The Activity of Daily Living (ADL) subgroups and Health impairment among Chinese elderly:A Latent Profile Analysis

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Research article

Keywords: social activity, having experience, diabetes

Posted Date: August 20th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-58737/v1

Version of Record: A version of this preprint was published on January 7th, 2021. See the published version at https://doi.org/10.1186/s12877-020-01986-x.

Abstract

Background

Disability in aged people became one of the major challenges in China due to the acceleration of population aging, yet appropriate methods are limited to discriminate the degree of combined basic activity of daily living (BADL) and instrumental activity of daily living (IADL).The present study explored an empirical typology of the activity of daily living (ADL) and its association with health status among the elderly in China.

Methods

Data throughout the Chinese Longitudinal Healthy Longevity Survey (CLHLS) was retrieved and Latent profile analysis (LPA) was conducted to identify the subgroups of ADL for included elderly subjects. Multinomial regression was performed to detect the effect of identified characteristics with class subgroups, and restricted cubic spine was drawn to show the relationship between ADL disability with age and BMI.

Results

The overall participants (n = 8108) were divided into three ADL classes by LPA - ‘no BADL limitation- IADL impairment’ (Class one, n = 1526, 19%), ‘no BADL limitation-no IADL limitation’ (Class two, n = 6062, 75%) and ‘BADL impairment-IADL impairment’ (Class three, n = 520, 6%). Compared with the participants in Class two, the oldest-old, living without spouse, lacking exercise and social activity, having experience of falls, having comorbidity of diabetes, heart disease, stroke, decreased cognitive function, depression symptom were highly associated with BADL/IADL difficulties in Class one and Class three,. Additionally, malnutrition and asthma were associated with combined ADL/IADL impairment (Class three), and illiteracy only was associated with IADL impairment (Class one). Furthermore, a significant U-shape relation was detected between age and BMI with ADL disability. The elderly with IADL impairment was less likely to evolve combined BADL/IADL impairment aged at 80–90, and the elderly with underweight or obese may have higher risk of combined BADL/IADL impairment.

Conclusion

A novel ADL assessment was explored using LPA, by which elderly people could be defined as three distinct classes of combined ADL/IADL. The predictors identified in the ADL classes could enlighten targeted intervention to address the onset of functional disability and consequent problems with the elderly.

Introduction

Aging of population, emerging as public health concerns, has become a great challenge to China because of increasing chronic prevalence and financial burden, as well as labor shortage [1].As reported by Chinese National Bureau of Statistics in 2019, the people aged65and above has exceeded 176 million, accounting for 12.6%of the whole population in China[2].Additionally, the report from World Health Organization (WHO) declared that healthy life expectancy was more significant than average life expectancy, along with the trend of increasing average life expectancy and chronic disease burden [3]. Life expectancy at birth of Chinese has increasedfrom71.8 to 74.5 years among male and76.9 to 79.9 years among female, while healthy life expectancy was not optimistic, which was in the range from 64.5 years to 66.6 years in male and 67.5 years to 69.7 years in femaleduring2013to 2017[4]. Chronic non-

communicable disease (NCDs), along with population aging universally,gradually became a significant barrier to the well-being and quality of life for the elderly in recent decades. Over one million of aged people suffered from at least one NCD, taking a half of overall elderly population in China, and the situation was being worsen as aged people with multiple NCDs simultaneously were still increasing [5]. Living with diverse NCDs, the functional ability of elderly would be definitely restricted and in which case the nursing and medical needs would be consequently enlarged.

Functional ability is the capacity of the individual to live and participate in social activities following his own concept and preference [6]. With regard to the elderly,functional ability reflects individual physical health to some extent and has a direct impact on the quality of life and the outcome of long-term care. On the contrary, the functional disability may threaten the survival of the elderly. For example,The Brazilian National Health Survey with 23,815 participants revealed that the functional disability rate reached 30.1% of people aged 60 and above in 2013 [7]. An investigation on senior people in China indicated that the overall functional disability rate was up to 41.0%, with age-specific rates as 6.9%, 23.6% and 42.7% for respondents aged 65–79 years, 80–89 years and 90–99 years, respectively [8].Currently, functional ability of the elderly was usually measured by the basic ADL (BADL) and instrumental ADL (IADL),which focus on to the evaluation of physical difficulty and complexity. The Katz's BADL was one of the most commonly used assessment, covering basic self-care ability including bathing, dressing, eating, indoor activities, etc [9]. In order to assess the ADL of the elderly in modern society, Lawton et al. designed the IADL, which represented individual's dependence and adaption for surrounding environment, such as call, shopping, food preparation, housework, etc [10].

Given ADL has been widely demonstrated to be associated with functional ability, identifying the specific profile of ADL was viewed as an important premise to understand and discriminate the functional heterogeneity in elders,which contributed to postpone or prevent disability specifically [11]. Meanwhile, previous studies proposed that discriminating normal and abnormal decline by ADL in older adults was still confusing and obscure, with crude extensive categories or unreasonable merge of evaluation items[12, 13]. This misclassification is partially attributed to the inappropriate defining of ADL in a specific context or improper processing with continuous variables. For example, some researchers attempted to score BADL and IADL separately, but some calculated total ability score over both BADL and IADL items[14, 15]. Additionally, the two scales are short of definite cut-off point, which may lead to the discriminate levels of disability through subjective experience of investigators.

Latent profile analysis (LPA) is a person-centered methods, which can confirm the internal association between discrete manifest variables, and also group individual into common profile, namely, several latent variables are to explain much information derived from a large of manifest variables, then keeping most of data characteristics and leading to the propose of "*Dimension reduction*" [16, 17].This novel cluster method has been applied in the region of psychology, sociology, clinical medical and public health.In this case, unobserved heterogeneity in ADL can be examined and identified by statistical techniques among older people.Additionally,The large proportion in disability and dependence is not only explained by increasing age, but also it was modified by other factors. For example, the generally positive effect of health outcome on ADL has been replicated across numerous studies. In summary, a person with better physical and mental status means that who has stronger self-care ability than who with poor health condition. The modifiable health factors associated with new functional limitation in the research are: cognitive impairment, depression, emaciation or obese, comorbidity, experience of fall [18–21]. Additionally, the confounding factors should be adjusted in this observational study such as background factor: gender, age, residence, education, marital status, exercise and social activity [22–24].

The present study was aiming to (1) explore of ADL groups in the elderly by LPA and to identify difference across derived subgroups and (2) explore the association between ADL subgroups and health and personal characteristics so that explaining the heterogeneity of ADL.

