



# Multidimensional health heterogeneity of Chinese older adults and its determinants

Yi Hu<sup>a,1</sup>, Zhenyu Wang<sup>b,\*</sup>, Liqun Wu<sup>a</sup>

<sup>a</sup> Shenzhen Health Development Research and Data Management Center, Shenzhen, Guangdong, 518028, China

<sup>b</sup> School of Government, Sun Yat-sen University, Guangzhou, Guangdong, 510006, China

## ARTICLE INFO

### Keywords:

Multidimensional health  
Latent class analysis  
Older adults  
Active ageing

## ABSTRACT

**Background:** Nowadays, the “Healthy China” and “Actively Addressing Population Aging” are two important national strategies in China. Promoting high-quality development of demand-driven older adults health services is an important way to achieve these strategies. From the perspective of active ageing, assessing the health status of older adults from multiple dimensions becomes crucial as it helps identify their specific health service needs, intervention measures, and health policies tailored to this population.

**Methods:** Data were derived from the China Health and Retirement Longitudinal Study (CHARLS) wave 4 (2018). A total of 4190 older adults (aged  $\geq 60$  years) were included as the analysis sample. Latent class analysis was performed to categorize older adults based on 6 health indicators, including Activities of Daily Living (ADLs), Instrumental Activities of Daily Living (IADLs), doctor diagnosed chronic diseases, depressive symptoms, cognitive function, and social participation. Multinomial logistic model was used to explore determinants associated with the various patterns of multidimensional health of older adults.

**Results:** The multidimensional health of older people was classified into three latent classes: Relatively Healthy (Class 1,  $n = 2806$ , 66.97%), Highly Depressed and Relatively Health Risk (Class 2,  $n = 1189$ , 28.38%), and Functional Impairment (Class 3,  $n = 195$ , 4.65%). Gender, age, education, marital status, number of children, alcohol consumption, physical activity, savings, residence, air quality satisfaction, and medical service satisfaction had significant effects on the attribution of all multidimensional health latent classes.

**Conclusion:** Heterogeneous and multidimensional health classes exist in China’s older population, and these classes are influenced by a variety of factors and to varying degrees. Policymakers and healthcare providers can use these evidence to further address the diverse needs of older adults and improve older-care health services, ultimately achieving the goal of Active Ageing and Healthy China.

## 1. Introduction

China has entered a new stage characterized by “aging society”, which, together with its original status as a “populous country”, makes it the country with the largest older population in the world (Yip & Hsiao, 2008). The “aging of the population” not only results in significant health transitions and increased utilization of healthcare resources but also impacts social security systems, such as healthcare and pension systems (Tsutsui, 2014). Older individuals’ health status varies considerably due to the variability and interdependence of health conditions (Lafortune et al., 2009a), resulting in heterogeneity and diverse health service and aged care needs (Gong et al., 2022). As a result, meeting the

complex and multiple health needs of older people in a timely manner has become more challenging.

To scientifically predict the future demand for care services for the older population and to construct a reasonable geriatric health policy system, the health status of older people needs to be comprehensively and accurately assessed (Yang & Song, 2020). The World Health Organization (WHO) has defined ‘health’ as a state of complete physical, mental, and social well-being, suggesting that health is a multi-layered concept and that the assessment of the health status of older people requires the use of multiple health measures (Ng et al., 2014). Thus, there is growing concern about the complex health conditions of the growing older population and their different needs for health services

\* Corresponding author.

E-mail addresses: [huyiworking@163.com](mailto:huyiworking@163.com) (Y. Hu), [wangzhy323@mail2.sysu.edu.cn](mailto:wangzhy323@mail2.sysu.edu.cn) (Z. Wang), [57128241@qq.com](mailto:57128241@qq.com) (L. Wu).

<sup>1</sup> These authors contributed equally to this work and share first authorship.

(Looman et al., 2018; Ye et al., 2019).

Chronological age, for a surprisingly substantial portion of the older population, is not a relevant marker when it comes to understanding, measuring, or experiencing healthy aging (Lowsky et al., 2014). In order to predict the health status of older individuals, it is typically necessary to consider various factors. These may include indicators of chronic disease, functional capacity, mental health, cognition, personal eating habits, and social and family support. By examining the independent relationship among these factors, it becomes possible to develop a more comprehensive understanding of an individual's overall health status (Boume & Mcgrowder, 2009; Chen et al., 2020; Kim et al., 2010; Kushida et al., 2020; Lafortune et al., 2009b; Martin et al., 2019). Older persons vary considerably in terms of health status and psychological needs, multiple dimensions of health indicators interact to influence the overall health status, resulting in a high degree of heterogeneity in the health status of older people (Wang & Liu, 2023).

To the best of our knowledge, there are not many studies investigating the health of older adults from a multidimensional perspective, especially for Chinese older adults (Chang et al., 2013; Ye et al., 2020). It is becoming increasingly necessary to assess the heterogeneity of a person's physical, psychological, and social health given the variety of health concerns they experience. Thus, over the past three decades, a recognition of the need for more sophisticated models that can differentiate between various levels of heterogeneity (Ye et al., 2020). As a "person-centered" approach, the latent class analysis (LCA) aims to identify subgroups of people who share common characteristics in such a way that people within the subgroups have a similar scoring pattern on the measured variables (Kongsted & Nielsen, 2017). LCA's classification is model-based and statistical diagnostic tools exist to assess the quality of the classification (Collins & Lanza, 2010; Muthén & Muthén, 2000). In geriatrics, LCA has been used to test for heterogeneity in the health of older people to test the validity of person-centered approach (Rely et al., 2020). In addition, LCA has been applied to distinguish or identify male older adults health service use (Bibiano et al., 2019), chronically ill patients in primary care (Smeets et al., 2020) as well as to the cognitive functioning among depressed older adults without dementia (Morin et al., 2019). Therefore, LCA can be a useful approach to study older people's health.

Despite the increase global research on health heterogeneity in older people, there is limited research on the heterogeneous and multidimensional health groups among the older Chinese population using person-centered approaches (Ye et al., 2019). There are still some knowledge gaps about what multidimensional health classes will emerge in the ageing process. More research is needed on the multidimensional health of older Chinese people and integrate physical, psychological, and social indicators to measure heterogeneous health more comprehensively. At the same time, two unanswered questions remain: a. What are the current classes of multidimensional health among Chinese older adults? and b. What factors influence these classes? This study aims to use latent class analysis to assess the health status of older people in terms of multiple dimensions in order to identify their specific health service needs and provide appropriate interventions and health policies for different groups of older people in China. Moreover, we hope that this study will inspire Southeast Asian countries that are in a similar situation to China.

## 2. Materials and methods

We utilized data from the China Health and Retirement Longitudinal Study (CHARLS) wave 4 (2018) and employed the LCA approach to analyze the health latent class of older people in China. The ultimate goal is to assist managers in comprehending the variability in the health status and health service needs of older people, and to develop targeted healthcare interventions to facilitate healthcare resource planning.

### 2.1. Conceptual framework of older people's health determinants

Ageing can only be a positive experience if it is accompanied by sustained health, engagement, and safety (World Health Organization, 2007). Identifying the factors that affect older people's health is a crucial initial step in providing help to older adults (Liu et al., 2019). According to the Active Ageing Framework proposed by the WHO, 'active ageing' is determined by a variety of factors, including personal, health and social services, behavioral, economic, physical environment, social environment, health and social service systems (World Health Organization, 2007). Gaining a comprehensive understanding of these determinants will not only enhance our understanding the ageing process but also enable the development of effective health promotion policies and programmes for older people.

In general, as individuals age, they become more susceptible to chronic diseases and their health is more vulnerable to impairment (Hu et al., 2015). Additionally, older people is often associated with an increased risk of various diseases and injuries, such as musculoskeletal problems, heart disease or obesity (Farrow & Reynolds, 2012). It is important to acknowledge that men and women may experience health disparities due to differences in biological and social status, making gender an important dimension in the studying health in geriatrics (World Health Organization, 2007). Research indicates significant gender differences in health self-assessment, physical illness, and levels of social engagement among older people (Carmel, 2019; Ye et al., 2020). Previous studies have also demonstrated the profound impact of education on the physical and mental health of older people (Côté-Sergent et al., 2020; Sperandei et al., 2023).

The importance of family social support for an individual's psychological health and well-being cannot be overstated (Dunst, 2023). Spouses and children are crucial sources of family social support. The influence of a spouse on the health and well-being of older adults has been well established, with many studies finding that separated or divorced, widowed, and unmarried individuals has higher rates of mortality, depression, and cognitive impairment compared to their married counterparts (Liu et al., 2019; Sandoval & Alvear, 2022; Srivastava et al., 2021). Children can also provide support to older adults, and the degree of closeness between children and older people can have an impact on the overall health status of older people (Bai & Gu, 2021). As China's population continues to age, it is worth exploring the impact of the number of children on the health of older people.

Health-related behavioral factors encompass a range of highly prevalent behaviors. According to Pender et al. (1990), health-related behavior refers to the actions taken by individuals to promote their own health, achieve self-satisfaction, and self-fulfillment. These behaviors encompass health responsibility, dietary nutrition, physical exercise, interpersonal interactions, stress management, and self-actualization (. As for older people's behavioral factor, a balanced diet, moderate exercise, and not smoking or drinking alcohol are all relevant to their health (Du, 2019; Wang, 2020).

