

# Growth Patterns of Activity of Daily Living Disability and Associated Factors Among The Chinese Elderly: A Twelve-Year Longitudinal Study

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## Research Article

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# Abstract

## Background

The acceleration of population aging has brought a lot of attention to the disability among older populations, but existing results about the development patterns of disability were largely mixed. The current study aimed to identify the potential different development patterns of disability and the influential factors using a large, nationally representative sample of the Chinese elderly.

## Methods

We adopted a five-wave longitudinal dataset from the Chinese Longitudinal Healthy Longevity Survey (CLHLS), and a total of 1,654 elderly aged 65 and over were obtained. Disability was measured using the Katz index scale which graded individuals on a scale of difficulty to carry out the activities of daily living (ADL). We utilized the conditional growth mixture model (GMM) with time-invariant covariates to identify various development patterns and associated factors.

## Results

Compared with those without disability ( $n = 1,140$ ), individuals living with ADL disability ( $n = 514$ ) were more likely to be old, female, or Han ethnic, eat more healthy food and suffer from chronic disease. Two groups with distinct developmental trajectories of ADL disability were identified among those with ADL disability, including the Slightly Increasing and the Quickly Increasing groups. People who did less housework (OR = 0.33, 95% CI: 0.12–0.90;  $p = 0.030$ ), suffered from stroke (OR = 5.39, 95% CI: 1.43–20.35;  $p = 0.013$ ) or dementia (OR = 10.29, 95% CI: 1.01–104.44;  $p = 0.049$ ) were more likely to be classified into the Quickly Increasing group.

## Conclusion

There existed two development patterns of ADL disability among the Chinese elderly. Besides, doing housework could help prevent the deterioration of disability to some extent, and suffering from stroke or dementia may accelerate the deterioration of ADL ability in later years. The findings provided implications for public health interventions.

## Background

Human aging and longevity are of broad interest to health researchers, policymakers, and the general public. The annual growth rate of the oldest in China is expected to increase on average by a staggering 4.4%, making this country one of the most rapidly aging societies in the world [1]. Almost 20% of the world's elderly individuals live in China, and there are predictions that this number will become more than

one quarter by 2050 [2]. Thus, the potential key to understanding successful aging and longevity may well rest in a greater understanding of this remarkably diverse and growing population in China.

The rapid aging process has brought a lot of attention to disability among older populations. Disability is defined as “a general term for impairment, limitation of activity and limitation of social participation, which denotes the negative aspects of the interaction between situational, environmental and personal factors under certain health conditions” by the World Health Organization (WHO) in 2001 [3]. Disability has been recognized as a significant predictor of the use of nursing homes [4], hospital services [5], and physician services [6]. Besides, the prevalence of disability was found to be associated with various health-related and lifestyle factors, like the presence of chronic diseases [7], feeling of loneliness [8], doing housework [9], and eating habits [10]. Generally, disability in old people is assessed by their difficulty to carry out the activities of daily living (ADL), which refers to the activities everybody does every day to live independently and integrated within the environment [3]. Several methods for examining ADL in older adults have been derived, and the Katz index scale [11] is one of the most popular tools. The Katz index scale was specially designed for the oldest and has been widely applied and verified in previous studies [12–14]. It grades individuals on a scale of dependent or independent for the hierarchical ordering of 6 activities: bathing, dressing, toileting, transferring, continence, and feeding. The scores on the Katz index scale represent the hierarchy of ADL difficulty with bathing being the most difficult and eating being the least difficult [11, 13]. Results from clinical practice reported that bathing was the most difficult and least independent task for disabled people because bathing could only be done in the bathroom where people fell easily [7]. Dressing requires both upper and lower limb functions, which are also associated with disability [15]. Furthermore, it was reported that the mid-loss functions were toilet use and locomotion, and the least difficult function was eating [16].

Existing results about the development patterns of disability were largely mixed. For example, scholars analyzed the growth of each ADL difficulty across four years and found they all show a trend of increasing over time [17]. Similarly, researchers recognized a growing trajectory of ADL disability among the elderly [12]. However, some recent research provided distinct results about the change of ADL disability over time. For example, some researchers found that most old individuals stayed at the same level of ADL disability across 5 years [15]. Some researchers reported that some disabled elderly individuals changed to lower disability or no-disability with age [18].