Methods

Data and participants

The data set used in current study was retrieved from the Chinese Longitudinal Healthy Longevity Survey (CLHLS). CLHLS was in charge of Center for Healthy Aging and Development Studies at Peking University and Duke University, and the work was carried out by Chinese Center for Disease Control and Prevention. The CLHLS launched a baseline survey in 1998, followed by seven waves in 2000, 2002, 2005, 2008, 2011, 2014 and 2018, and the study sample covers 23 provinces with approximately 85% of China's total population, and about one-half of the cities/counties in each province were selected as primary survey units. Therefore, this longitudinal survey was deemed as the first largest survey targeting the elderly in developing countries [25]. Participants in CLHLS were recruited by a targeted random sampling- investigators firstly recruit eligible centenarian interviewees in sampled city/county, and then trace done nonagenarian, one octogenarian and three elders aged 65–79 nearby in the same street, village or town with each previously identified centenarian.The predefined age and sex were randomly determined to ensure the comparability between the participants at each age from 65–99 and the centenarians with randomly assigned code numbers [26]. CLHLS investigated a wide range of data for the participants, including the basic information of individual and family, life evaluation and personality, cognitive ability, lifestyle, personal background and family structure, physical health and mental health. In addition, CLHLS data base was recognized to be high quality because of its high reliability and validity on health indicators, little missing data and high response rate [27]. More detailed information on CLHLS can be found at: http://www.icpsr.umich.edu/icpsrweb/NACDA/studies/36179.

In order to respond to latest ADL sub-type of elderly people in China, we screened individuals aged 65 years old and above participating in the cross-sectional survey in 2018, while those CLHLS participants with missing values, individual reported dementia, or more than 105 years were excluded. Finally, 8108elderlyindividuals were included into formal analyses in the present study.

Assessment of BADL/IADL

Basic ADL were measured with the following six aspects – *(1) Bathing; (2) Dressing; (3)Toilet; (4) Indoor Transfer; (5) Continence; (6) Eating.* Each item was assigned from 1 to 3 score (1 represent complete dependence; 2 represent partial independence; 3 represent complete independence). The more scores the respondents obtained, the higher ADL dependence they would be. IADL were rated with eight questions- *(1) Can you visit your neighbors by yourself? (2) Can you go shopping by yourself? (3) Can you cook a meal by yourself whenever necessary? (4) Can you wash clothing by yourself whenever necessary? (5) Can you walk continuously for kilometer at a time by yourself? (6) Can you lift a weight of 5 kg, such as a heavy bag of groceries? (7) Can you continuously crouch and stand up three times? (8) Can you take public transportation by yourself?* Item were rated on a three-point scale ranging from 1(yes, independently) to 3 (no, can't). The more scores respondents obtained in b- and I- ADL assessment, the higher ADL dependence they would be and required more external care from family members or nursing staff. Previous study also reported that BADL and IADL can be considered as independent indicators for predicting functional disability among the elderly with a good validity [28–30]. Meanwhile, Spector et al. argued that a multidimensional structure in ADL measurement could more effectively target on older people needs more hours of care, and combining BADL and IADL was feasibility and validity [31]. The Cronbach's of BADL/IADL was 0.818 with 2018 CLHLS sample. The responses of "complete dependence" was defined as "ADL disability" for the last one item.

Coding of basic characteristics and health indicators

Basic characteristics included age (The early older people/aged 65–79 = 0,The oldest-old people/aged 80–105 = 1), gender (female = 0,male = 1), marital status (living without spouse = 0,married and living with spouse = 1), education

(uneducated = 0, educated = 1), having regular exercise at present (no = 0,yes = 1), having regular social activity at present (no = 0,yes = 1), residence (urban = 0, rural = 1). Health indicators included physical(BMI and comorbidities) and mental factors(cognitive function and depression symptom)from self-reported or objectively measured data.Chinese version of the Mini Mental State Examination (MMSE) was used to evaluate the global cognitive function. MMSE refers to four dimensions of cognitive function, consisted of cognitive orientation, and calculation, recall and language capacity [24],with a total of 24 items scored from 0 to 30 scores, by which the higher scores indicate a higher level of dependence. The elderly scored above 24 were considered to be “normal cognitive function”, while those scored less than 24 were evaluated to be“cognitive impairment”[32]. The 10-item Center for Epidemiologic Studies Short Depression Scale (CES-D) was adopted to measure the depression symptom, ranging from 0 to 30, with a cutoff point of ten to distinguish normal and depressive groups[33]. BMI was calculated as weight (kg) /height (m^2). Weight status was categorized into four types [34], namely, underweight (BMI < 18.5 kg/m^2), normal weight (18.5 kg/m^2 ≤ BMI < 24 kg/m^2), overweight (24 kg/m^2 ≤ BMI < 28 kg/m^2), and obese (≥ 28 kg/m^2). Comorbidities, such as hypertension, diabetes, heart disease, stroke, asthma and cancer,were logged through self-reports, as well as experience of falls,.

Data Analysis

Descriptive analysis and statistical inference were conducted using Stata 16.0, and LPA were fitted using Mplus 7.4. The continuous variables were described using mean ± standard deviation (SD) and converted into the categorical variable,and then all the categorical variables were presented using number and proportion (%). LPA was used to identify the number of potential class for ADL scored as continuous data, that is, participants were divided into a latent class with an estimated LPA proportion via the homogeneity of responses to the questionnaire. LPA model gradually increased a latent class at a time,then tested and fitted model with the previous class. The procedure ended up with involving *k* latent class model which completed the comparison successively to the *k-1* prior latent class model when algorithm iteration has been completed. Maximum likelihood estimation (MLE) was adopted to run the algorithm iteration at two stages – (1) set a starting value as zero to estimate and achieve maximum value, (2) Repeatedly estimated maximum based on the value in the last step, until the final value meet aggregation standard in initial setting[35].

The best type of latent classes was determined if Akailke’s Information Criterion (AIC), Bayesian Information Criterion (BIC) and sample size-adjusted BIC (aBIC) were calculated as small as possible[36–38]. Bootstrap Likelihood Ratio Test (BLRT) and Lo-Mendell-Rubin (LMR) were performed to compare differential distribution of log likelihood ratio between nested models, and statistical significance (P 0.05) implied the *k*-class model was better than the *k*-1 model [39, 40]. Entropy, varying between 0 and 1,indicated a more accurate classification when the value was getting close to 1. The value of entropy, pointed out by Lubke and Muthén, less than 0.60 meant that 20 percent of individual were misclassification, while more than 0.80 meant that precision of classification was higher than 90 percent [41].

Chi-square test and Fisher’s exact test were performed to analyze categorical variables. Multinomial logistic regression was performed to test the association between every latent class detected by LPA and any other characteristics with the reference of Class two. Restricted cubic spines with three knots at the 10th, 50th, 90th percentiles was used to flexibly fit the statistical association of age and BMI with the odds ratio (OR)and 95% confidence interval (CI) of ADL impairment.