The relationship between socioeconomic status and health has been explored in various fields of social science, and it is often found that individuals with higher socioeconomic status tend to have better health outcomes, indicating the presence of a socioeconomic status-health gradient (Demakakos et al., 2008). Economic resources, such as savings and wealth, as an important dimension of socioeconomic status, also exhibit a significant positive relationship with health. Economic resources represent the ability to meet various needs during this life stage for older adults. Individuals with greater economic resources can improve their health status by purchasing more healthcare services. Higher social status, as reflected in abundant economic resources, also contributes to higher levels of psychological satisfaction or well-being, which in turn improves overall health (Xue & Witvorapong, 2022).

A number of studies have shown that health is related to various aspects of the physical and social environment, and that older persons in particular are more sensitive and susceptible to negative features of the

living environment than other age groups (Dujardin et al., 2014; Liu et al., 2017). Considering that the community serves as the primary platform for social engagement among older people in China, it is important to examine physical environment factors by assessing at the external surrounding in which older people live, such as the accessibility of older people services, activity facilities, clean air and safe housing (Xie & Wang, 2019). Given the disparities in physical environmental conditions and support services, special attention must be paid to those older people living in rural areas, where disease patterns may differ. Moreover, the provisions of primary healthcare and care services within community play a crucial role in the health of older adults. Health and social service professionals can contribute to the establishment of social networks for older people through initiatives like social and community groups, home care, intergenerational programmes, and outreach services (World Health Organization, 2007). Hence, factors related to health and social service systems should be incorporated into the assessment of the social environment factor.

Some of the research on factors affecting the health of older people broadly follows the framework of the ‘social-psychological-biomedical model’, focusing on natural attributes (age and gender), socioeconomic status (occupation, education, marriage, living arrangements, sources of livelihood, health insurance) and lifestyle (tobacco use, alcohol consumption, exercise, participation in social activities) (Jiang et al., 2015). However, this framework may overlook the impact of the home, physical environment, and social environment on the health of older adults. In the Chinese context in particular, the number of children and marital status have a significant impact on older people’s retirement arrangements (Wang et al., 2022). In summary, taking into account China’s national context and related studies, this study modified and expanded on the WHO framework of influencing factors for Active Ageing, and proposed a framework for analyzing factors influencing the health of older people in China (see Fig. 1).

2.2. Data

The data utilized for this study were derived from the CHARLS wave 4 (2018). The CHARLS was implemented by the National School of Development of Peking University, it collected a high-quality nationally representative sample of Chinese residents aged 45 and older. Detailed information about the CHARLS design strategy has been described elsewhere, and the ethical approval of data collection was from the Biomedical Ethics Review Committee of Pecking University (IRB00001052-11015) (Zhao et al., 2014). After excluding participants

who were not older adults and those with missing key variables, the final study population consisted of 4190 older adults (aged 60 or above). This rigorous sample selection process ensured the inclusion of a representative sample for analysis.

2.3. Measurements

2.3.1. Multidimensional health

In this study, six indicators, Activities of Daily Living (ADLs), Instrumental Activities of Daily Living (IADLs), Doctor Diagnosed Chronic Diseases, Depressive Symptoms, Cognitive Function, and Social Participation, were selected to represent the multidimensional health of older adults.

ADLs and IADLs reflect an individual’s ability to live independently without assistance of others, and are considered to be indicators that allow for a detailed, precise, and objective assessment of the “functioning” of older people (Katz et al., 1963; Lawton & Brody, 1969). ADLs were assessed with the ADL scale (Katz et al., 1963). Participants were asked if they had difficulties with bathing, eating, getting in or out of bed, dressing, using the toilet, and controlling urination and defecation. A score of 0 was assigned to an item if the respondent could complete it without help, and a score of 1 was assigned if assistance was required. The total score of ADLs ranges from 0 to 6, representing the cumulative difficulty level across the six activities. Based on the ADLs score, The subjects were divided into seven categories, with serial numbers ranging from 1 (without difficulties) to 7 (6 items with difficulties).

IADLs were measured by the Lawton IADL Scale (Lawton & Brody, 1969). The respondents were asked, “Because of health and memory problems, do you have any difficulties with doing household chores/preparing hot meals/shopping for groceries/taking medications/managing your money?” The IADLs is scored in the same way as the ADLs. Based on the IADLs score, the subjects were divided into six categories, with serial numbers ranging from 1 (without difficulties) to 6 (5 items with difficulties).

The prevalence of chronic diseases can effectively reflect the objective physical health status of older adults. Doctor diagnosed chronic diseases were measured by the question “Have you been diagnosed with conditions listed below by a doctor?” The conditions included hypertension, dyslipidemia, diabetes, cancer, liver diseases, chronic lung diseases, heart attack, stroke, kidney disease, stomach or other digestive diseases, psychiatric problems, memory-related disease, arthritis or rheumatism, and asthma. According to the answers, subjects were categorized as “no chronic disease”, “diagnosed with 1 chronic diseases”

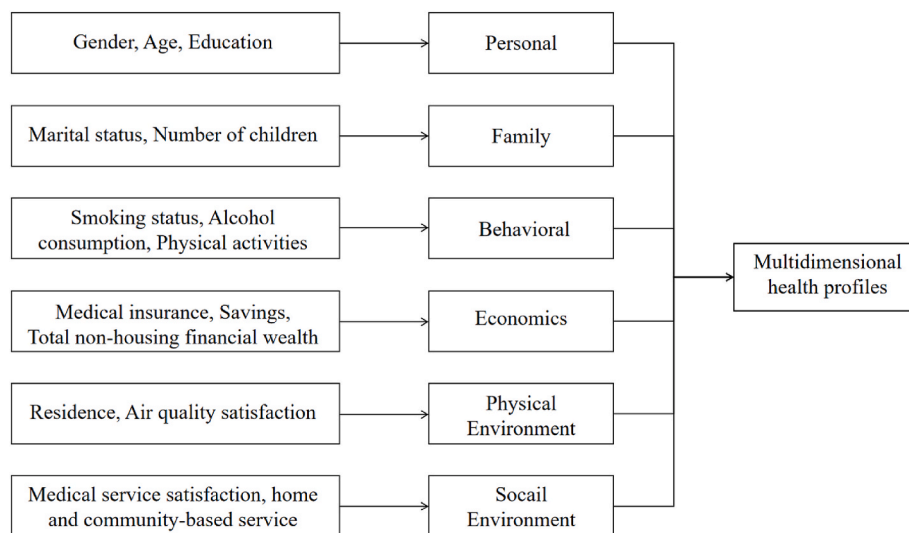


Fig. 1. Conceptual framework for the influencing factors of multidimensional health profiles  
 Alt Tex: Specific factors influencing the multidimensional health profiles of older adults proposed within the framework of active ageing.

and “diagnosed with 2 or more chronic diseases”.

Mental health dimensions are growing in importance as key dimensions of health indicators in old age. The mental health of older adults is usually measured using conventional diagnostic scales for mental disorders, which include depression and cognitive functioning in older adults. Depressive symptoms were assessed using the 10-item Center for Epidemiological Studies Depression Scale (CES-D 10) (Sil-verstein et al., 2020). The survey respondents were asked about their feelings and behaviors over the past week. Total score on the CES-D 10 scale is 0–30, with higher scores indicating more severe depression. Generally, a cutoff score of  $\geq 10$  on the CES-D 10 scale is considered to indicate the respondent has depressive symptoms (Andresen et al., 1994). In this study, subjects scoring  $<10$  on the CES-D 10 scale were categorized as “not having depressive symptoms”, and those scoring  $\geq 10$  on the CES-D 10 scale were categorized as “having depressive symptoms”.

Cognitive function was measured using the brief Community Screening Instrument for Dementia (CSI-D) (Prince et al., 2011). The scale consists of two sections: the section for respondent, consisting of seven cognitive test items, and the informant part, consisting of six questions assessing changes in the subject’s daily functioning. The CSI-D score is calculated by subtracting the informant section score from the respondent section score, with scores ranging from  $-6$  to  $9$ . Scores of 4 or less are indicative of a high likelihood of dementia. Based on their CSI-D score, subjects were classified as “low probability of being demented” (CSI-D score  $\leq 4$ ) and “high probability of being demented” (CSI-D score  $>4$ ).

Social functioning emphasizes benign interactions between people and their environment, and social participation serves as an objective indicator for measuring it (Ware, 1987). Social participation was elicited by asking the respondents “Have you done any of these activities in the last month?” Depending on the number of social activities they reported being involved in, subjects were categorized as “not involved in social activity”, “involved in 1 social activity” or “involved in 2 or more social activities”.

### 2.3.2. Independent variables

Personal variables included gender, age, and education, all of which were assessed by self-reports during the interview. Gender was categorized as either male or female. Age was given as a categorical variable for 60–69 years old, 70–79 years old, and  $\geq 80$  years old, respectively. Education was divided into three groups: “illiterate”, “elementary school”, and “middle school or above” according to the question “What’s the highest level of education you have now?”

Family indicators included marital status and the number of children. Marital status was divided into two categories, those with spouses, including married and live with spouse, married but don’t live with spouse temporarily for reasons such as work, and those without spouses, including don’t live together as a couple anymore, divorced, widowed, never married. According to the question “How many children who are still alive do you have?” subjects were categorized as “no children”, “have 1–2 children” and “have 3 or more children”.

Behavioral indicator included smoking status, alcohol consumption, and physical activity. Smoking status was assessed by two questions: “Have you ever chewed tobacco, smoked a pipe, smoked self-rolled cigarettes, or smoked cigarettes/cigars?” “Do you still have the habit or have you totally quit?” The subjects were grouped into “still smoking”, “quit” and “never smoked”. As for alcohol consumption, the respondents were categorized into three groups: “non-drinkers”, “light drinkers” and “heavy drinkers”. Heavy drink refers to the respondents drinking alcoholic beverages more than twice a week in the past year. Physical activity was divided into three categories, including “vigorous-intensity physical activity: yes/no”, “moderate physical activity: yes/no”, and “mild physical activities: yes/no”.

