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Impact of New Disability Subtypes on 3-year Mortality in Chinese Older Adults

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Abstract

Objectives—To examine a new method for classifying disability subtypes by combining self-reported and performance-based tools to predict mortality in Chinese older adults.

Design—Prospective cohort study.

Setting—Community-dwelling old adults.

Participants—16,020 Chinese adults over age 65 from the Chinese Longitudinal Healthy Longevity Survey (CLHLS).

Measurements—Self-reported Basic Activities of Daily Living (ADLs) and physical performance (PP) tests (chair standing, lifting a book from floor, turning 360 degrees) cross-classified to create mutually exclusive disability subtypes: subtype 0 (no limitations in PP or ADL), subtype 1 (limitations in PP, no limitations in ADL), subtype 2 (no limitations in PP, limitations in ADL), and subtype 3 (limitations in both PP and ADL). Outcome was mortality over three years.

Results—Cox proportional hazard models, controlling for sociodemographics, living situation, healthcare access, social support, health status, and life style, showed that older adults without any limitations in ADL or PP had significantly lower mortality risk than those with other disability subtypes, and that there was a graded pattern of increased mortality according to subtypes 1, 2, and 3 (hazard ratios = 1.31 [1.20, 1.42], 1.39 [1.23, 1.59], and 1.88 [1.72, 2.05], respectively). When compared with the average survival curve in the cohort, subtypes of isolated performance deficits or self-reported disability did not substantially discriminate risks of death over three years.

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Conclusion—Combined use of self-reported and physical performance tools is necessary when screening for mutually exclusive disability subtypes that confer significantly elevated or decreased mortality risks to a population of older adults.

Keywords

physical disability; activities of daily living; physical performance; mortality

Introduction

With the world's population rapidly aging, greater emphasis is being placed on measurement of disability in later life.¹ This is especially true for developing countries such as China where costs relevant to age-associated disabilities have broad policy implications, due in part to the sheer size of the world's largest elderly populations in those countries.^{2,3}

Though conceptual models of disability have been somewhat fluid in recent decades, commonly-used protocols for measuring age-associated physical disability frequently employ self-reported assessments, and include, for example, basic activities of daily living (ADL), instrumental ADL (IADL), and mobility limitations.⁴⁻⁶ Self-reported measures, however, have been criticized for their potential to be affected by differences in perceptions, values, and thresholds for self-reporting disability and their consequences across individuals and/or groups.^{7,8} In contrast, performance-based tools have been recognized in the geriatric literature for merits such as objectivity, reproducibility, and sensitivity to change, and include tests such as gait speed or short physical performance battery, which have proven powerful in predicting the development of dependency in ADL and hospitalization.⁹⁻¹² On the other hand, limitations of performance-based tools also are important, including requiring more time and/or special equipment, and not necessarily reflecting performance in the context of the person's living environment. The independent strengths and relative advantages of both types of tools for predicting objective medical outcomes are thus quite notable.^{13,14} Numerous studies have demonstrated good but not perfect correlations between the two types of measurement, prompting researchers more recently to focus on their complementary strengths and weaknesses.¹⁵⁻¹⁸

For example, Reuben et al. reported that directly combining self-reported and physical performance measurement enhances identification of meaningful gradients in physical function, but that use of physical performance tools have greatest “added value” in the most functional older adults.¹⁸ Another study examined prevalence and predictors of disability subtypes based on a combination of self-reported and performance based measures of physical function, and found substantial proportions of persons in four distinct and mutually exclusive subtypes, each of which also was found to have etiologically different predictors including rural/urban residence, living arrangement, social support, income and education, and ethnicity.¹⁹

The purpose of the current research was to evaluate whether the four previously identified mutually exclusive disability subtypes identified by combining self-reported and performance-based assessments differentially predicts short-term mortality. We hypothesized that this approach would facilitate identification of disability subtypes that clearly differentiate mortality risks over a three-year period in a large population of Chinese older adults.