Results

Basic characteristics

A total of 8108 participants were recruited in our study. As shown in Table 1, the average age of participants was 82.46 ± 11.01 years,and 53.03% (n = 4300) of subjects were female. The percentage of participants who were living in urban area, educated and living with spouse were58.76% (n = 4764),57.84%(n = 4690) and 47.13%(n = 3821), respectively.Proportion of participant shaving exercise and social activities were only 36.36% (n = 2948) and 16.56% (n = 1343), respectively. With regard to the health indicators, BMI showed that 51.60% (n = 4184) of subjects were normal in weight, followed by overweight (25.44%, n = 2063),obese (8.72%, n = 707) and underweight (14.23%, n = 1154). 21.46% (n = 1740) of the elderly had the experience of falls,and participants having the comorbidities of hypertension,diabetes,heart disease,stroke, asthma and cancer were 44,63% (n = 3619), 11.10% (n = 900),17.96% (n = 1456),10.80% (n = 876),1.54% (n = 125), respectively.MMSE test showed that 78.48% (n = 6363) of the elderly belonged to the cognition decline, and CES-D showed that 26.63%(n = 2159) of subjects having depression symptoms. In addition, the average value of combined BADL/IADL was 18.9 ± 6.6.

Table 1
Sample characteristics

Variables	Mean ± *SD/N(%)*
Gender	
Male	3808 (46.97%)
Female	4300 (53.03%)
Age(year)	82.46 ± 11.01
65–79	3496 (43.12%)
80–105	4612 (56.88%)
Residence	
Urban	4764 (58.76%)
Rural	3344 (41.24%)
Education	
Uneducated	3418 (42.16%)
Educated	4690 (57.84%)
Marital status	
without spouse	4287 (52.87%)
Married and living with spouse	3821 (47.13%)
Exercise (regularly at present)	
No	5160 (63.64%)
Yes	2948 (36.36%)
Social activity (at present)	
No	6765 (83.44%)
Yes	1343 (16.56%)
BMI	22.58 ± 3.65
underweight	1154 (14.23%)
normal	4184 (51.60%)
overweight	2063 (25.44%)
obese	707 (8.72%)
Experience of falls	
No	6368 (78.54%)
Yes	1740 (21.46%)
Hypertension	

Variables	Mean ± *SD/N(%)*
No	4489 (55.37%)
Yes	3619 (44.63%)
Diabetes	
No	7208 (88.90%)
Yes	900 (11.10%)
Heart disease	
No	6652 (82.04%)
Yes	1456 (17.96%)
Stroke	
No	7232 (89.20%)
Yes	876 (10.80%)
Asthma	
No	7324 (90.33%)
Yes	784 (9.67%)
Cancer	
No	7983 (98.46%)
Yes	125 (1.54%)
MMSE	
Total score	25.9 ± 5.5
Normal	6363 (78.48%)
Decreased	1745 (21.52%)
Depression	
Total score	7.5 ± 4.2
Normal	5949 (73.37%)
Depression symptoms	2159 (26.63%)
BADL	6.6 ± 1.7
BADL disability	943 (11.63%)
IADL	12.3 ± 5.4
IADL disability	3186 (39.29%)
BADL/IADL	18.9 ± 6.6
BADL/IADL disability	3245 (40.02%)

Latent classification of ADL

Profiles of ADL was showed in Table 2.According to model fitting criteria, AIC, BIC and aBIC decreased continuously along with the addition of the number of classes. Entropy showed excellent ability for five models ranged from 0.97 to 0.98. BLRT were highly significant for 2-, 3-, 4-class model, and LMR indicated that the posterior model (3- and 4-class) were better than the prior model. In summary, 2-class was firstly excluded because of inferior model fitting and higher AIC and BIC. LMR of 5-class was not better than 4-class ($P = 0.556$), and the size of two in five clusters were only 4% and 3%, in which case 5-class LPA model was next excluded. 4-class model had two clusters with similar distribution in item response but 3-class was more concise and clear. Therefore, 3-class model was considered as the best fitted model based on the parsimonious principle. Figure 1 showed the patterns of the 3-class solution of BADL/IADL

Table 2
Fit indices of latent class analysis on ADL types.

Model	K	AIC	BIC	aBIC	Entropy	LMR	BLRT	Class Probability
1	28	182235.96	182431.98	182343.02	-	-	-	1
2	43	120223.44	120524.47	120387.83	0.97	0.023	0.001	0.78/0.22
3	58	85654.45	86060.49	85876.17	0.98	0.001	0.001	0.19/0.75/0.06
4	73	73010.91	73521.96	73289.98	0.99	0.001	0.001	0.18/0.75/0.04/0.03
5	98	60971.16	61587.22	61307.57	0.98	0.556	0.001	0.18/0.62/0.13/0.04/0.02

Table 3 presented the estimation of item response mean of ADL types for each classes. Class one, with 1526 subjects accounting for a proportion of 19%, had a low item response mean in BADL (mean = 1.131, ranging from 1.016 to 1.634) but a high item response mean in IADL(means = 2.502,ranging from 1.941 to 2.832). This class was therefore defined as ‘no BADL limitation-IADL impairment’. Class two, with the largest size (n = 6062, 75%),had a low item response mean with both of BADL and IADL (BADL means = 1.00, ranging from 1.001 to 1.039;IADL means = 1.184, ranging from1.015to 1.401),and it was labeled as ‘no BADL limitation no IADL limitation’. Class three (n = 520, 6%) was relatively high in item response mean with both of BADL and IADL(BADL means = 2.041, ranging from 1.292 to 2.861, IADL means = 2.822, ranging from2.608 to 2.914), which was labeled as ‘BADL impairment IADL impairment’.

Table 3
Item response mean and standard errors in latent profile analysis of ADL

Item	Class One		Class Two		Class Three		Total sample Mean(SD)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SD
	n = 1526 (19%)		n = 6062(75%)		n = 520 (6%)		n = 8108 (100%)	
BADL	1.131		1.001		2.041			
1	1.634	0.025	1.039	0.003	2.736	0.025	1.260	0.634
2	1.025	0.005	1.001	0.001	2.861	0.017	1.126	0.470
3	1.062	0.007	1.001	0.001	2.001	0.030	1.077	0.319
4	1.043	0.006	1.002	0.001	1.826	0.031	1.063	0.278
5	1.041	0.006	1.006	0.001	1.292	0.024	1.030	0.189
6	1.016	0.003	1.002	0.001	1.522	0.031	1.038	0.225
IADL	2.502		1.184		2.822			
1	1.941	0.028	1.015	0.002	2.608	0.035	1.291	0.668
2	2.460	0.026	1.049	0.005	2.820	0.023	1.427	0.764
3	2.474	0.028	1.066	0.005	2.842	0.021	1.444	0.782
4	2.409	0.031	1.052	0.004	2.878	0.018	1.424	0.770
5	2.667	0.018	1.249	0.008	2.852	0.020	1.618	0.829
6	2.612	0.019	1.278	0.008	2.820	0.022	1.628	0.842
7	2.666	0.016	1.401	0.009	2.846	0.019	1.731	0.842
8	2.832	0.013	1.339	0.011	2.914	0.016	1.720	0.891