Economic indicators were reflected by medical insurance, savings and total non-housing financial wealth. Medical insurance indicated

whether the respondent was covered by any public or private health insurance program, such as urban employee medical insurance, new rural cooperative medical insurance, long-term care insurance, private medical insurance. Savings was measured based on the question “What is the total amount of deposits you are currently holding in financial institutions (e.g.: bank, credit union)?” Total non-housing financial wealth was calculated according to the question for the respondent’s own financial situation, in which we exclude property and business assets (Dinh et al., 2022). Specifically, total non-housing financial wealth is derived by adding the value of cash, deposit, stocks, mutual funds, government bonds, all other savings, and subtracting the total value of debt. Savings and total non-housing financial wealth were operationalized as categorical variables.

Physical environment indicators included residence and air quality satisfaction. The residence categories were city and village. Air quality satisfaction was used to measure the subjective satisfaction level of older adults for with air quality.

Social environment indicators included medical service satisfaction, and home and community-based service (HCBS). The variable “medical service satisfaction” reflected the satisfaction with the quality, cost, and convenience of local medical services. HCBS was measured by whether the respondent had received home and community care services, which included daycare centers, nursing homes, senior dining tables, regular physical examination, onsite visits, family beds, community nursing, health management, entertainment.

## 2.4. Statistical analysis

This study used LCA to identify latent classes of multidimensional health among older adults. LCA is a person-centered analysis technique that explains the relationship between observed variables and latent variables (Vermunt & Magidson, 2003). LCA aims to identify subgroups with shared characteristics, where individuals within each subgroup exhibit similar distributions in observed variables, while the distributions between subgroups are as distinct as possible (Collins & Lanza, 2010). Starting with an initial model assuming one category, the number of categories in the model is gradually increased until the optimal model fit test index was achieved. By comparing models with different numbers of categories, the best latent class model was determined based on both fit quality and practical significance considerations (Weller et al., 2020).

The Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and adjusted BIC (aBIC) are used as model fit test indexes for LCA, and a smaller index indicates a better model fit (Hagenaars & McCutcheon, 2002). Entropy values were used to assess the accuracy of the model classification, with Entropy values ranging from 0 to 1. Lubke and Muthén (2007) stated that Entropy  $<0.60$  corresponds to more than 20% of individuals with classification errors. The difference in fit between  $n$  and  $n-1$  models was compared using Lo–Mendell–Rubin adjusted likelihood ratio test (LMR) and the bootstrapped likelihood ratio test (BLRT), and the significant  $p$ -value ( $p < 0.05$ ) indicating that the  $k$  model significantly outperformed the  $n-1$  model. LCA analyses were carried out using Mplus 8.3.

A multinomial logistic model was adopted to examine the influencing factor on the health latent classes of older adults. Data management and analysis were performed using SPSS 22.0. A  $p$ -value  $<0.05$  was regarded as statistically significant.

## 3. Results

### 3.1. Descriptive statistics

The descriptive statistics of 4190 older adults are presented in Table 1. The analysis reveals that the majority (91.5%) of the participants reported having no difficulties in ADLs, while 79.8% reported having no difficulties in IADLs. Just 9.6% of the participants had no chronic diseases, whereas 71.8% reported having two or more chronic



**Table 1**  
Characteristics of health indicators and determinants of older adults.

Variables	N (%)
<b>Multidimensional health</b>	
<b>ADLs</b>	
Without difficulties	3832 (91.5)
1 item with difficulties	258 (6.2)
2 items with difficulties	55 (1.3)
3 items with difficulties	16 (0.4)
4 items with difficulties	16 (0.4)
5 items with difficulties	9 (0.2)
6 items with difficulties	4 (0.1)
<b>IADLs</b>	
Without difficulties	3344 (79.8)
1 item with difficulties	447 (10.7)
2 items with difficulties	203 (4.8)
3 items with difficulties	116 (2.8)
4 items with difficulties	50 (1.2)
5 items with difficulties	30 (0.7)
<b>Doctor diagnosed chronic diseases</b>	
No chronic diseases	403 (9.6)
Diagnosed with 1 chronic disease	780 (18.6)
Diagnosed with 2 or more chronic diseases	3007 (71.8)
<b>Depressive symptoms</b>	
Not having depressive symptoms	2384 (56.9)
Having depressive symptoms	1806 (43.1)
<b>Cognitive function</b>	
Low probability of being demented	2288 (54.6)
High probability of being demented	1902 (45.4)
<b>Social participation</b>	
Not involved in social activity	2032 (48.5)
Involved in 1 social activity	1298 (31.0)
Involved in 2 or more social activities	860 (20.5)
<b>Independent Variables</b>	
<b>Gender</b>	
Male	1962 (46.8)
Female	2228 (53.2)
<b>Age (years)</b>	
60-69	2724 (65.0)
70-79	1211 (28.9)
≥80	255 (6.1)
<b>Education</b>	
Illiterate	997 (23.8)
Elementary school	1995 (47.6)
Middle school or above	1198 (28.6)
<b>Marital status</b>	
Without spouses	672 (16.0)
With spouses	3518 (84.0)
<b>Number of children</b>	
No children	14 (0.3)
Have 1–2 children	1001 (23.9)
Have 3 or more children	3175 (75.8)
<b>Smoking status</b>	
Still smoking	2386 (56.9)
Quit	769 (18.4)
Never smoked	1035 (24.7)
<b>Alcohol consumption</b>	
Heavy drinkers	696 (16.6)
Light drinkers	578 (13.8)
Non-drinkers	2916 (69.6)
<b>Vigorous-intensity physical activity</b>	
No	3120 (74.5)
Yes	1070 (25.5)
<b>Moderate physical activity</b>	
No	2200 (52.5)
Yes	1990 (47.5)
<b>Light physical activity</b>	
No	744 (17.8)
Yes	3446 (82.2)
<b>Medical insurance</b>	
No	204 (4.9)
Yes	3986 (95.1)
<b>Savings (yuan)</b>	
0	2632 (62.8)
(0–10000]	737 (17.6)
(10,000–20,0000]	238 (5.7)
(20,000–50,0000]	330 (7.9)

**Table 1 (continued)**

Variables	N (%)
>50,000	253 (6.0)
<b>Total non-housing financial wealth (yuan)</b>	
<0	294 (7.0)
0	543 (13.0)
(0–10000]	2155 (51.4)
(10,000–20,0000]	330 (7.9)
(20,000–50,0000]	441 (10.5)
>50,000	427 (10.2)
<b>Residence</b>	
City	1269 (30.3)
Village	2921 (69.7)
<b>Air quality satisfaction</b>	
Completely satisfied	181 (4.3)
Very satisfied	1108 (26.4)
Somewhat satisfied	2193 (52.3)
Not very satisfied	586 (14.0)
Not at all satisfied	122 (2.9)
<b>Medical service satisfaction</b>	
Very satisfied	646 (15.4)
Somewhat satisfied	965 (23.0)
Neutral	1805 (43.1)
Somewhat dissatisfied	382 (9.1)
Somewhat dissatisfied	392 (9.4)
<b>HCBS</b>	
No	3274 (78.1)
Yes	916 (21.9)

diseases. Depressive symptoms and high probability of being demented were reported by 43.1% and 45.4% of participants, respectively. A considerable proportion (48.5%) of the sample reported having no involvement in social activities.

Among the 4190 older adults included in this study, 53.2% were female. A small proportion of participants (6.1%) were aged 80 years or older, while the majority (65.0%) fell into the age range of 60–69 years. The majority of the respondents (47.6%) had only attained elementary level education. 84.0% were with spouses, and 75.8% were having 3 or more children. A significant proportion of the respondents reported they were still smoking (56.9%), but a large majority reported they were non-drinkers (69.6%). In terms of physical activity, 25.5%, 47.5%, 82.2% of the respondents engage in vigorous-intensity physical activity, moderate physical activity, and mild physical activity every week. The majority of the respondents had medical insurance (95.1%). More than half of the respondents reported having no savings (62.8%), and possessing a total non-housing financial wealth of 0–10000 yuan (51.4%). Additionally, more than half of respondents lived in village (69.7%), and expressed somewhat satisfied with the air quality (52.3%). 43.1% of the respondents reported being neutral satisfaction with the medical service, and 78.1% reported not received HCBS.

### 3.2. Identification of patterns of multidimensional health

Six multidimensional health indicators were used as explicit indicators, and the number of health latent classes was sequentially increased to estimate the fit of the model. A comparison of LCA model fit statistics was shown in Table 2. The five-class model obtained the smallest AIC. However, the BIC (35138.613) and aBIC (34970.201) value for three-class were smallest. Besides, the Entropy index is greater than 0.60 in three-class, representing the high certainty of classification. Therefore, we adopted the three-class LCA model as the final solution. The average posterior probabilities of belonging to each class were 0.825, 0.782, and 0.855 respectively, which indicates good classification reliability.