The inconsistency that existed in previous results indicated that there might exist distinct ADL disability trajectories among the elderly individuals, and this was not considered because most previous researchers ignored the potential heterogeneity of the dynamic process. Recently, a study grouped the elderly according to chronic diseases situation and described various ADL disability trajectories in different groups [7]. However, this study might be limited because it relied on artificial grouping, which might ignore the underlying heterogeneity in the development process. Besides, the factors affecting these potential development trends have not been discussed before. To obtain a deep understanding of the development of ADL disability, it is necessary to identify different potential growth patterns and the influential factors. Allow delineation of distinctive development trends for subgroups of elderly

individuals or even identify the influential factors at the same time would certainly be beneficial from both a prevention and intervention perspective.

The rapid development in statistical technology provided plenty of assistance in longitudinal studies. Various statistical methods have been used to explore the development trends of ADL disability, like the discrete survival models [17], cross-sectional analyses [15], multi-state models [18], and covariance analyses [7]. However, these methods could not take into account the potential heterogeneity in the whole population. One of the recent advances in statistical techniques for testing heterogeneity in longitudinal studies is the growth mixture model (GMM) [19]. The main advantage of GMM is that it does not rely on the assumption that all participants shared a single development pattern, which is the common limitation of traditional analyses. In GMM, the potential different development patterns are captured by a categorical latent variable, and the probabilities of classification for each individual are estimated to avoid the subjectivity of artificial grouping. Furthermore, several covariates can be included in the GMM, which is called the conditional GMM, to identify the factors affecting these development patterns [19, 20].

The current study aims to identify potential distinct trajectories of ADL disability development and the influential factors of trajectory membership using conditional GMM. To our knowledge, this is the first study to present the potential growth patterns of ADL disability and the influential factors in the old population from the person-centered viewpoint. By identifying the underlying trajectories that had not been recognized before, our study could provide more valuable information about the development of ADL disability for health researchers and policymakers. The following two questions will be addressed:

- 1) Are there potentially distinct ADL disability trajectories among elderly individuals? What are the characteristics of different trajectories?
- 2) Which specific factors affect the trajectory membership? Are these effects positive or negative?

## Methods

### Sample

The data we used were from the CLHLS, a collaborative effort between Duke University in the United States and Peking University in China. The CLHLS dataset is publicly available at the National Archive of Computerized Data on Aging (ICPSR 36179) (<http://opendata.pku.edu.cn/dataverse/CHADS>) after sending a data user agreement to the CLHLS team. With the emphasis on the oldest-old from 22 provinces in mainland China, the CLHLS collected face-to-face interviews with the elderly in 1998, 2000, 2002, 2005, 2008, 2011, and 2014 using internationally compatible questionnaires [21]. The CLHLS interviewed all centenarians in the sampled provinces, and various sources whenever available were used to validate the accuracy of their age, including the birth certificate, genealogical documents, and household booklets [21]. Newly recruited participants were added to augment the sample sizes at each measure occasion. In 1998 and 2000, surviving centenarians who volunteered to participate in the survey

were interviewed and participants aged 65 or older were also included since 2002. All participants provided informed consent forms, and the quality of the data was verified in previous studies [22, 23].

Depending on different initial measure occasions, the total samples from 1998 to 2014 were divided into 7 sub-samples, and each of these sub-samples contained a complete longitudinal survey. To obtain a sample that balanced a larger sample size and more measure occasions in a complete longitudinal survey, we used the sub-sample collected from 2002 to 2014, which consisted of a five-wave dataset. Overall, 16,064 elderly participants were interviewed in 2002, of those, 2,015, 1,464, 494, and 143 respondents were lost to follow-up respectively before 2005, 2008, 2011, 2014 (based on the index of ADL disability), and that 5,874, 2,520, 1,183, and 717 died before 2005, 2008, 2011, 2014. Ultimately, a total of 1,654 of the 2002 initial interviewees were included in this study who were re-interviewed in 2014.

## Measures

### ADL disability

The ADL disability of elderly individuals was measured using the Katz index scale. It asked the elders whether they needed help in the following activities: bathing, dressing, going to the toilet, transferring, continence, and feeding, organized as a scale of ordered profiles of levels of dependence in carrying out these functions [11].