Subgroup analysis

As shown in Table 4,the majority of subjects in Class one were female (n = 951, 62.32%) while 49.84%of subjects in Class two were male (n = 3021). About 93.45% of Class one were oldest-old people, and this proportion were relatively low in Class two (n = 2714, 44.77%). Urban residents were dominated in Class three (n = 358, 68.85%). The illiterate was highest in Class one (n = 974, 63.83%) and that ratio of having a spouse was also lowest in this class (n = 300, 19.66%). The member of Class three were less likely to taking in exercise (n = 52, 10.00%) and social activity (n = 26, 5.00%).The elderly of Class three were more inclined to emaciated (n = 133, 25.58%) and fall (n = 170, 32.69%) and those of Class two were overnutrition (n = 2289, 37.76%). Furthermore, the subjects of Class three were mostly suffered from heart disease (24.42%), stroke (22.50%), asthma (16.15%) and cancers (1.92%), and the composition of cognition decline (66.54%) and depression symptom (39.81%) was highest in this class. Hypertension (45.65%) and diabetes (11.55%) were most prevalence in Class two. There were statistically significant difference among subjects in Class one, two and three in all the included variables except for having cancer.

Table 4
Difference among ADL types with included variables.

Variables	Class one	Class two	Class three	*P* value
Gender				0.001
Male	575 (37.68%)	3021 (49.84%)	212 (40.77%)	
Female	951 (62.32%)	3041 (50.16%)	308 (59.23%)	
Age(year)				0.001
65–79	100 (6.55%)	3348 (55.23%)	48 (9.23%)	
80–105	1426 (93.45%)	2714 (44.77%)	472 (90.77%)	
Residence				0.001
Urban	934 (61.21%)	3472 (57.27%)	358 (68.85%)	
Rural	592 (38.79%)	2590 (42.73%)	162 (31.15%)	
Education				0.001
Illiterate	974 (63.83%)	2146 (35.40%)	298 (57.31%)	
Educated	552 (36.17%)	3916 (64.60%)	222 (42.69%)	
Marital status				0.001
without spouse	1226 (80.34%)	2644 (43.62%)	417 (80.19%)	
Married and with spouse	300 (19.66%)	3418 (56.38%)	103 (19.81%)	
Exercise (regularly at present)				0.001
No	1249 (81.85%)	3443 (56.80%)	468 (90.00%)	
Yes	277 (18.15%)	2619 (43.20%)	52 (10.00%)	
Social activity (at present)				0.001
No	1435 (94.04%)	4836 (79.78%)	494 (95.00%)	
Yes	91 (5.96%)	1226 (20.22%)	26 (5.00%)	
BMI				0.001
underweight	331 (21.69%)	690 (11.38%)	133 (25.58%)	
normal	837 (54.85%)	3083 (50.86%)	264 (50.77%)	
overweight	258 (16.91%)	1725 (28.46%)	80 (15.38%)	
obese	100 (6.55%)	564 (9.30%)	43 (8.27%)	
Experience of falls				0.001
No	1076 (70.51%)	4942 (81.52%)	350 (67.31%)	
Yes	450 (29.49%)	1120 (18.48%)	**170 (32.69%)**	

*Fisher's exact test.

Variables	Class one	Class two	Class three	*P* value
Hypertension				0.001
No	901 (59.04%)	3295 (54.35%)	293 (56.35%)	
Yes	625 (40.96%)	**2767 (45.65%)**	227 (43.65%)	
Diabetes				0.037
No	1385 (90.76%)	5362 (88.45%)	461 (88.65%)	
Yes	141 (9.24%)	**700 (11.55%)**	59 (11.35%)	
Heart disease				0.001
No	1247 (81.72%)	5012 (82.68%)	393 (75.58%)	
Yes	279 (18.28%)	1050 (17.32%)	**127 (24.42%)**	
Stroke				0.001
No	1347 (88.27%)	5482 (90.43%)	403 (77.50%)	
Yes	179 (11.73%)	580 (9.57%)	**117 (22.50%)**	
Asthma				0.001
No	1355 (88.79%)	5533 (91.27%)	436 (83.85%)	
Yes	171 (11.21%)	529 (8.73%)	**84 (16.15%)**	
Cancer*				0.646
No	1505 (98.62%)	5968 (98.45%)	510 (98.08%)	
Yes	21 (1.38%)	94 (1.55%)	**10 (1.92%)**	
MMSE				0.001
Normal	782 (51.25%)	5407 (89.19%)	174 (33.46%)	
Decreased	744 (48.75%)	655 (10.81%)	**346 (66.54%)**	
Depression				0.001
Normal	997 (65.33%)	4639 (76.53%)	313 (60.19%)	
Depression symptoms	529 (34.67%)	1423 (23.47%)	**207 (39.81%)**	
*Fisher's exact test.				

Multinomial logistic regression

The Multinomial logistic regression was performed to calculate the OR of being a member of Class one (no BADL limitation-IADL impairment) or Class three (no BADL limitation no IADL limitation) versus Class two (reference = BADL impairment IADL impairment). Logistic regression model (Table 5) showed that the elderly who were oldest-old(OR = 8.26, 95%CI = 6.58–10.38), living in the rural area (OR = 0.65, 95% CI = 0.56–0.74),uneducated (OR = 0.84, 95%CI = 0.72–0.98), without spouse (OR = 0.48, 95%CI = 0.41–0.57), having exercise (OR = 0.39, 95%CI = 0.34–0.46) and social activity(OR = 0.45, 95%CI = 0.34–0.58)were less likely to be allocated into Class one compared to Class two. Furthermore, individuals suffering from diabetes(OR = 1.35, 95%CI = 1.06–1.72), heart disease(OR = 1.27, 95% CI =

