educational level (Junior middle school)	2.783	1.254	0.642	0.753	0.633
Educational level (Senior high school and above)	2.439	0.925	0.708	1.099	0.897
Region (Liangping)	ref.	ref.	ref.	ref.	ref.
Region (Kashgar)	3.413***	1.850**	2.550***	2.418***	2.961***
Region (Xuanwei)	1.459	1.763**	2.426***	1.452*	0.973
Region (Longsheng)	17.318***	10.930***	7.595***	8.210***	17.23***
Whether known targeted poverty alleviation policies (Yes)	1.446	1.842*	2.027***	2.025***	2.211***
Whether applied for poverty assessment (Yes)	2.429**	1.313	1.373**	1.619***	1.365*
Whether known poverty household assessment standards (Yes)	1.870	0.949	0.450**	0.394***	0.193***
Whether known poverty identification procedures and methods (Yes)	0.832	0.814	0.577*	0.639	1.926**
Whether known the results of poor households assessment (Yes)	1.026	0.850	2.200*	1.742	1.634
Whether known the person responsible for poverty alleviation (Yes)	1.043	0.717	0.874	0.997	0.585
Constant	0.115	0.676	0.366	0.214	0.165

¹ K represents the number of poverty indicators. Poverty indicators include serious illness, chronic disease, functional disorder, activity of daily living, medical assistance, social security, poverty alleviation through land and breeding industries, financial poverty alleviation, food and clothing, housing, clean energy, drinking water, electricity, household income, financial support from children and pension

² Perform binary Logistic regression analysis, with gender, age, BMI, marital status, education level, region, whether known targeted poverty, whether applied for poverty assessment, whether known the poverty household assessment standards, whether known the poverty identification procedures and methods, whether known the results of poor households assessment, whether known the person responsible for poverty alleviation as independent variables, and whether poverty occurs as dependent variable when the multidimensional poverty indicators are 6, 7, 8, 9, and 10, respectively

³ Reference items are in brackets

****P*<0.01; ***P*<0.05; **P*<0.10

interest-free credit to poor households, supplemented by other aid such as investment, funds, and, in some areas, individual stock participation [29, 30]. Interest-free credit can be as important as physical and human capital in terms of reducing multidimensional poverty [31]. Therefore, systems providing credit should be improved, and policies calling for its provision should be reliably implemented. Financial institutions should prioritize low-income rural households and work toward resolving their limited access to formal credit [32]. They should also conduct credit evaluations and increase microfinance loans to improve the income generation capacity of such households. Local governments should collaborate with banks to promote credit usage in rural areas. Extensive campaigns should be granted to individuals, villages, and towns with good credit ratings within an appropriate scope. A credit rating review team with members from grassroots governments, village committees, and

farmers should be established to assess rural household creditworthiness comprehensively. This process will help determine the form and scale of appropriate loans. Banks should educate low-income elderly farmers regarding integrity and credit awareness, which will help enhance their creditworthiness and increase their access to formal credit.

We found that people over the age of 80 were less likely to experience multidimensional poverty. This could be because of China’s elderly allowance, which fully covers individuals over 80 years of age. However, for *K*=10, this policy was not as effective. We also found that married older individuals had a lower risk of experiencing poverty than widowed, unmarried, and divorced older individuals. Specifically, the risk of multidimensional poverty among widowed, unmarried, and divorced older adults was 5.581 to 5.209 times that among married older adults. Spouses play an important role in spiritual

companionship and daily care. Additionally, we found that very few elderly individuals were unmarried (1.18%). As the K value increases, the impact of marital status on poverty disappears in Model II to V when $K \geq 7$.

The predictive power of education level may be confounded by awareness of poverty alleviation. This highlights the importance of publicizing poverty alleviation policies and increasing awareness among older adults with limited formal education. University for the older people can provide literacy education and skills training for low-income older adults. Volunteers can be recruited to re-educate older individuals and enhance their understanding of poverty alleviation policies and application procedures.

Older adults in different regions face different levels of multidimensional poverty. For example, older people in Lianping, Kashgar, and Longsheng regions are more likely to fall into multidimensional poverty than those in Xuanwei. A specific dimension analysis revealed that when $K=6, 7, 8, 9,$ and 10 , the multidimensional poverty indices in the Xuanwei area are $0.6573, 0.6486, 0.6022, 0.5526,$ and 0.5097 , respectively, which are higher than Lianping area. Compared with Lianping, the multidimensional poverty indices in Kashgar and Longsheng are decreasing. The data indicate that older people in Xuanwei face the most significant difficulty in overcoming deep multidimensional poverty. Therefore, this area should be a priority for targeted poverty alleviation efforts for older people.

The construction of medical institutions, training of health technicians, poverty alleviation measures, and resource support can help alleviate health-driven poverty [33]. In China, medical services have been improved nationwide, and there is now full coverage for basic medical insurance and serious illness insurance, as well as medical assistance available for all impoverished people [34]. One crucial component is to improve dynamic monitoring and assistance mechanisms for people who have fallen into poverty due to illness and to monitor the treatment of those who have been lifted out of poverty. Grassroots medical and health services are being improved to promote their transformation from disease treatment to health management programs [35]. This will help improve health and provide a feeling of medical security among rural people who have been lifted out of poverty while preventing others from falling into or returning to poverty due to illness.

Limitations

This study has three shortcomings. Firstly, it is a cross-sectional survey, which cannot infer the causal relationship of poverty in explaining the causes of poverty. Secondly, this study only conducted surveys among 1272 older people in four rural areas in China, which

limits the extrapolation to other regions and populations. Finally, the poverty indicators were collected in the form of self-report, which may result in reporting bias. Further researches are needed on larger samples and wider ranges of populations to explore the causes and influencing factors of poverty.

Conclusions

Enhancing subsidies for older people, increasing financial support, and strengthening basic vocational education are essential. Practical tactics to encourage social participation should be implemented.

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Author contributions

JZ, XL, and YW contributed to the study's conception and design, accomplished the surveys, and edited the manuscript. XL and DL contributed to the statistical analyses and drafted the tables and figures. YG, FL, FZ, and FL contributed to the data acquisition, analysis, and interpretation. XL, JZ, and DL reviewed and revised the manuscript. JZ and XL contributed equally to this manuscript. All of the authors have read and approved the final manuscript.

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Data availability

The study's datasets are available from the author Dr. Jingpu Zhao on reasonable request.

Declarations

Ethical approval

The study was approved by the Medical Ethics Committee of Shenzhen Second People's Hospital (No.20180926006). It was registered retrospectively in June of 2020 (<https://www.chictr.org.cn/>) with registration number ChiCTR2000034067. All of the respondents provided written informed consent to participate. All of the methods were carried out in accordance with relevant guidelines and regulations (including the Declaration of Helsinki).

Consent to publish

Not Applicable.

Competing interests

The authors declare no competing interests.

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