Consistent with the previous scoring methods, the performance of ADL disability was classified into seven levels: 1 (Independent in feeding, continence, transferring, going to the toilet, dressing, and bathing), 2 (Independent in all but one of these functions), 3 (Independent in all but bathing and one additional functions), 4 (Independent in all but bathing, dressing, and one additional functions), 5 (Independent in all but bathing, dressing, going to the toilet, and one additional functions), 6 (Independent in all but bathing, dressing, going to the toilet, transferring, and one additional functions), and 7 (Dependent in all six functions), then higher scores represented higher levels of ADL disability [11]. Table 1 presents the scoring method of ADL disability used in this study.

Table 1  
The scoring method of ADL disability that used in this study.

Scores	Specific definitions of ADL disability
1	Independent in feeding, continence, transferring, going to the toilet, dressing, and bathing.
2	Independent in all but one of these functions.
3	Independent in all but bathing and one additional function.
4	Independent in all but bathing, dressing, and one additional function.
5	Independent in all but bathing, dressing, going to the toilet, and one additional function.
6	Independent in all but bathing, dressing, going to the toilet, transferring, and one additional function.
7	Dependent in all six functions.

## Covariates

Several time-invariant covariates were considered, which have been recognized as important to the elderly's ADL in previous studies [24, 25]. All covariates were collected in 2002, the first wave of data collection, which included 3 demographic variables (age; gender - "male = 1, female = 0"; ethnicity - "Han = 1, non-Han = 0"), 7 behavioral variables (do physical labor regularly; do housework; read newspapers/books; raise domestic animals/pets; play cards/mahjong; watch TV or listen to the radio; do any personal outdoor activities); 6 dietary variables (eat fresh fruit; eat vegetables; eat salt-preserved vegetables; eat meat; eat eggs; eat sugar), and 6 medical variables (suffering from hypertension; suffering from diabetes; suffering from heart disease; suffering from stroke; suffering from cataract; suffering from dementia). All the behavioral, dietary, and medical variables were coded as 1 for "yes" and 0 for "never".

## Analysis

Rates of missing data were generally 0.3% for the ADL disability and 0.8% for all covariates. Multiple imputation was used to handle missing data with five imputed datasets. Descriptive statistics were calculated using SPSS version 25.0, including sample information and the covariates mentioned above.

1 class to 4 classes of conditional GMM with covariates were employed to distinguish different trajectories of the elderly individuals with ADL disability. All covariates mentioned above were included in the conditional GMM. In GMM, means of intercepts and slopes were allowed to vary between classes and within classes [19, 20]. Figure 1 presents the structural model of GMM using ADL disability as an illustration. Conditional GMMs were fitted using the Mplus version 8.0 [26] with the Full-Information Maximum Likelihood (FIML) estimation.

Three types of indices were used to select the optimal model: 1) information criteria (Akaike Information Criterion, AIC; Bayesian Information Criterion, BIC; Sample-size Adjusted Bayesian Information Criterion, SABIC) [27, 28]. Lower AIC, BIC, and SABIC values were indicative of better model fit; 2) Likelihood ratio test (Lo-Mendell-Rubin Likelihood Ratio Test, Lo-Mendell-Rubin LRT; Lo-Mendell-Rubin Adjusted Likelihood Ratio Test, Lo-Mendell-Rubin Adjusted LRT) [29, 30]. A significant  $p$ -value represented that the  $k$  class model fit the data better; 3) entropy [31]. Higher entropy indicated the classification was more accurate. After determining the number of different trajectories, the subgroups with various trajectories would be named according to the characteristics of their trajectories, besides, we used the Odd Ratio (OR) values to depict the impact of covariates on the classification of different trajectories [32].

## Results

### Descriptive statistics

Given that a substantial number of elderly individuals kept independent in all six functions from 2002 to 2014, we were cognizant that those with ADL disability were not necessarily comparable to the general population. Thus, we treated the elderly who kept independent over the 12 years as without ADL disability ( $n = 1,140$ ), and the remaining elderly with ADL disability ( $n = 514$ ) were included in the final classification analysis.