Methods

Research Design

Data were obtained from the Chinese Longitudinal Healthy Longevity Survey (CLHLS), a longitudinal investigation designed to study the oldest old Chinese.²⁰ The survey was launched in 1998 and follow-ups were implemented in 2000, 2002 and 2005 with replacement for deceased. The survey randomly selected half of the counties/cities in 22 out of 31 provinces in China, representing approximately 85.0% of the Chinese population. All centenarians in chosen counties/cities were interviewed along with one nearby octogenarian and nonagenarian matched by geographical unit and gender. This selection process was designed to ensure comparable numbers of randomly selected male and female octo-, nona-, and centenarians. Beginning in 2002, a cohort aged 65-79 years has been followed, which were randomly chosen from the neighborhood of centenarians based on pre-designated age-sex ratios. All information was obtained through in-home interviews.

We used the 2002 wave of CLHLS, which contained 16,020 older adults over age 65, including 6,826 males and 9,194 females, 4,045 elderly aged 65-79 and 11,175 aged 80+. The baseline data also included 2,642 survivors from the 1998 cohort and 3,674 from the 2000 cohort. To estimate three-year mortality, we used the 2005 follow-up survey, in which 5,872 older adults from the 2002 baseline cohort had died (36.7%), 2,012 were lost to follow (12.6%) and 8,136 survived (50.8%).

Dates of death were collected from several sources. Death certificates were used when available, otherwise next-of-kin's reported date of death was used and validated by neighborhood registries. Reliability, validity, and consistency of measures including date of death have been previously reported.²¹

Disability Subtypes

Following previously proposed methodology, we created disability subtypes using cross-classifications of self-reported dependency in activities of daily living with observed physical performance.¹⁹ First, self-reported need for human help in one or more ADLs (continence, feeding, bathing, dressing, toileting, and indoor-transfer) was used to construct a binary variable characterizing any self-reported ADL disability. Approximately 5.5% of individuals with ADL disabilities in the sample were actually identified via proxy reports (n=4760, unweighted). We then constructed a dichotomous indicator about presence or absence of any physical performance (PP) limitation. The three performance-based tests, administered in participants' homes by trained technicians, included independent ability to stand from a chair without using hands, lifting a book from the floor from a standing position, and turning 360 degrees. Four mutually exclusive disability subtypes were generated with two-by-two classification: neither PP nor ADL limited (subtype 0); limited in PP but not in ADL (subtype 1); limited in ADL but not in PP (subtype 2); both PP and ADL limited (subtype 3).

Covariates

We controlled for a broad range of covariates shown to be associated with old-age mortality in literature. Demographic covariates included gender, ethnicity (Han versus minorities) and age. Socioeconomic indicators included education (no schooling versus at least one year of schooling) and household income per capita for the previous year (unit: 10,000 Yuan). Living environment (urban, town, or rural residence) and living arrangements (living with household members, institutionalized or living alone) were included. A 4-question index of social support (score= 0-12 with higher numbers indicating better social support) was applied, based on the type of social ties used by respondents when talking about daily life,

expressing their thoughts, being sick, or seeking help. The question “can you get adequate medical service when you are sick?” was used as a marker of access to health care.

Health status covariates included a Chinese version of the Mini-Mental Status Examination (score = 0-29 with higher numbers indicating better functioning), a 5-question index of depressive symptoms (score 0-5 with higher numbers indicating more depressive symptoms), and self-reported health (good or very good, fair, poor or very poor, do not know). We also controlled for the chronic diseases of highest mortality among Chinese elderly (heart disease, stroke/cerebrovascular disease, bronchitis/emphysema/asthma/pneumonia, and cancer).