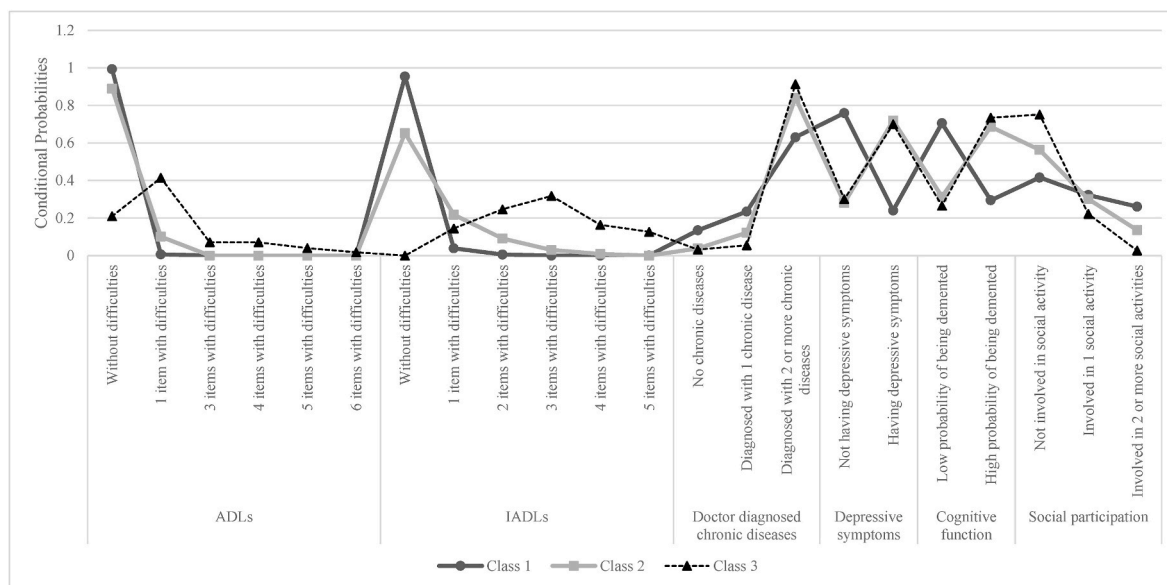
Based on the identification of the latent health profiles, the health indicator conditional probabilities ( $\lambda$ ) were obtained, as shown in Fig. 2, based on which the characteristics of each class were further analyzed and labeled.

Class 1 had the highest number of people ( $n = 2806, 66.97%$ ), and

**Table 2**  
The model fit statistics for 1- to 5-class models.

model	k	AIC	BIC	aBIC	entropy	LMR	BLRT	Classes Probabilities
1	17	36,179.013	36,286.801	36,232.782	–	–	–	1.00
2	35	34,992.957	35,214.873	35,103.658	<b>0.702</b>	***	***	0.829/0.171
3	53	34,802.569	<b>35,138.613</b>	<b>34,970.201</b>	<b>0.619</b>	***	***	0.670/0.284/0.046
4	71	34,759.080	35,209.252	34,983.644	0.548	0.037	***	0.495/0.133/0.045/0.327
5	89	<b>34,740.069</b>	35,304.369	35,021.565	0.495	1.000	***	0.138/0.021/0.315/0.138/0.388

**Notes:** k: Number of parameters. AIC: Akaike Information Criterion. BIC: Bayesian Information Criterion. aBIC: adjusted BIC. LMR: Lo–Mendell–Rubin adjusted likelihood ratio test. BLRT: Bootstrapped Likelihood Ratio Test. \*\*\*: significance levels of 0.1%.



**Fig. 2.** Conditional probabilities per health latent class for older adults

**Alt Text:** Overview of the distribution in the three latent classes. This figure shows the distribution probabilities of older adults in each health indicator for each class.

this group of older adults was characterized by the highest probabilities of without difficulties in ADLs ( $\lambda = 0.993$ ) and without difficulties in IADLs ( $\lambda = 0.945$ ); higher probabilities of having no chronic disease ( $\lambda = 0.135$ ) and diagnosed with 1 chronic disease ( $\lambda = 0.235$ ) than the other two groups, but lower probability of diagnosed with 2 or more chronic diseases ( $\lambda = 0.630$ ). The probabilities of having no depressive symptoms ( $\lambda = 0.759$ ), low probability of being demented ( $\lambda = 0.705$ ), and involving in social activities ( $\lambda = 0.584$ ) was higher than the other two groups. In general, older adults in class 1 were better off physically, mentally, and socially engaged, so this class was named the “Relatively Healthy”; The class 2 ( $n = 1189, 28.38\%$ ) had the highest probability of having depressive symptoms ( $\lambda = 0.719$ ). Moreover, the class 2 was relatively high probabilities of ADLs difficulties ( $\lambda = 0.111$  in 1–2 items with difficulties) and IADLs difficulties ( $\lambda = 0.348$  in 1–4 items with difficulties), high probabilities of diagnosed with 2 or more chronic diseases ( $\lambda = 0.840$ ) and high probability of being demented ( $\lambda = 0.686$ ). We labeled this class as “Highly Depressed and Relatively Health Risk”; Class 3 ( $n = 195, 4.65\%$ ) was characterized by the highest probabilities of ADLs difficulties ( $\lambda = 0.790$  in 1–6 items with difficulties), IADLs difficulties ( $\lambda = 1.00$  in 1–5 items with difficulties), diagnosed with 2 or more chronic conditions ( $\lambda = 0.913$ ), high probability of being demented ( $\lambda = 0.734$ ) and not involving in social activities ( $\lambda = 0.751$ ). The health status was the worst among the three classes, hence this class is named the “Functional Impairment”.

3.3. Determinants of the patterns of multidimensional health

Table 3 presents the results of multinomial logistic regression analysis.

3.3.1. Class 2 versus class 1

Older adults who had lower levels of education, such as illiterate (OR: 2.216, 95% CI: 1.753–2.800) and elementary education (OR: 1.629, 95% CI: 1.340–1.979), and those who did not have a spouse (OR: 1.265, 95% CI: 1.035–1.546), did not engage in moderate physical activity (OR: 1.201, 95% CI: 1.034–1.395) and light physical activity (OR: 1.326, 95% CI: 1.103–1.395), and with savings of 0 yuan (OR: 2.909, 95% CI: 1.492–5.674), 0–10,000 yuan (OR: 2.521, 95% CI: 1.282–4.956), and 20,000–50,0000 yuan (OR: 1.943, 95% CI: 1.068–3.533) were more likely to belong to the “Highly Depressed and Relatively Health Risk” class compared to the “Relatively Healthy” class.

Older adults who were male (OR: 0.719, 95% CI: 0.575–0.899), aged 60–69 years old (OR: 0.723, 95% CI: 0.524–0.996), had 1–2 children (OR: 0.736, 95% CI: 0.611–0.886), were heavy drinkers (OR: 0.739, 95% CI: 0.593–0.920) and light drinkers (OR: 0.786, 95% CI: 0.627–0.985), lived in city area (OR: 0.669, 95% CI: 0.557–0.804), were completely satisfied (OR: 0.457, 95% CI: 0.269–0.779), very satisfied (OR: 0.486, 95% CI: 0.319–0.742), and somewhat satisfied (OR: 0.612, 95% CI: 0.407–0.920) with air quality, and were very satisfied (OR: 0.578, 95% CI: 0.431–0.775), somewhat satisfied (OR: 0.585, 95% CI: 0.446–0.768), and neutral satisfied (OR: 0.587, 95% CI: 0.457–0.754) with medical service were less likely to be in the “Relatively Healthy” class compared to the “Highly Depressed and Relatively Health Risk” class.

3.3.2. Class 3 versus class 1

According to our analysis, older adults who did not engage in vigorous-intensity physical activity (OR: 5.150, 95% CI: 2.576–10.294), moderate physical activity (OR: 2.999, 95% CI: 2.033–4.424), and light

**Table 3**  
Determinants of the patterns of multidimensional health using a multinomial logistic regression.

	All	
	Class 2 vs. Class 1	Class 3 vs. Class 1
	OR (95% CI)	OR (95% CI)
<b>Gender (ref: Female)</b>		
Male	0.719 (0.575–0.899) *	1.272 (0.806–2.006)
<b>Age (years) (ref: ≥ 80)</b>		
60–69	0.723 (0.524–0.996) *	0.409 (0.233–0.717)*
70–79	0.909 (0.659–1.254)	0.715 (0.415–1.232)
<b>Education (ref: Middle school or above)</b>		
Illiterate	2.216 (1.753–2.800) *	1.238 (0.766–2.001)
Elementary school	1.629 (1.340–1.979) *	0.966 (0.651–1.434)
<b>Marital status (ref: With spouses)</b>		
Without spouses	1.265 (1.035–1.546) *	0.895 (0.581–1.379)
<b>Number of children (ref: Have 3 or more children)</b>		
No children	1.537 (0.484–4.876)	2.965 (0.322–27.332)
Have 1–2 children	0.736 (0.611–0.886) *	0.873 (0.580–1.315)
<b>Smoking status (ref: Never smoked)</b>		
Still smoking	0.821 (0.654–1.032)	1.400 (0.852–2.302)
Quit	1.247 (0.996–1.561)	1.585 (0.979–2.566)
<b>Alcohol consumption (ref: Non-drinkers)</b>		
Heavy drinkers	0.739 (0.593–0.920) *	0.432 (0.253–0.738)*
Light drinkers	0.786 (0.627–0.985) *	0.409 (0.219–0.762)*
<b>Vigorous-intensity physical activity (ref: Yes)</b>		
No	0.927 (0.782–1.100)	5.150 (2.576–10.294)*
<b>Moderate physical activity (ref: Yes)</b>		
No	1.201 (1.034–1.395) *	2.999 (2.033–4.424)*
<b>Mild physical activity (ref: Yes)</b>		
No	1.326 (1.103–1.594) *	2.506 (1.813–3.465)*
<b>Medical insurance (ref: Yes)</b>		
No	1.075 (0.777–1.487)	1.167 (0.584–2.332)
<b>Savings (yuan) (ref: &gt; 50,000)</b>		
0	2.909 (1.492–5.674)*	16.175 (2.885–90.694) *
(0–10,000]	2.521 (1.282–4.956) *	10.850 (1.869–62.976) *
(10,000–20,0000]	1.810 (0.896–3.656)	10.215 (1.669–62.505) *
(20,000–50,0000]	1.943 (1.068–3.533) *	6.561 (1.268–33.941)*
<b>Total non-housing financial wealth (yuan) (ref: &gt; 50,000)</b>		
<0	1.578 (0.897–2.774)	0.945 (0.305–2.927)
0	1.045 (0.604–1.810)	0.649 (0.224–1.880)
(0–10,000]	1.064 (0.634–1.785)	0.536 (0.194–1.481)
(10,000–20,0000]	0.836 (0.477–1.464)	0.315 (0.094–1.056)
(20,000–50,0000]	0.924 (0.572–1.494)	0.390 (0.141–1.081)
<b>Residence (ref: Village)</b>		
City	0.669 (0.557–0.804) *	0.711 (0.489–1.033) *
<b>Air quality satisfaction (ref: Not at all satisfied)</b>		
Completely satisfied	0.457 (0.269–0.779) *	0.379 (0.127–1.134)
Very satisfied	0.486 (0.319–0.742) *	0.668 (0.299–1.492)
Somewhat satisfied	0.612 (0.407–0.920) *	0.518 (0.236–1.136)
Not very satisfied	0.755 (0.489–1.167)	0.560 (0.237–1.321)
<b>Medical service satisfaction (ref: Somewhat dissatisfied)</b>		
Very satisfied	0.578 (0.431–0.775) *	0.481 (0.269–0.860)*
Somewhat satisfied	0.585 (0.446–0.768) *	0.572 (0.338–0.968)*