In Table 2, we presented descriptive statistical results based on the total sample, the subjects without ADL disability, and those with ADL disability, separately. Of the total sample over the 12 years, elderly participants' scores on ADL disability increased from 1.05 (SD = 0.30) (37.6 %) at the first wave to 1.62 (SD = 1.46) at the fifth wave. At the first wave, the mean age of the elderly individuals was 73.32 (SD = 6.70) and more than half of them were female. Almost all the elderly were of Han ethnic background. The elderly individuals who reported that they did physical labor regularly took up more than 80% of the total sample, the same for the elderly who did housework, watched TV, listen to the radio, or did any personal outdoor activities at leisure time. Vegetables, meat, eggs were the most favorite food among the elderly, and they were eaten by more than 80% of the sample. More than 10% of the elderly individuals reported that they suffered from hypertension.

Table 2  
Descriptive statistics for analyzed variables, 2002–2014 CLHLS.

<b>Analyzed Variables</b>	<b>Total sample (<i>n</i> = 1,654) Mean (SD)</b>	<b>Without ADL disability (<i>n</i> = 1,140) Mean (SD)</b>	<b>With ADL disability (<i>n</i> = 514) Mean (SD)</b>
Main variables			
ADL disability (2002)	1.05(0.30)	1.00(0.00)	1.16(0.53)
ADL disability (2005)	1.06(0.39)	1.00(0.00)	1.20(0.68)
ADL disability (2008)	1.07(0.49)	1.00(0.00)	1.23(0.86)
ADL disability (2011)	1.27(0.89)	1.00(0.00)	1.87(1.44)
ADL disability (2014)	1.62(1.46)	1.00(0.00)	3.00(2.02)
Demographic variables (2002)			
Age	73.32(6.70)	71.92(5.70)	76.41(7.67)
Gender, male	0.47(0.49)	0.49(0.50)	0.43(0.50)
Ethnicity, Han	0.93(0.25)	0.91(0.28)	0.96(0.20)
Behavioral variables (2002)			
Do physical labor regularly	0.85(0.35)	0.86(0.34)	0.83(0.37)
Do housework	0.87(0.33)	0.90(0.30)	0.80(0.40)
Read newspapers/books	0.27(0.44)	0.28(0.45)	0.25(0.43)
Raise domestic animals/pets	0.51(0.50)	0.56(0.50)	0.41(0.49)
Play cards/mahjong	0.24(0.42)	0.24(0.43)	0.24(0.43)
Watch TV or listen radio	0.84(0.36)	0.85(0.36)	0.82(0.38)
Do any personal outdoor activities	0.86(0.35)	0.86(0.35)	0.85(0.36)
Dietary variables (2002)			
Eat fresh fruit	0.79(0.40)	0.79(0.41)	0.80(0.40)
Eat vegetables	0.99(0.10)	0.99(0.09)	0.99(0.12)
Eat salt-preserved vegetables	0.70(0.46)	0.70(0.46)	0.69(0.46)
Eat meat	0.84(0.36)	0.86(0.35)	0.81(0.39)
Eat eggs	0.86(0.35)	0.85(0.36)	0.88(0.33)

Analyzed Variables	Total sample	Without	With
	( <i>n</i> = 1,654)	ADL disability	ADL disability
	Mean (SD)	( <i>n</i> = 1,140)	( <i>n</i> = 514)
		Mean (SD)	Mean (SD)
Eat sugar	0.67(0.47)	0.66(0.47)	0.68(0.47)
Medical variables (2002)			
Suffering from hypertension	0.15(0.36)	0.13(0.34)	0.20(0.40)
Suffering from diabetes	0.01(0.11)	0.01(0.10)	0.02(0.12)
Suffering from heart disease	0.07(0.26)	0.06(0.23)	0.11(0.31)
Suffering from stroke	0.03(0.17)	0.02(0.15)	0.04(0.20)
Suffering from cataract	0.07(0.25)	0.05(0.22)	0.10(0.30)
Suffering from dementia	0.00(0.06)	0.00(0.04)	0.01(0.09)

Table 2 indicated that people without ADL disability and those with ADL disability differed in a variety of characteristics. Specifically, compared with those without disability, the elderly with ADL disability were more likely to be old, female, or Han ethnic, and they tended to eat more fresh fruit, eggs, or sugar daily and had a higher probability to suffer from at least one chronic disease (hypertension, diabetes, heart disease, stroke, cataract, or dementia). Furthermore, the elderly with the ADL disability were less involved in all 7 behavioral projects.