1.05–1.52), stroke (OR = 1.72, 95%CI = 1.38–2.15), fall (OR = 1.58, 95%CI = 1.36–1.85), cognitive impairment (OR = 3.79, 95% CI = 3.26–4.40) and depression (OR = 1.24, 95% CI = 1.07–1.44)were more likely to be grouped into Class one. aging above 80 (OR = 4.55, 95% CI = 3.22–6.44), being underweight (OR = 1.34, 95% CI = 1.03–1.73) and obese (OR = 1.57, 95% CI = 1.06–2.32), experiencing falls (OR = 1.71, 95% CI = 1.37–2.15), having comorbidities of diabetes (OR = 1.51, 95% CI = 1.06–2.16), heart disease(OR = 1.67, 95% CI = 1.27–2.18), stroke (OR = 3.55, 95% CI = 2.66–4.73), asthma (OR = 1.56, 95% CI = 1.15–2.12), cognitive impairment (OR = 9.57, 95% CI = 7.61–12.03) and depression symptoms (OR = 1.33, 95% CI = 1.07–1.65) were positively associated with the allocation into Class three, while living in rural (OR = 0.47, 95% CI = 0.37–0.59), living with spouse (OR = 0.44, 95% CI = 0.34–0.58), having physical activities (OR = 0.19, 95% CI = 0.14–0.27) and social activities (OR = 0.36, 95% CI = 0.23–0.57) were negatively associated with the allocation into Class three.. Figure 2 (Class three vs. Class one) showed a significant U-shape relation between predicted age and ADL impairment ($P < 0.001$). Figure 3 (Class three vs. Class two) showed a significant dose-response relationship between predicted BMI and ADL impairment ($P < 0.001$).

Table 5
Multinomial logistic regression on ADL subgroups

Variable[a]	Class 1		Class 3	
	OR	95%CI	OR	95%CI
Gender (Female)	0.90	0.77–1.05	0.80	0.63–1.02
Age (80–105)	8.26***	6.58–10.38	4.55***	3.22–6.44
Residence (Rural)	0.65***	0.56–0.74	0.47***	0.37–0.59
Education (Educated)	0.84*	0.72–0.98	1.22	0.96–1.56
Marital status (married and live with spouse)	0.48***	0.41–0.57	0.44***	0.34–0.58
Exercise (Yes)	0.39***	0.34–0.46	0.19***	0.14–0.27
Social activity (Yes)	0.45***	0.34–0.58	0.36***	0.23–0.57
BMI				
underweight	1.07	0.89–1.27	1.34*	1.03–1.73
overweight	0.90	0.75–1.08	0.79	0.59–1.07
obese	1.16	0.89–1.52	1.57*	1.06–2.32
Experience of falls (Yes)	1.58***	1.36–1.85	1.71***	1.37–2.15
Hypertension(Yes)	0.95	0.82–1.10	0.98	0.78–1.22
Diabetes(Yes)	1.35*	1.06–1.72	1.51*	1.06–2.16
Heart disease(Yes)	1.27*	1.05–1.52	1.67***	1.27–2.18
Stroke(Yes)	1.72***	1.38–2.15	3.55***	2.66–4.73
Asthma(Yes)	1.19	0.95–1.47	1.56**	1.15–2.12
MMSE (Decreased)	3.79***	3.26–4.40	9.57***	7.61–12.03
Depression (Depression symptoms)	1.24***	1.07–1.44	1.33***	1.07–1.65

Note. ***$P < 0.001$; **$P < 0.01$; *$P < 0.05$; [a] Reference group: Class 2.OR: Odds ratio.95%CI: 95%Confidence Interval.

Discussion

In most cases of conventional practice, the ADL disability was roughly transformed into an ‘either-or’ variable (binary as normal or impairment) through an ambiguous understanding of scales. Moreover, a relatively absolute measure was usually adopted to define functional dependence and independence by which the functional dependence was defined as only one item of BADL/IADL showed a dependent outcome, while the functional independence was defined as all the items were total independent[42]. The advantage of the classification basis was clear and easy to compute, by which researchers can select mature binary *logit* model to analysis data. However, the disadvantage of it was rough and biased as the boundary of the elderly with ADL disability were very fluctuating. Meanwhile, Rather than focusing on the combining effect of BADL/IADL, the present study have adopted LPA to explore an efficient measurement to identify the classes of ADL in the elderly, in order to discriminate status of functional impairment. Three latent classes were constructed based on ADL item response mean of a large population-based study among Chinese elderly. Accordingly, the functional ability was graded in three levels, namely ‘no BADL limitation-IADL impairment’(Class one), ‘no BADL limitation no IADL limitation’(Class two), ‘BADL impairment IADL impairment’ (Class three).

According to previous Chinese reports, a wide range of interval was reached from 1.5–12.4% in BADL disability, and from 2.95–30% in IADL disability [43]. In the present study, the percentage of BADL disability evaluated by the conventional way was 11.63%, which was less than 18% for the US Health and Retirement Study (HRS) and 28% for the English Longitudinal Study of Ageing (ELSA) [44, 45]. On the contrary, the proportion of IADL impairment (39.29%) was significantly higher than those reported from the HRS (17%) and the ELSA (28%) [44, 45]. According to the classification approach proposed in the present study, LPA addressed the confusion of combined BADL/IADL disability using cluster algorithm, which showed that the sever BADL/IADL dependence was approximately 6%, and IADL impairment was 19%, and a large number of people (75%) was categorized into the almost independence.

In comparison with Class two, Class one and Class three were not significantly predicted by gender. A longitudinal study conducted in Brazil reported that female suffered more from the loss of IADL than male, which was inconsistent with our findings [23]. One reason was that female was generally more longevous than male, and the odds of IADL limitation was greater[46].

In line with previous evidence and medical practice, age was a risk predictor for combined BADL/IADL impairment [22]. As is well known, the body function of people would gradually decrease along with the growing age, and the ability of socialized ability, such as shopping, visiting, doing housework, and even basic self-care, might be getting limited [22]. In addition, the prevalence of chronic disease, such as hypertension and rheumatism, would evolve rapidly with the increasing trend of population aging according to disability expansion theory, which would also enhance the ADL impairment to some extent[47]. Interestingly, we found that the OR of Class one was up to two times than that in Class three. One potential mechanism should be illustrated that successful aging would reduce the events of combined ADL difficulties. Hung et al. argued that the elderly with comorbidities may improve the management of chronic disease over the past 20 years, and much pharmaceutical treatment can ameliorate physical function of the old people such as mobility, cognition and control [45] The U-shape relation between predicted age and ADL impairment suggested that the elderly with IADL impairment was less likely to evolve to combine ADL/IADL impairment among aged 80–90 years. Our findings supported the viewpoint of Hung that IADL impairment may increase the alertness of the elderly[45] .

Favorable living surrounding may provide a healthier life to individuals. People living in urban area more or less have better income, education and medical service than those in rural. Zhang et al. found that inadequate access to health care was potential factor associated with ADL limitation [48], which suggested that national policy and funding should adequately provide for the elderly in rural areas. Having said that, inconsistent clue was detected in our study. We found that Class one and Class three had more likely to live in urban compared with people in Class two. Besides the

residence condition, there are also rural-urban differences existing in characteristics of labor which cannot be neglected in the Chinese context. Rural residents probably participant in more physical activities like farming and harvesting, by which they may have more exercises doing good to the functional ability and improve the ADL.Meanwhile, we found that education was a significantly protective factor in Class one that showed property of normal BADL and worse IADL. Previous study also showed that the elderly with higher education level had better health awareness, and education was significantly associated with IADL but no with BADL [49, 50]. A possible reason is that the educated elderly may make better use of social support, while the less educated ones were limited in the knowledge to seek health assistance[49].