**Table 3 (continued)**

	All	
	Class 2 vs. Class 1	Class 3 vs. Class 1
	OR (95% CI)	OR (95% CI)
Neutral	0.587 (0.457–0.754) *	0.476 (0.290–0.781)*
Somewhat dissatisfied	0.737 (0.534–1.016)	0.616 (0.321–1.184)
<b>HCBS (ref: Yes)</b>		
No	1.090 (0.913–1.301)	1.402 (0.916–2.145)

Notes: \*denote significance levels of 5%.

physical activity (OR: 2.506, 95% CI: 1.813–3.465), and with savings of 0 yuan (OR: 16.175, 95% CI: 2.885–90.694), 0–10,000 yuan (OR: 10.850, 95% CI: 1.869–62.976), 10,000–20,0000 yuan (OR: 10.215, 95% CI: 1.669–62.505) and 20,000–50,0000 yuan (OR: 6.561, 95% CI: 1.268–33.941) were more likely to be in the “Functional Impairment” class compared to the “Relatively Healthy” class.

Older adults aged 60–69 years old (OR: 0.409, 95% CI: 0.233–0.717), heavy drinkers (OR: 0.432, 95% CI: 0.253–0.738) and light drinkers (OR: 0.409, 95% CI: 0.219–0.762), and those who were very satisfied (OR: 0.481, 95% CI: 0.269–0.860), somewhat satisfied (OR: 0.572, 95% CI: 0.338–0.968), and neutral satisfied (OR: 0.476, 95% CI: 0.290–0.781) with medical service were less likely to be classified in the “Functional Impairment” class compared to the “Relatively Healthy” class.

### 3.4. Discussion

Utilizing the CHARLS, we have identified three latent classes of multidimensional health among older adults and examined the factors associated with these patterns. The study categorized the multidimensional health status of 4190 older adults into three classes: “Relatively Healthy” (Class 1, 66.97%), “Highly Depressed and Relatively Health Risk” (Class 2, 28.38%), and “Functional Impairment” (Class 3, 4.65%). Previous research employing LCA to describe the latent classes of multidimensional health among older adults has produced varying results in terms of the number of identified classes. For instance, a Dutch study identified six latent classes using six variables encompassing physical, psychological, social, and cognitive functioning domains within a cross-sectional sample of 43,704 older adults (Looman et al., 2018). Another study conducted LCA on seven health indicators among 2444 older adults (aged ≥60 years) in Singapore, resulting in the identification of two distinct health status profiles (Ng et al., 2014). Liu (2014) categorized older adults in Taiwan into four groups based on their health status: High Comorbidity, Functional Impairment, Frail, and Relatively Healthy. These studies suggest disparities in the distribution and characteristics of health status among older adults. Our findings contribute to a better understanding of the heterogeneity of health among Chinese older adults.

Consistent with previous studies in Singapore (Ng et al., 2014), our findings reveal significant disparities in health status between two classes of older adults, with one class exhibiting better physical, psychological, and social health while the other faces higher health risks. Class 1 represents the largest percentage, suggesting a relatively optimistic overall health status among Chinese older adults, which is a positive result. In addition, Class 2 in this study is a unique finding that deserves attention. Nearly 30% of the respondents were in Class 2, and although their probabilities for other health indicators did not significantly differ from Class 1, they exhibited the highest probability of experiencing depressive symptoms among the three groups. Class 3 showed only slightly lower levels of depressive symptoms compared to Class 2, indicating that as depressive symptoms progress, the quality of life for older adults could be severely affected. However, further research is needed to establish the causal relationship between depressive symptoms and other dimensions of health indicators. In China, the

detection rate of depressive symptoms among older individuals aged 55 years and above was 23.6%, much higher than other age groups (Li et al., 2014). Prevention of depression is the key goal of promoting healthy ageing and active ageing. Considering the factors influencing the Highly Depressed and Relatively Health Risk Group, it is essential to prioritize the prevention and treatment of depression among key groups to safeguard their mental well-being.

Moreover, our study utilizes the analytical framework of active ageing to identify and select health determinants, enabling a more comprehensive assessment of the relationship between multidimensional health and these factors compared to earlier studies (Looman et al., 2018; Ye et al., 2019). Regarding personal factors, being male and younger were identified as protective factors for the health of older adults, whereas lower levels of education attainment were found to be a negative factor. Women are known to experience significant health disparities compared to men, which can be attributed to differences in socioeconomic status, physical status, and access to healthcare services (Balachandran & James, 2021; Kieny et al., 2021). Ageing can lead to systemic impairment of function, loss of adaptive responses to stress, and increased risk of age-related disease as a disease risk factor (Niccoli & Partridge, 2012). Previous research has consistently demonstrated that higher levels of education can enhance health literacy and facilitate access to medical or preventive health services (Hinata, A., Kabasawa, K., Watanabe, Y., Kitamura, K., Ito, Y., Takachi, R., Tsugane, S., Tanaka, J., Sasaki, A., Narita, I., & Nakamura, K., 2021). Additionally, from a human capital perspective, higher levels of education can help build psychological resources to avoid potential health problems associated with depression in later life (Pei et al., 2020). Therefore, providing mental health education to older adults within the community becomes particularly vital for those with low levels of education, which can increase their social participation, improve their health literacy, and prevent the onset of depressive symptoms.

Concerning family factors, it is evident that marital status and the number of children can significantly impact the multidimensional health patterns of older adults. Older adults without spouses were more likely to be classified in Class 2, indicating an association between marital status and depressive symptoms in this population. Numerous studies have shown that men and women with spouses outperform those without spouses on various indices of mental, physical and emotional well-being. And compared to those without spouses, those with spouses usually benefit from three major health-promoting factors: general social support, health monitoring and stress reduction (Goldscheider, 1994). The diminished social support among older adults without spouses partially explains their higher risk of depression, as spouses often serve as a significant source of individual social support, thereby promoting the psychological well-being of older individuals. Older adults with 1–2 children tend to exhibit better health outcome, potentially due to the increased financial and emotional support they receive from their children, which can positively affect their emotional well-being (Gariépy et al., 2016). However, further research is required to establish a more precise relationship between the number of adult children and improved health outcomes among older adults. In conclusion, our findings highlight the positive role of family support in promoting the health of older adults, which can help alleviate and prevent the physical and mental damage caused by negative emotions to a certain extent. Throughout history, as a typical Asian country, China, which promotes a traditional culture of filial piety, the family has been the most important area in which members of society have access to welfare resources, and the functions of the family are irreplaceable by any formal or informal social security system established outside the family (Shi, 2014). Governments should activate the family's older-care function and improve the overall health of older persons by enacting public policies that encourage older persons to remarry, provide tax incentives for family members to bring home older relatives with disabilities, provide public funding for "respite" and other supportive services, and provide cash grants to low-income families to care for older

relatives (Doty, 1986).

In terms of behavioral factors, an interesting finding emerged from our study, suggesting that older people who were either light or heavy drinkers appeared to be relatively healthier. This implies that drinking alcoholic beverage may have a protective effect on the health of older adults to some extent. One possible explanation for this observation is that a higher frequency of alcohol consumption is associated with increased social participation (Vogelsang & Lariscy, 2020). Alcohol is often consumed during social activities such as socializing with friends, attending parties or events, and engaging in sports or recreational activities. Although alcohol consumption is known to be harmful to health, there has been a great deal of evidence in the past that moderate alcohol consumption in older people can have some benefits, such as reducing the risk of cardiovascular disease (Mukamal et al., 2003), reducing the risk of premature death, reducing the chances of Alzheimer's disease (Ferreira & Weems, 2008), providing some protection against cancer and even positively affecting bone density in older women (Knight et al., 2003; McPherson, 2007). However, it is important to note that this finding may be a temporary illusion. While alcohol can initially alleviate negative emotions to some extent, it can deplete the neurotransmitter serotonin in the brain, leading to depression and anxiety. This may result in a need to increase alcohol consumption to treat depression, creating a vicious cycle (Eashwar et al., 2020). A clear and robust conclusion from our study is that older adults who do not engage in physical activity have poorer health status. Engaging in any form of physical activity, whether it be vigorous-intensity physical activity, moderate physical activity, or mild physical activity, can have a positive impact on health. A meta analysis has shown that physically active older adults were at reduced risk of all-cause and cardiovascular mortality, ADL disability and functional limitation, as well as dementia and depression (Cunningham et al., 2020). The WHO 2020 guidelines on physical activity and sedentary behaviour recommend that individuals aged 65 years and older should aim for 150–300 minutes of moderate-intensity exercise, or 75–150 minutes of vigorous-intensity physical activity, or some equivalent combination of both, on a weekly basis (Bull et al., 2020).