## Conditional GMM with covariates

### Fitting result

Table 3 presents the fitting results of the GMM models. We comprehensively considered three types of indices. The AIC, BIC, SABIC continued to decrease and entropy kept at 1.00 from 1 class to 4 classes solutions. Additionally, we used the Lo-Mendell-Rubin LRT and Lo-Mendell-Rubin Adjusted LRT to determine the number of latent classes, which compared whether a *k* class solution fitted better than a *k*-1 class solution. Both the Lo-Mendell-Rubin LRT and Lo-Mendell-Rubin Adjusted LRT suggested a 2-class solution fit better than a 1-class solution ( $p < 0.05$ ), and that a 3-class solution or a 4-class solution did not fit significantly better than a 2-class solution or a 3-class solution ( $p > 0.05$ ) respectively. Finally, we chose the 2-class solution.

Table 3  
Fitted indices for GMMs with 1 to 4 classes.

Number of Classes	AIC	BIC	SABIC	Entropy	Lo-Mendell-Rubin LRT	Lo-Mendell-Rubin Adjusted LRT
1	7299.50	7341.92	7310.18	—	—	—
2	6799.39	6947.86	6836.77	1.00	vs 1 79.04**	vs 1 546.61*
3	6616.12	6870.65	6680.20	1.00	vs 2 0.00	vs 2 231.78
4	6202.50	6563.09	6293.28	1.00	vs 3 0.00	vs 3 0.00
<p><i>NOTE.</i> AIC: Akaike's Information Criterion; BIC: Bayesian Information Criterion; SABIC: Sample-size Adjusted Bayesian Information Criterion; Lo-Mendell-Rubin LRT: Lo-Mendell-Rubin likelihood ratio test; Lo-Mendell-Rubin Adjusted LRT, Lo-Mendell-Rubin Adjusted Likelihood Ratio Test.</p>						
<p>* <math>p &lt; 0.05</math>, ** <math>p &lt; 0.01</math>, *** <math>p &lt; 0.001</math>.</p>						

## Two-class GMM

Figure 2 presents the development trends of ADL disability in the 2-class solution. The total number of participants in the first group was 497, which accounted for 96.69% of all the elderly with ADL disability. The first group had a low initial level and a slightly increasing trend of ADL disability, and its mean intercept was 1.06 (SE = 0.02,  $p < 0.001$ ) and the mean of the linear slope was 0.08 (SE = 0.02,  $p < 0.001$ ). Therefore, this group was labeled as the Slightly Increasing Group. The second group ( $n = 17$ ) which accounted for 3.31% of all the elderly with ADL disability showed a higher initial level and a faster-increasing trend. In the second group, the mean of intercept was 1.69 (SE = 0.31,  $p < 0.001$ ) and the mean of the linear slope was 1.58 (SE = 0.20,  $p < 0.001$ ), therefore, this group was named the Quickly Increasing Group.

## The impact of covariates

After identifying the development trends of ADL disability, influential factors of the trajectory membership were examined. In this study, we considered 3 demographic variables, 7 behavioral variables, 6 dietary variables, and 6 medical variables as covariates, which were all collected in 2002. Table 4 presents the effects of these covariates in the 2-class solution.

Table 4  
Effects of different covariates using Slightly Increasing Group as the reference group.

Covariates	Quickly Increasing Group		
	OR	95% CI	<i>P</i> -value
Demographic variables (2002)			
Age	1.01	(0.95–1.08)	0.697
Gender, male	1.51	(0.57–3.99)	0.403
Ethnicity, Han	-	-	-
Behavioral variables (2002)			
Do physical labor regularly	0.63	(0.20–1.99)	0.434
Do housework	0.33	(0.12–0.90)	0.030
Read newspapers/books	0.40	(0.09–1.78)	0.229
Raise domestic animals/pets	0.59	(0.20–1.70)	0.326
Play cards/mahjong	0.19	(0.03–1.48)	0.114
Watch TV or listen radio	0.38	(0.14–1.07)	0.066
Do any personal outdoor activities	0.41	(0.14–1.19)	0.100
Dietary variables (2002)			
Eat fresh fruit	0.35	(0.13–1.05)	0.058
Eat vegetables	0.20	(0.02–1.72)	0.141
Eat salt-preserved vegetables	0.38	(0.14–1.00)	0.051
Eat meat	0.74	(0.24–2.32)	0.603
Eat eggs	1.07	(0.24–4.79)	0.931
Eat sugar	0.51	(0.19–1.33)	0.168
Medical variables (2002)			
Suffering from hypertension	2.25	(0.81–6.23)	0.119
Suffering from diabetes	4.38	(0.51–37.70)	0.179
Suffering from heart disease	1.09	(0.24–4.91)	0.907
Suffering from stroke	5.39	(1.43–20.35)	0.013
<i>NOTE.</i> All the elderly individuals in the Quickly Increasing Group were from Han ethnic backgrounds.			
95% CI: 95% Confidence Interval.			