A significantly negative association was examined between marital status and BADL/IADL limitation in the present study,which was partially consistent with a longitudinal study performed among Irish people, indicating that the elderly who were divorced or separated had a predicted high-risk of IADL disability compared to married individuals [51]. It is because the spouse usually play a role of caregivers when a elderly person has disease or functional dependency, and the elderly will be in an inferior situation once lack of the company by the spouse [52]. This point should be further verified in longitudinal studies.

The present study found that lack of social activities and exercises were significantly associated with BADL/IADL disabilities. According to the Activity Theory, human beings, as social individuals, have psychological sense of gain when playing their social roles and taking social engagement [53]. Previous evidence showed that a growing number of older people preferred to participate in social activities and became social integration and adaptation [54]. Therefore, lack of social activities may predict a decline of IADL. A cohort study in Japanese indicated that the elderly with functional disability were less likely to participant frequently in community activities [55]. Meanwhile, lacking exercise has previously been reported to be independently associated with an increased risk of decline of functional ability [22]. Therefore, it is in need to promote social activity and exercise to prevent and delay the onset of functional disability.

In our study, the elderly with underweight or obese was more likely to be Class three compared with Class one, and this difference was not found between Class two and Class one. The positive association between obese and high BADL impairment can be explained by the reason that obese increased the odds of having chronic diseases so that the physical function would be decreased [56]. Meanwhile, we also found that underweight also was a risk factor for ADL difficulties. Previous studies indicated that the underweight elderly had some features and symptoms of malnutrition, such as low visceral proteins, sarcopenia and inadequate energy intake. Compared with normal people, underweight ones showed a significant decrease in bone mineral content and bone mineral density, which meant a higher risk of osteoporosis even fracture [57]. In addition, having falls were also positively associated with ADL decline in our study, in which case the happening of all-cause fracture would be increased among aged people, and the prevention of falls should be therefore paid close attention to.[58], Additionally, we found that BMI was not significantly associated with Class one, in line with Bahat’s conclusion which indicated that the obese was not a risk factor for IADL[59]. It was probably because IADL impairment would be more susceptible than BADL to multidimensional factors such as society and economic. In addition, higher BMI predicted better living standard and medical resources, which improve development and maintenance of IADL. Correspondingly, a dose-response relationship was detected between ADL impairment and BMI between Class three and Class two in restricted cubic spline.

The present study found that diabetes, heart disease, stroke were independently risk factors in Class one and Class three. Comorbidities was independently associated with functional disability in the elderly population[60]The elderly with diabetes often have the Diabetes-Multimorbidity combinations, such as retinal angiopathy, diabetic foot and arteriosclerosis, which usually gives rise to decline of body function and life activities, and then increases ADL disability [61]. Meanwhile, the causes of diabetes were overweight/obese, lacking exercise and sedentary. Heart disease consist of myocardial infarct, angina pectoris, coronary disease and heart failure et al. The elderly with chronic disease

performed a series of symptom of activity tolerance decline, heart rate increased and dyspnea, finally leading to BADL/IADL impairment [62]. In our study, having stroke was about three times risky in Class three than that in Class one. Stroke refer to acute cerebrovascular disease, which may cause some sequels so that it would lead to ADL/IADL disability.Additionally, asthma was a predictor in Class three but not in Class one. One potential reason was that asthma can disappear spontaneously or taking antiasthmatic drug in mild ADL impairment. However, severe patients would combined pulmonary heart disease increased the difficulties of ADL/IADL [63].

Depression and cognitive impairment were independently associated with BADL/IADL difficulties in Class one and Class three. Ormel et al. suggested that depression symptom and ADL limitation had a mutual reinforcement among the elderly overt time [64]. Especially, the elderly living in community must take part in housework and managing money. Hence, those people would feel more negative emotion if IADL was limited rather than BADL. In contrast, a positive association was found between depression and BADL but not in IADL in community elderly in Japan[65]. The elderly living in hospital was well cared by doctor and nurse, whose self-support ability was effectively supplied (e.g., housework and heavy labor)[65]. Cognitive function mirrored physical and mental health, and life quality among the elderly. Fisher et al. argued that cognitive impairment increased the risk of fall for the elderly [66]. Connolly et al. pointed out that cognitive impairment significantly decreased the function of IADL because loss of language and mobility[51]. Somatic disease may reduce the change of receiving external stimuli for the elderly, and decreased the cognitive function, resulted in ADL/IADL difficulties further. Timely cognitive assessment among the elderly could be carried out for early detection of cognitive impairment and help to prevent ADL disability.

There are several limitations that must be discussed. Firstly, the cross-sectional dataset limits the causality that can be inferred from the associations observed, meanwhile, bi-directional relationship between healthy factors and ADL would be considered as well. Therefore, longitudinal study is in need to further detect and verify the mechanism. Secondly, self-rated questionnaire was used for evaluating individual health status, which might lead in the risk of recall bias more or less. Thirdly, the subjects with missing value were excluded from analysis which may cause an under- or over-estimate BADL/IADL to some extent. Meanwhile, the Hawthrone effect, in which case the elderly may conceal poor characteristics of health and lifestyle,, may cause an overrating of ADL. Finally, limited by the secondary data extraction, individual hospitalization history and economic status were not achieved.

Conclusion

ADL assessment was established using cluster LPA. Three distinct classes of combined BADL/IADL among Chinese older people were identified. The largest group was Class two (no BADL limitation-no IADL limitation) for all item of ADL scales. The oldest-old, stroke and cognitive impairment were strongest associated with ADL/IADL difficulties in Class one (no BADL limitation IADL impairment) and Class three (BADL impairment IADL impairment), and a remarkable U-shape relation was detected forage and BMI with ADL impairment. Targeted interventions would be initiated in terms of the major predictors that have significant effects in the ADL classes, and further well designed longitudinal studies are in need to examine the reliability and validity of the outcomes.

Abbreviations

BMI: body mass index; ADL:activity of daily living; BADL:basic activity of daily living; IADL:Instrumental activity of daily living; CES-D:Epidemiologic Studies Short Depression Scale; MMSE:Mini-Mental State Examination; CLHLS:Chinese longitudinal healthy longevity survey.

Declarations

Ethics approval and consent to participate

The CLHLS study was approved by research ethics committees of Peking University (IRB00001052-13074). All participants provided written informed consent. No experimental interventions were performed.