With respect to economic factors, older adults with savings of less than 50,000 yuan was much more likely to be classified into Class 2 and Class 3 on compared to those with savings exceeding 50,000 yuan. It has been observed that the lower the savings level, the higher the health risk. The savings situation of older adults, to a certain extent, reflects their economic situation, which can significantly impact their daily life quality and access to medical services. Studies have suggested that individuals with poor economic conditions were more susceptible to adverse health outcomes due to unfavorable living conditions, unhealthy lifestyle, low social capital, and reduced ability to cope with stressful life events (Bialowolski et al., 2023). It is important to note that poor health status among older adults may also lead to a diminished capacity to save due to long-term healthcare needs, and in some cases, may even result in poverty as a consequence of illness. Therefore, it is necessary to apply the concept of inclusive governance, synergistically promote institutional care, family care and community care, mobilise multiple forces to provide diversified service products, reduce the cost of older-care service prices, and encourage social and non-profit organisations to provide services in the community, so as to create a friendly environment for older people (Wang et al., 2022).

On the subject of physical environment, older adults residing in rural areas were found to be more vulnerable in terms of their mental health compared to those living in urban areas. This disparity can be attributed to variations in healthcare resources, informal social support, and social capital between urban and rural areas in China (Zhang et al., 2021). Additionally, satisfaction with air quality was found to impact the multidimensional health patterns of older adults, with those who were expressing satisfaction with air quality tending to have better mental health. Previous studies have indicated that individuals living in regions with poor air quality were more likely to experience symptoms of depression (Yao et al., 2022). Moreover, satisfaction with air quality



may influence depression symptoms through perceived health status (Niu et al., 2022). Efforts should be made to improve air quality and environmental conditions, and to minimize the gap between facilities and resources for older persons in urban and rural areas in order to promote better health outcomes for older persons, particularly in terms of mental health.

As for social environment, it was found that older adults who reported higher levels of satisfaction with medical services tended to have better overall health. This can be attributed to the fact that when older adults are more satisfied with their medical services, they are more likely to adhere to their physician's treatment recommendations. This, in turn, contributes to improved health outcomes and facilitates the process of health recovery. Furthermore, previous research has established that satisfaction with medical services is not only an outcome of good health but also a determinant of health status, indicating a reciprocal relationship between the two (Paul et al., 2016). It is therefore important for communities to improve the capacity and quality of health-care services to continuously meet the health-care needs of older persons. For example, relying on contract-based family physician services, focusing on health promotion activities to prevent illnesses in older persons, controlling and maintaining the slow progression of chronic diseases, and reducing unnecessary wastage of medical and geriatric care resources are also fundamental solutions (Wang et al., 2022).

However, several limitations must be considered in interpreting the findings. Firstly, this study only utilized the data from one wave in the CHARLS study. Future studies should consider expanding the analysis to include multiple waves of data, spanning several years, in order to provide more robust evidence on the multidimensional health and its influencing factors in older individuals based on longitudinal cohort study data. Secondly, some health indicators relied on self-reported data, which may introduce reporting bias. It is crucial to validate and corroborate these self-reported measures with objective and accurate health indicators to ensure the reliability of the findings.

#### 4. Conclusion

In summary, this study used data from CHARLS 2018 to assess the multidimensional health of older adults aged 60 years and over using the LCA method to identify three health latent classes. Different subgroups of multidimensional health have been defined, and further exploration has been conducted on the risk factors that impact multidimensional health from the perspective of active aging. It shows the importance of formulating a sound health support system and providing targeted intervention measures based on heterogeneous groups to improve the multidimensional health of older people. To achieve this, it is necessary to assess and classify the health classes of older adults and provide timely and effective health management. The government should focus on improving the health level of older adults by implementing improvement strategies precisely and categorically. Additionally, the aged health support system needs improvement, and the planning and configuration of aged care service facilities should be enhanced to promote a livable environment for older people.

#### Author statement

Yi Hu: Conceived and designed the study; Collected data, processed statistics, analyzed results, and wrote and revised the article; Proofreading the article.

Zhenyu Wang: Conceived and designed the study; Collected data, wrote and revised the article; Proofreading the article and for funding acquisition.

Liqun Wu: Proofreading the article and for funding acquisition.

#### Funding

This work was supported by Sanming Project of Medicine in Shenzhen [No.SZSM202111001].

#### Declaration of interest statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

#### Ethical statement

The ethical approval of data collection was from the Biomedical Ethics Review Committee of Pecking University (IRB00001052-11015).

#### Declaration of competing interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

#### Data availability

Data will be made available on request.

#### Acknowledgments

The authors thank the CHARLS research team and all respondents for their contribution.

#### References

- Andresen, E. M., Malmgren, J. A., Carter, W. B., & Patrick, D. L. (1994). Screening for depression in well older adults: Evaluation of a short form of the CES-D (center for epidemiologic studies depression scale). *American Journal of Preventive Medicine*, 10(2), 77–84. [https://doi.org/10.1016/S0749-3797\(18\)30622-6](https://doi.org/10.1016/S0749-3797(18)30622-6)
- Bai, L., & Gu, H. (2021). Study on the influence of intergenerational support of children on the health level of the elderly in rural area. *Modern Economic Research*, 7, 40–47. <https://doi.org/10.13891/j.cnki.mer.2021.07.006>
- Balachandran, A., & James, K. S. (2021). A multi-dimensional perspective on the gender gap in health among older adults in India and China: Application of a new ageing measure. *Ageing and Society*, 41(5), 1000–1020. <https://doi.org/10.1017/S0144686X19001521>
- Bialowolski, P., Xiao, J. J., & Weziak-Bialowolska, D. (2023). Do all savings matter equally? Saving types and emotional well-being among older adults: Evidence from panel data. *Journal of Family and Economic Issues*. <https://doi.org/10.1007/s10834-023-09891-2>
- Bibiano, A., de Lima, S. V., & Da, S. M. R. (2019). Factors associated with the use of health services by elderly men in Brazil: A cross-sectional study. *BMC Public Health*, 19(1), 859. <https://doi.org/10.1186/s12889-019-7232-0>
- Boume, P. A., & Mcgrowder, D. A. (2009). Health status of patients with self-reported chronic diseases in Jamaica. *North American Journal of Medical Sciences*, 1(7), 356–364. <https://doi.org/10.4297/najms.2009.7356>
- Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J. P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., & Katzmarzyk, P. T. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, 54(24), 1451–1462. <https://doi.org/10.1136/bjsports-2020-102955>
- Carmel, S. (2019). Health and well-being in late life: Gender differences worldwide. *Frontiers of Medicine*, 6: 218. <https://doi.org/10.3389/fmed.2019.00218>
- Chang, W. C., Lu, F. P., Lan, T. Y., & Wu, S. C. (2013). Multidimensional health-transition patterns among a middle-aged and older population. *Geriatrics and Gerontology International*, 13(3), 571–579. <https://doi.org/10.1111/j.1447-0594.2012.00937.x>
- Chen, C., Liu, G. G., Shi, Q. L., Sun, Y., Zhang, H., Wang, M. J., & Jia, H. P., Zhao, Y. L., & Yao, Y. (2020). Health-related quality of life and associated factors among oldest-old in China. *The Journal of Nutrition, Health & Aging*, 24(3), 330–338. <https://doi.org/10.1007/s12603-020-1327-2>
- Collins, L. M., & Lanza, S. T. (2010). *Latent class and latent transition analysis: With applications in the social, Behavioral, and Health Sciences: Latent class and latent transition analysis.* John Wiley & Sons.
- Côté-Sergent, A., Fonseca, R., & Strumpf, E. (2020). Comparing the education gradient in health deterioration among the elderly in six OECD countries. *Health Policy*, 124(3), 326–335. <https://doi.org/10.1016/j.healthpol.2019.12.015>