Covariates	Quickly Increasing Group		
	OR	95% CI	<i>P</i> -value
Suffering from cataract	2.95	(0.92–9.40)	0.068
Suffering from dementia	10.29	(1.01–104.44)	0.049
<i>NOTE.</i> All the elderly individuals in the Quickly Increasing Group were from Han ethnic backgrounds.			
95% CI: 95% Confidence Interval.			

Using Slightly Increasing Group as the reference group, the elderly individuals who did housework (OR = 0.33, 95% CI: 0.12–0.90;  $p = 0.030$ ) were more likely to be classified to the Quickly Increasing Group.

Regarding to medical conditions, the individuals who suffered from stroke (OR = 5.39, 95% CI: 1.43–20.35;  $p = 0.013$ ) and those who suffered from dementia (OR = 10.29, 95% CI: 1.01–104.44;  $p = 0.049$ ) were more likely to be classified to the Quickly Increasing Group.

## Discussion

To distinguish the underlying development trends of ADL disability, this current study analyzed the change of ADL disability across 12 years among the Chinese elderly from the CLHLS. The ADL disability was measured by the Katz index scale, which graded individuals on a scale of dependent or independent for 6 activities: bathing, dressing, toileting, transferring, continence, and feeding. The change of ADL disability and the influential factors were examined by the GMM.

Our findings indicated that there were 1,140 elderly individuals kept independent in all six functions from 2002 to 2014, which took up more than 2/3 (68.92%) of our sample. It was also reported that the majority of the oldest old did not exhibit any ADL disability [33]. Thus we realized that the elderly individuals with ADL disability were not necessarily comparable to the general population. Therefore, we treated the elderly individuals who kept independent as without ADL disability ( $n = 1,140$ ), and the remained sample of elderly individuals with ADL disability ( $n = 514$ ) was included in the final classification analysis.

Results from the conditional GMM suggested that there were two latent trajectories of ADL disability among the elderly. The first group was the Slightly Increasing Group. The number of elderly individuals in this group was 497, which accounted for 96.69% of the elderly with ADL disability. The elderly in this group showed a low initial level and a rather gentle growth trend of ADL disability. It was shown that the proportion of those elderly who at least scored 2 points increased gradually as time went by, and based on the scoring method used in this study, the results implied that the proportion of those who were dependent in at least one of the six functions slightly increased across twelve years. This result was similar to the previous finding that the elderly who suffered from cognitive impairment but no dementia had a mild increase trajectory of ADL disability [34]. Another group was the Quickly Increasing Group.

There were 17 elderly individuals in this group which took up 3.31% of the sample with ADL disability. Compared with the other group, individuals in the Quickly Increasing Group reported relatively higher initial levels of ADL disability and experienced a faster increasing trend over time. In other words, these elderly individuals were dependent in at least one of six functions at the first measure occasions, and then they were entirely dependent on other functions. This result could be supported by previous studies, which found that the level of dependency in ADL significantly increased with age [35, 36], and as time went by, a small part of the elderly became fully dependent in all activities [8]. In general, we could conclude that most of the elderly individuals in China didn't suffer ADL disability, and for those with ADL disability, the level of disability increased over time, but only a few were entirely dependent finally.

Additionally, it was found that doing less housework might accelerate the deterioration of ADL disability. This current study showed that among the elderly with ADL disability, those who did housework at first were less likely to be classified into the Quickly Increasing Group than the Slightly Increasing Group. Previous evidence suggested that doing more housework might have a positive impact on physical health among the elderly [37, 38]. For example, gardening was found to be associated with a lower risk of mortality [39] and better condition of blood pressure [40]. Gardening and maintenance activities might increase fitness levels and muscle strength because they required some form of physical exertion, such as carrying equipment for repair works, lawn mowing, shoveling, digging holes, and carrying soil [9]. Furthermore, a positive association between childcare and health status among older people was discovered in the former research [9]. It was found that grandparenting and caregiving support, especially caring for grandchildren, were positively associated with better self-reported health [41]. Therefore, we believed that doing housework was generally helpful for ADL ability among the elderly.