Consent for publication

Not applicable.

Availability of data and materials

The CLHLS questionnaires are available at https://sites.duke.edu/centerforaging/programs/chinese-longitudinal-healthy-longevity-survey-clhls/survey-documentation/questionnaires/. The full datasets used in this analysis are available from the corresponding author upon reasonable request.

Conflicts of Interest:

The authors declare no conflict of interest.

Funding:

This research was funded by National Natural Science Foundation of China, grant number 71603034.

Author Contributions:

Conceptualization, X.L. and Y.Z.; Methodology, Y.X. ;Validation, Y.X.; Formal Analysis, Y.Z. S.S. and Q.Y.; Writing-Original Draft Preparation, Y.Z. and Y.X; Writing-Review & Editing, X.L. S.S. and L.C. ; Visualization, L.C.; Funding Acquisition, X.L.

Acknowledgments:

Data used in this research were provided by the study entitled “Chinese Longitudinal Longevity Survey” (CLHLS) was jointly implemented by the Center for Healthy Aging and Development Studies of Peking University and Duke University. CLHLS is supported by funds from the U.S. National Institutes on Aging (NIA), China Natural Science Foundation, China Social Science Foundation, and UNFPA.

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Figures

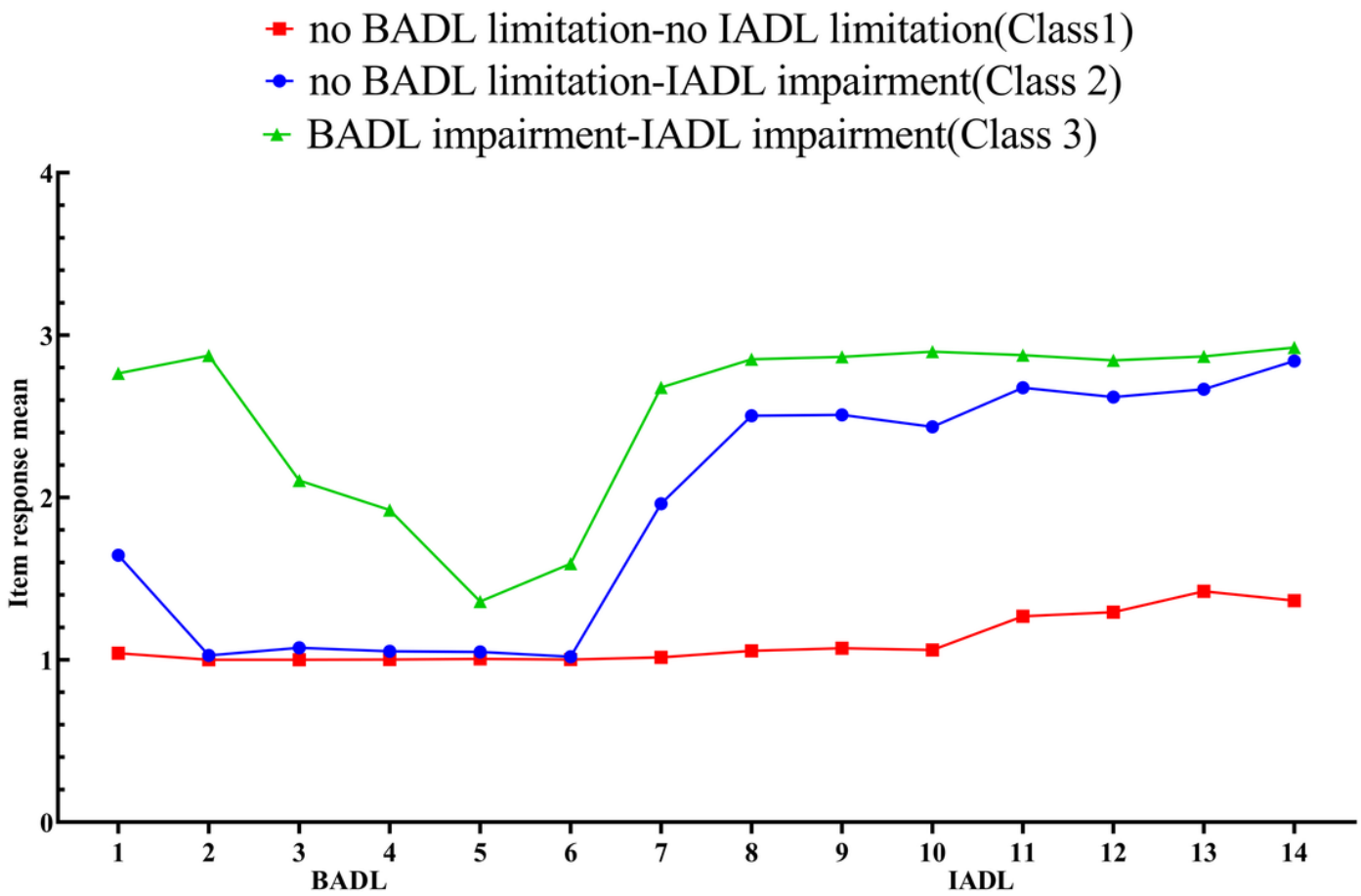

Figure 1

Item response mean of ADL types.