- Cunningham, C., SR, O., Caserotti, P., & Tully, M. A. (2020). Consequences of physical inactivity in older adults: A systematic review of reviews and meta-analyses. *Scandinavian Journal of Medicine & Science in Sports*, 30(5), 816–827. <https://doi.org/10.1111/sms.13616>
- Demakakos, P., Nazroo, J., Breeze, E., & Marmot, M. (2008). Socioeconomic status and health: The role of subjective social status. *Social Science & Medicine*, 67(2), 330–340. <https://doi.org/10.1016/j.socscimed.2008.03.038>
- Dinh, H., Strazdins, L., Doan, T., Do, T., Yazidjoglou, A., & Banwell, C. (2022). Workforce participation, health and wealth inequality among older Australians between 2001 and 2015. *Archives of Public Health*, 80(1), 104. <https://doi.org/10.1186/s13690-022-00852-z>
- Doty, P. (1986). Family care of the elderly: The role of public policy. *The Milbank Quarterly*, 64(1), 34–75. <https://doi.org/10.2307/3350005>
- Du, C. (2019). Study on lifestyle evaluation systems for the health of Chinese elderly. *International Journal of Environmental Research and Public Health*, 16(2), 284. <https://doi.org/10.3390/ijerph16020284>
- Dujardin, C., Laurant, V., & Thomas, I. (2014). Self-assessed health of elderly people in Brussels: Does the built environment matter? *Health & Place*, 27, 59–67. <https://doi.org/10.1016/j.healthplace.2014.01.003>
- Dunst, C. J. (2023). A meta-analysis of informal and formal family social support studies: Relationships with parent and family psychological health and well-being. *International Journal of Caring Sciences*, 16(2), 514.
- Eashwar, V. M. A., Umadevi, R., & Gopalakrishnan, S. (2020). Alcohol consumption in India- an epidemiological review. *Journal of Family Medicine and Primary Care*, 9(1), 49–55. <https://doi.org/10.4103/jfmpc.jfmpc.873.19>
- Farrow, A., & Reynolds, F. (2012). Health and safety of the older worker. *Occupational Medicine (London)*, 62(1), 4–11. <https://doi.org/10.1093/ocmed/kqr148>
- Ferreira, M. P., & Weems, M. K. (2008). Alcohol consumption by aging adults in the United States: Health benefits and detriments. *Journal of the American Dietetic Association*, 108(10), 1668–1676. <https://doi.org/10.1016/j.jada.2008.07.011>
- Gariépy, G., Honkaniemi, H., & Quesnel-Vallée, A. (2016). Social support and protection from depression: Systematic review of current findings in western countries. *British Journal of Psychiatry*, 209(4), 284–293. <https://doi.org/10.1192/bjp.bp.115.169094>
- Goldscheider, F. K. (1994). Divorce and remarriage: Effects on the elderly population. *Reviews in Clinical Gerontology*, 4(3), 253–259. <https://doi.org/10.1017/S0959259800003889>
- Gong, J., Wang, G., Wang, Y., Chen, X., Chen, Y., Meng, Q., Yang, P., Yao, Y., & Zhao, Y. (2022). Nowcasting and forecasting the care needs of the older population in China: Analysis of data from the China health and retirement longitudinal study (CHARLS). *The Lancet Public Health*, 7(12), Article e1005–e1013. [https://doi.org/10.1016/S2468-2667\(22\)00203-1](https://doi.org/10.1016/S2468-2667(22)00203-1)
- Hagenaars, J. A., & McCutcheon, A. L. (2002). *Applied latent class analysis*. Cambridge University Press.
- Hinata, A., Kabasawa, K., Watanabe, Y., Kitamura, K., Ito, Y., Takachi, R., Tsugane, S., Sasaki, A., Narita, I., & Nakamura, K. (2021). Education, household income, and depressive symptoms in middle-aged and older Japanese adults. *BMC Public Health*, 21(1), 2120. <https://doi.org/10.1186/s12889-021-12168-8>
- Hu, Y., Pikhart, H., Maluyutina, S., Pajak, A., Kubinova, R., Nikitin, Y., et al. (2015). Alcohol consumption and physical functioning among middle-aged and older adults in central and eastern Europe: Results from the HAPIEE study. *Age and Ageing*, 44(1), 84–89. <https://doi.org/10.1093/ageing/afu083>
- Jiang, X. Q., Wei, M., & Zhang, W. J. (2015). Study on the health status and influencing factors of China's aging population. *Population Journal*, 37(2), 46–56.
- Katz, S. C., Ford, A. B., Moskowitz, R. W., Jackson, B. A., & Jaffe, M. W. (1963). Studies of illness in the aged. The index of adl: A standardized measure of biological and psychosocial function. *Journal of the American Medical Association*, 185(12), 914–919. <https://doi.org/10.1001/jama.1963.03060120024016>
- Kieny, C., Flores, G., & Maurer, J. (2021). Assessing and decomposing gender differences in evaluative and emotional well-being among older adults in the developing world. *Review of Economics of the Household*, 19, 189–221. <https://doi.org/10.1007/s11150-020-09521-y>
- Kim, G., Chiriboga, D. A., Jang, Y., Lee, S., Huang, C. H., & Parmelee, P. (2010). Health status of older Asian Americans in California. *Journal of the American Geriatrics Society*, 58(10), 2003–2008. <https://doi.org/10.1111/j.1532-5415.2010.03034.x>
- Knight, E. L., Stampfer, M. J., Rimm, E. B., Hankinson, S. E., & Curhan, G. C. (2003). Moderate alcohol intake and renal function decline in women: A prospective study. *Nephrology Dialysis Transplantation*, 18(8), 1549–1554. <https://doi.org/10.1093/ndt/gfg228>
- Kongsted, A., & Nielsen, A. M. (2017). Latent class analysis in health research. *Journal of Physiotherapy*, 63(1), 55–58. <https://doi.org/10.1016/j.jphys.2016.05.018>
- Kushida, O., Moon, J., Matsumoto, D., Yamasaki, N., & Takatori, K. (2020). Eating alone at each meal and associated health status among community-dwelling Japanese elderly living with others: A cross-sectional analysis of the KAGUYA study. *Nutrients*, 12(9), 2805. <https://doi.org/10.3390/nu12092805>
- Lafortune, L., Béland, F., Bergman, H., & Ankri, J. (2009a). Health status transitions in community-living elderly with complex care needs: A latent class approach. *BMC Geriatrics*, 9(1), 1–14. <https://doi.org/10.1186/1471-2318-9-6>
- Lafortune, L., Béland, F., Bergman, H., & Ankri, J. (2009b). Health state profiles and service utilization in community-living elderly. *Medical Care*, 47(3), 286–294. <https://doi.org/10.1097/MLR.0b013e3181894293>
- Lawton, M. P., & Brody, E. M. (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *The Gerontologist*, 9(3), 179–186.
- Liu, L. F. (2014). The health heterogeneity of and health care utilization by the elderly in Taiwan. *International Journal of Environmental Research and Public Health*, 11(2), 1384–1397. <https://doi.org/10.3390/ijerph110201384>
- Liu, Y., Dijkstra, M., Faber, J., Geertman, S., & Cui, C. (2017). Healthy urban living: Residential environment and health of older adults in Shanghai. *Health & Place*, 47, 80–89. <https://doi.org/10.1016/j.healthplace.2017.07.007>
- Liu, J., Rozelle, S., Xu, Q., Yu, N., & Zhou, T. (2019). Social engagement and elderly health in China: Evidence from the China health and retirement longitudinal survey (CHARLS). *International Journal of Environmental Research and Public Health*, 16(2), 278. <https://doi.org/10.3390/ijerph16020278>
- Liu, H., Zhang, Y., Burgard, S. A., & Needham, B. L. (2019). Marital status and cognitive impairment in the United States: Evidence from the national health and aging trends study. *Annals of Epidemiology*, 38, 28–34. <https://doi.org/10.1016/j.annepidem.2019.08.007>
- Li, D., Zhang, D. J., Shao, J. J., Qi, X. D., & Tian, L. (2014). A meta-analysis of the prevalence of depressive symptoms in Chinese older adults. *Archives of Gerontology and Geriatrics*, 58(1), 1–9. <https://doi.org/10.1016/j.archger.2013.07.016>
- Looman, W. M., Fabbri, I. N., Blom, J. W., Jansen, A., Lutomski, J. E., Metzger, S. F., et al. (2018). The frail older person does not exist: Development of frailty profiles with latent class analysis. *BMC Geriatrics*, 18(1), 84. <https://doi.org/10.1186/s12877-018-0776-5>
- Lowsky, D. J., Olshansky, S. J., Bhattacharya, J., & Goldman, D. P. (2014). Heterogeneity in healthy aging. *Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences*, 69(6), 640–649. <https://doi.org/10.1093/gerona/glt162>
- Lubke, G., & Muthén, B. O. (2007). Performance of factor mixture models as a function of model size, covariate effects, and class-specific parameters. *Structural Equation Modeling: A Multidisciplinary Journal*, 14(1), 26–47. <https://doi.org/10.1080/10705510709336735>
- Martin, P., Gondo, Y., Arai, Y., Ishioka, Y., Johnson, M. A., Miller, L. S., Woodard, J., Poon, L. W., & Hirose, N. (2019). Cardiovascular health and cognitive functioning among centenarians: A comparison between the Tokyo and Georgia centenarian studies. *International Psychogeriatrics*, 31(4), 455. <https://doi.org/10.1017/S104160218001813>
- McPherson, K. (2007). Moderate alcohol consumption and cancer. *Annals of Epidemiology*, 17(5, Supplement), S46–S48. <https://doi.org/10.1016/j.annepidem.2007.01.011>
- Morin, R. T., Insel, P., Nelson, C., Butters, M., Bickford, D., Landau, S., Saykin, A., Weiner, M., Mackin, R. S., & Project, R. D. (2019). Latent classes of cognitive functioning among depressed older adults without dementia. *Journal of the International Neuropsychological Society: JINS*, 25(8), 811. <https://doi.org/10.1017/S1535617719000596>
- Mukamal, K. J., Kronmal, R. A., Mittleman, M. A., O'Leary, D. H., Polak, J. F., Cushman, M., & Siscovick, D. S. (2003). Alcohol consumption and carotid atherosclerosis in older adults: The cardiovascular health study. *Arteriosclerosis, Thrombosis, and Vascular Biology*, 23(12), 2252–2259. <https://doi.org/10.1161/01.ATV.0000101183.58453.39>
- Muthén, B., & Muthén, L. K. (2000). Integrating person-centered and variable-centered analyses: Growth mixture modeling with latent trajectory classes. *Alcoholism: Clinical and Experimental Research*, 24(6), 882–891. <https://doi.org/10.1111/j.1530-0277.2000.tb02070.x>
- Ng, C. W., Luo, N., & Heng, B. H. (2014). Health status profiles in community-dwelling elderly using self-reported health indicators: A latent class analysis. *Quality of Life Research*, 23(10), 2889–2898. <https://doi.org/10.1007/s11136-014-0723-7>
- Niccoli, T., & Partridge, L. (2012). Ageing as a risk factor for disease. *Current Biology*, 22(17), R741–R752. <https://doi.org/10.1016/j.cub.2012.07.024>
- Niu, Z., Zhai, M., Dong, Y., Wen, W., Xue, L., Aossman, M., Qin, W., & Duan, Z. (2022). Association between air quality satisfaction, family relationships, and depression symptoms among middle-aged and elderly Chinese people: The mediation role of perceived health status. *BMC Public Health*, 22(1), 2439. <https://doi.org/10.1186/s12889-022-14711-7>
- Paul, P., Hakobyan, M., & Valtonen, H. (2016). The association between self-perceived health status and satisfaction with healthcare services: Evidence from Armenia. *BMC Health Services Research*, 16, 67. <https://doi.org/10.1186/s12913-016-1309-6>
- Pei, Y., Cong, Z., & Wu, B. (2020). Education, adult children's education, and depressive symptoms among older adults in rural China. *Social Science & Medicine*, 253, Article 112966. <https://doi.org/10.1016/j.socscimed.2020.112966>
- Pender, N. J., Walker, S. N., Sechrist, K. R., & Frank-Stromborg, M. (1990). Predicting health-promoting lifestyles in the workplace. *Nursing Research*, 39(6), 326–332. <https://doi.org/10.1097/00006199-199011000-00002>
- Prince, M., Acosta, D., Ferri, C. P., Guerra, M., Huang, Y., Jacob, K. S., Llibre Rodríguez, J. J., Salas, A., Sosa, A. L., Williams, J. D., & Hall, K. S. (2011). A brief dementia screener suitable for use by non-specialists in resource poor settings—the cross-cultural derivation and validation of the brief Community Screening Instrument for Dementia. *International Journal of Geriatric Psychiatry*, 26(9), 899–907. <https://doi.org/10.1002/gps.2622>
- Rely, K., Vargas-Chanes, D., García-Peña, C., Salinas-Escudero, G., Gutiérrez-Robledo, L., & Wong, R. (2020). Multidimensional dependency subgroups in community-dwelling older adults: A latent class analysis. *Revista de la Universidad Industrial de Santander. Salud*, 52(2), 101–109. <https://doi.org/10.18273/revsal.v52n2-2020004>
- Sandoval, M. H., & Alvear, P. M. (2022). Marital status, living arrangements and mortality at older ages in Chile, 2004–2016. *International Journal of Environmental Research and Public Health*, 21(1), 19. <https://doi.org/10.3390/ijerph192113733>
- Shi, Z. (2014). The effect of family planning policy in China on family development capability. *Journal of Public Management*, 11(4), 83–94+115+142–143.
- Silverstein, M., Gong, C. H., & Kendig, H. (2020). Perceived availability of future care and depressive symptoms among older adults in China: Evidence from CHARLS. *BMC Geriatrics*, 20(1), 31. <https://doi.org/10.1186/s12877-020-1435-1>
- Smeets, R., Elissen, A., Kroese, M., Hamelers, N., & Ruwaard, D. (2020). Identifying subgroups of high-need, high-cost, chronically ill patients in primary care: A latent