Besides, our findings suggested that suffering from stroke or dementia might increase the risk of ADL disability. This was consistent with previous findings [42]. Stroke is a common chronic disease that impacts physical functions and contributes to disability [43]. It was found that 40% of acute stroke survivors reported total or severe ADL disabilities at hospital discharge [44], and scholars reported that nearly 40% of patients at 6 years post-stroke still were dependent [45]. The majority of the patients who suffered from chronic stroke needed assistance with bathing, and half of them ceased several activities [43]. As for patients with dementia, around 40% of them were unable to perform any of the ADL tasks [46]. Moreover, previous studies found that people with dementia experienced increased difficulty in process skills such as finishing up the tasks, clarifying situations appropriately, noticing their problems, and responding appropriately to solve those problems [47]. One population study analyzed the combined effects of stroke and dementia on ADL disability, and the results showed that individuals with stroke and dementia comorbidity suffered a little higher ADL limitations than those with stroke or dementia respectively [48]. And the effects of comorbidity in chronic diseases on the development trends of ADL disability should be clarified in the future. Overall, the current results indicated that doing housework could help prevent the deterioration of disability to some extent, and suffering from stroke or dementia might accelerate the deterioration of ADL disability, which provided implications for public health programs targeting older people.

The strengths of the study included that: 1) we analyzed longitudinal data from the CLHLS, and this was a large multi-wave nationally representative longitudinal study concerning the general older population in China, and the ADL disability was measured using a widely recommended tool, the Katz index scale. 2) the current study used the scoring method which reflected the change of ADL disability levels during the longitudinal process. 3) a novel longitudinal method, the conditional GMM, was adopted to identify the potential development trends of ADL disability, and this was able to avoid limitations in the traditional artificial grouping. 4) our findings verified the influential factors of the development of ADL disability by including covariates in GMM, and this was rarely considered in previous studies. However, this study also had some shortcomings. First, previous evidence suggested that there existed gender inequality in doing housework, that elderly women usually spend more time on housework activities than men, and this activity might affect the development trends of ADL disability [37, 49]. Future research should consider different trends of ADL disability across genders. Besides, this study only included time-invariant covariates, and it would be interesting to consider some time-varying covariates in future studies.

## Conclusion

This study used the conditional GMM to examine various development trajectories of ADL disability and the influential factors in a nationally representative sample across 12 years. Two subgroups with distinct ADL disability trajectories were identified: the Slightly Increasing Group and the Quickly Increasing Group. Furthermore, our findings suggested that doing housework could help prevent the deterioration of disability to some extent, and suffering from stroke or dementia might accelerate the deterioration of ADL disability.

## Abbreviations

ADL

Activities of daily living.

CLHLS

Chinese Longitudinal Healthy Longevity Survey.

GMM

Growth mixture model.

## Declarations

**Ethics approval and consent to participate** (The data we used was from an open database.)

**Consent for publication** (Not applicable.)

**Availability of data and material** (The dataset used is available from the corresponding author on reasonable request.)

**Competing interests** (The authors have no financial or proprietary interests in any material discussed in this article.)