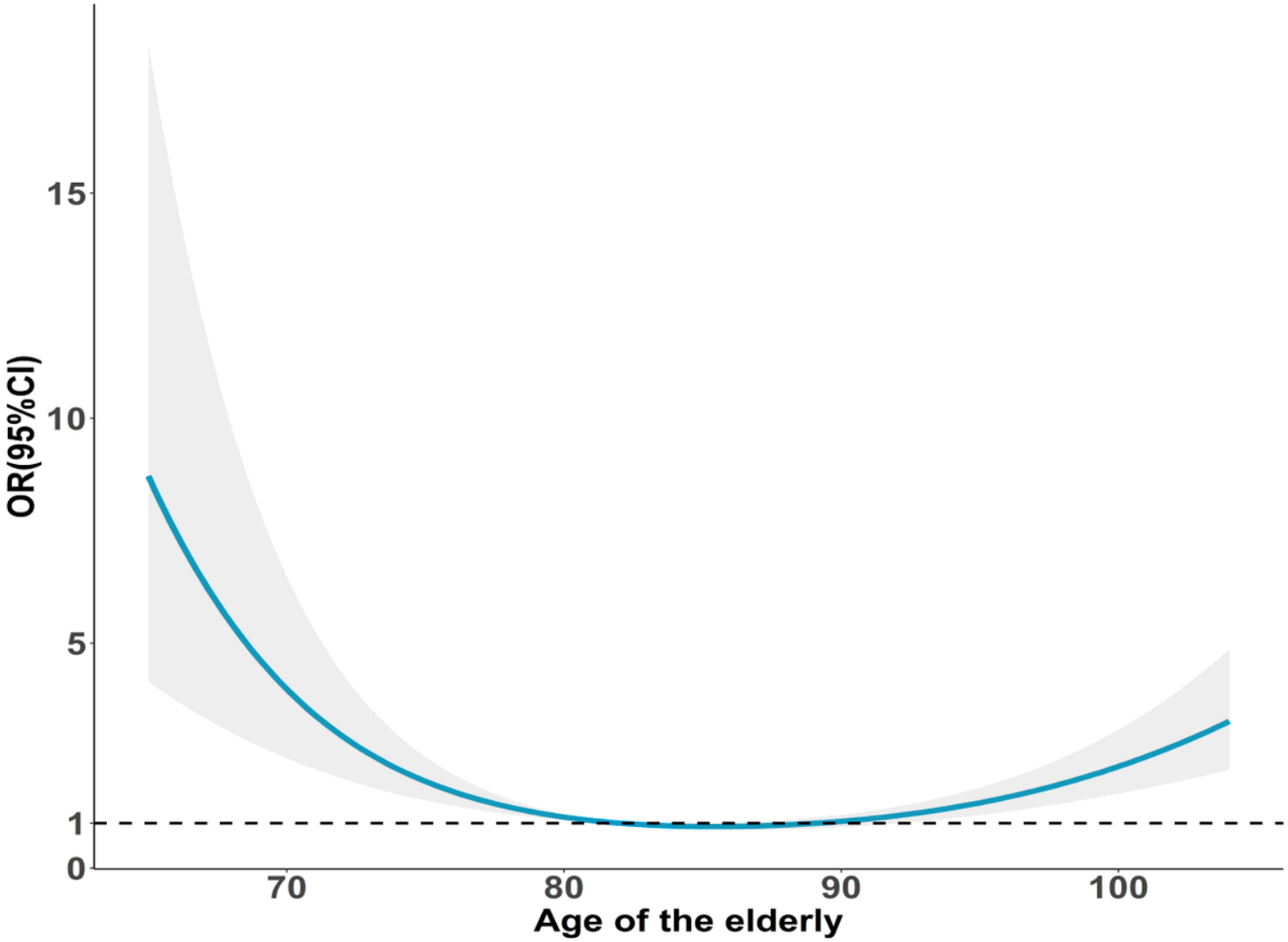

Figure 2

Curve association between ADL disability(Class 3 vs. Class 1) and the age among the elderly. Note. Shading indicates 95% CIs. The reference point is 82, after adjusting sex, fall experience, marital status, having exercise, social activities, residence place, having chronic disease, cognitive function and BMI.

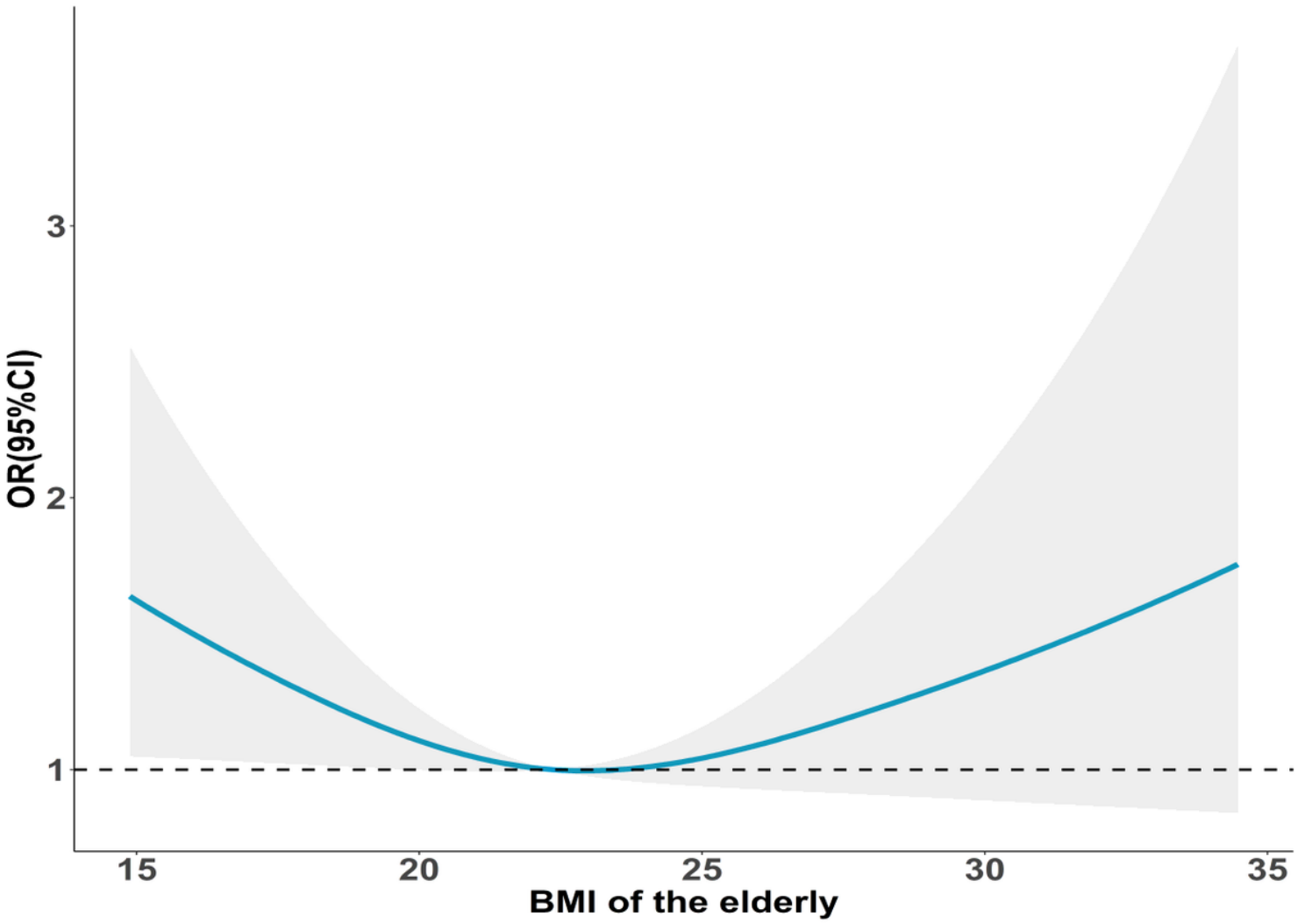

Figure 3

Curve association between ADL disability(Class 3 vs. Class 2) and BMI among the elderly. Note. Shading indicates 95% CIs. The reference point is 22, after adjusting age, sex, fall experience, marital status, having exercise, social activities, residence place, having chronic disease, cognitive function.