- class analysis. *PLoS One*, 15(1), Article e228103. <https://doi.org/10.1371/journal.pone.0228103>
- Sperandei, S., Page, A., Spittal, M. J., & Pirkis, J. (2023). Low education and mental health among older adults: The mediating role of employment and income. *Social Psychiatry and Psychiatric Epidemiology*, 58(5), 823–831. <https://doi.org/10.1007/s00127-021-02149-y>
- Srivastava, S., Debnath, P., Shri, N., & Muhammad, T. (2021). The association of widowhood and living alone with depression among older adults in India. *Scientific Reports*, 11(1), Article 21641. <https://doi.org/10.1038/s41598-021-01238-x>
- Tsutsui, T. (2014). Implementation process and challenges for the community-based integrated care system in Japan. *International Journal of Integrated Care*, 14, e2. <https://doi.org/10.5334/ijic.988>
- Vermunt, J. K., & Magidson, J. (2003). Latent class models for classification. *Computational Statistics & Data Analysis*, 41(3–4), 531–537. [https://doi.org/10.1016/S0167-9473\(02\)00179-2](https://doi.org/10.1016/S0167-9473(02)00179-2)
- Vogelsang, E. M., & Lariscy, J. T. (2020). Let's drink to being socially active: Family characteristics, social participation, and alcohol abuse across mid- and later-life. *Journal of Health and Social Behavior*, 61(4), 453–469. <https://doi.org/10.1177/0022146520962456>
- Wang, W. J. (2020). The effects of leisure participation on elderly health in China. *Population and Development*, 26(6), 52–64.
- Wang, Z., & Liu, Z. (2023). Latent classes and related predictors of demand for home-and community-based integrated care for older Chinese adults. *Frontiers in Public Health*, 11, Article 1109981. <https://doi.org/10.3389/fpubh.2023.1109981>
- Wang, Z., Wei, H., & Liu, Z. (2022). Older adults' demand for community-based adult services (CBAS) integrated with medical care and its influencing factors: A pilot qualitative study in China. *International Journal of Environmental Research and Public Health*, (22), 19. <https://doi.org/10.3390/ijerph192214869>
- Ware, J. J. (1987). Standards for validating health measures: Definition and content. *Journal of Chronic Diseases*, 40(6), 473–480. [https://doi.org/10.1016/0021-9681\(87\)90003-8](https://doi.org/10.1016/0021-9681(87)90003-8)
- Weller, B. E., Bowen, N. K., & Faubert, S. J. (2020). Latent class analysis: A guide to best practice. *Journal of Black Psychology*, 46(4), 287–311. <https://doi.org/10.1177/0095798420930932>
- World Health Organization. (2007). *Active ageing: A policy framework*. [http://whqlibdoc.who.int/hq/2002/WHO\\_NMH\\_NPH\\_02.8.pdf](http://whqlibdoc.who.int/hq/2002/WHO_NMH_NPH_02.8.pdf). (Accessed 4 August 2021).
- Xie, L. L., & Wang, B. (2019). Social participation profile of the Chinese elderly in the context of Active Ageing: Patterns and determinants. *Population Research*, 43(3), 17–30.
- Xue, Q., & Witvorapong, N. (2022). Effects of socioeconomic status on aging people's health in China. *Journal of Family and Economic Issues*, 43(3), 476–488. <https://doi.org/10.1007/s10834-022-09840-5>
- Yang, L., & Song, L. J. (2020). The trajectory of multi-dimensional health indicators of elderly health change: Evidence from CLHLS 2002-2014 longitudinal data. *Northwest Population Journal*, 41(4), 72–89. <https://doi.org/10.15884/j.cnki.issn.1007-0672.2020.04.007>
- Yao, Y., Lu, T., Liu, Y., Qin, Q., Jiang, J., & Xiang, H. (2022). Association of depressive symptoms with ambient PM(2.5) in middle-aged and elderly Chinese adults: A cross-sectional study from the China health and retirement longitudinal study wave 4. *Environmental Research*, 203, Article 111889. <https://doi.org/10.1016/j.envres.2021.111889>
- Ye, L., Luo, J., Shia, B., & Fang, Y. (2019). Multidimensional health groups and healthcare utilization among elderly Chinese: Based on the 2014 CLHLS dataset. *International Journal of Environmental Research and Public Health*, 16(20), 3884. <https://doi.org/10.3390/ijerph16203884>
- Ye, L., Luo, J., Shia, B. C., & Fang, Y. (2020). Heterogeneous health classes for older adults and their regional disparities in China: Based on multidimensional health. *Public Health*, 178, 15–22. <https://doi.org/10.1016/j.puhe.2019.08.023>
- Ye, L., Shia, B. C., Fang, Y., & Lee, T. S. (2019). Heterogeneous health profiles and healthcare utilization of the middle-aged and elderly with multiple health insurance schemes in China. *Public Health*, 170, 61–69. <https://doi.org/10.1016/j.puhe.2019.01.011>
- Ye, L., Xiao, J., & Fang, Y. (2020). Heterogeneous trajectory classes of social engagement and sex differences for older adults in China. *International Journal of Environmental Research and Public Health*, 17(22), 8322. <https://doi.org/10.3390/ijerph17228322>
- Yip, W., & Hsiao, W. C. (2008). The Chinese health system at a crossroads. *Health Affairs*, 27(2), 460–468. <https://doi.org/10.1377/hlthaff.27.2.460>
- Zhang, C., Zhang, S., & Niu, Q. (2021). A new perspective of urban-rural differences: The impact of social support on the mental health of the older adults: A case from shaanxi province, China. *Healthcare*, 9(2). <https://doi.org/10.3390/healthcare9020112>
- Zhao, Y., Hu, Y., Smith, J. P., Strauss, J., & Yang, G. (2014). Cohort profile: The China health and retirement longitudinal study (CHARLS). *International Journal of Epidemiology*, 43(1), 61–68. <https://doi.org/10.1093/ije/dys203>