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## Figures

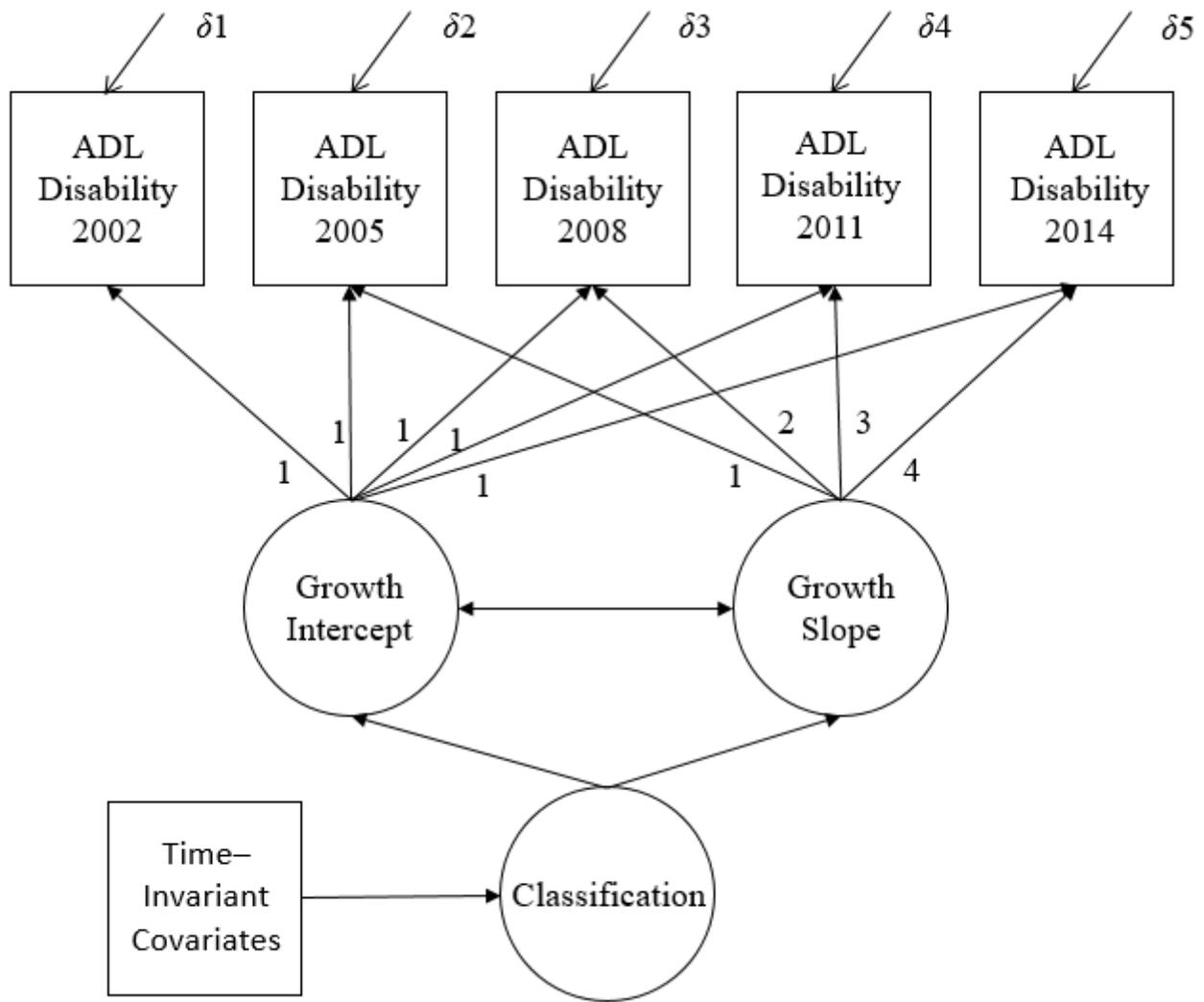


Figure 1

Structural model of the conditional GMM.

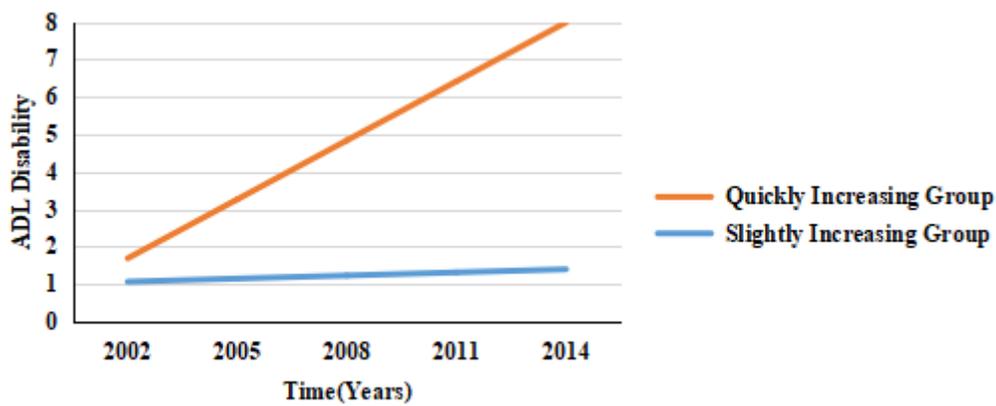


Figure 2

Development trends of ADL disability.