Lifestyle covariates included past history of smoking (yes/no), current drinking (yes/no), current regular exercise (yes/no), and regular participation in religious activities (yes/no). Weight in kilograms and knee height (a marker of overall height) in centimeters were included as anthropomorphic variables. To account for an observed non-linear relationship between weight and mortality, weight square was added to the model. Finally, a proxy indicator was included to adjust for potential confounding effects.

Statistics

Analyses were performed using Stata/SE 10.0. Due to the non-random sampling scheme, descriptive statistics are reported with weighting for age, gender and rural/urban residence.²² Weighting was not used in regression because unweighted regression coefficients are unbiased, and weighted regression results also have standard errors that are inflated. After checking proportional hazard assumptions, Cox proportional hazard models were applied to estimate the relative risks of mortality in each disability subtype.

Result

Descriptive Statistics

Table 1 shows that average age was about 73 years. Females accounted for more than half of the cohort, and approximately 6.0% were non-Han minorities. Roughly one fifth of Chinese older adults lived in urban areas, about 16.0% lived in towns, and rural residence accounted for 65.0%. Most (85.0%) lived with household members. About half of aged Chinese had no schooling experience. Average household income per capita in the previous year was about 6,400 Yuan. Social support (range=0-12) was high on average (mean=11.0, SD=1.9) and most reported the availability of medical services if needed (91.4%).

Approximately half of this population reported their health status as good or very good, 35.1% considered their health status as “fair” and about 15.0% responded negatively. On average, there were low levels of depressive symptoms, and the average MMSE score was 21.3 (SD=3.9). About one fourth had at least one of the major chronic conditions mentioned above. Approximately one third were previous smokers, 23.3% reported currently drinking alcohol, a little over 60.0% reported not currently exercising, and roughly 20.0% reported regular religious participation.

Prevalence of disability subtypes

The prevalence of these new disability subtypes has been reported previously,¹⁹ therefore we briefly summarize for the reader. Just over 8.0% of Chinese older adults had at least one ADL disability (Table 1). Bathing difficulty was reported most frequently (6.7%), while for other ADL items, the prevalent rate was generally around 2.0%. Almost one fifth of the Chinese elderly were incapable of independently carrying out at least one of the PP tests. Across the three tests, the average rate of PP limitation was approximately 10.0%.

With respect to disability subtypes, 78.9% of Chinese older adults were free of both self-reported ADL disability and observed performance limitations (subtype 0), while 5.1% were in the most severe category (subtype 3), i.e. having both PP limitation and ADL disability. In comparison, fewer cases (3.0%) were limited in ADL disability but not in PP performance (subtype 2), but a comparably large group (13.0%) of subjects had PP limitation but no ADL disability (subtype 1).

Effect of disability subtypes on survival

Figure 1 shows adjusted patterns of survival curves stratified by disability subtypes. The curves clustering in the middle of the figure, from high to low, respectively, are the grand mean, the subtype 1 curve for participants with observed PP limitations but no dependency with ADL tasks, and the subtype 2 curve for individuals who reported ADL disability but did not have PP limitations. The close proximity of these curves to each other shows that the sole presence of disability, either self-reported or performance-based, did not discriminate mortality gradients from the average curve. Moreover, PP limitations and self-reported measures of ADL performed similarly in their very small decrease relative to the overall survival curve for the population.

However, when classified by the dual presence and/or non-presence of both observed performance limitations and self-reported disability, survival curves were very distinct from the average. Not surprisingly, participants classified as subtype 0, who were free of both self-reported dependency in ADLs and observed PP limitations, had the greatest survival rates over the period of follow-up. Similarly, older adults with both types of disabilities (subtype 3) had much lower rates throughout the observation period.

Table 2 also shows that in comparison with the sole presence of self-reported disability or performance-based limitations and with the average of the cohort, use of a combined assessment approach identified a mortality hazard about 50.0% higher (subtype 3) or 30.0% lower (subtype 0) in the three-year follow-up.

Covariate effects on survival

Table 2 also shows parameter estimates, P values and confidence intervals for covariates from the fully adjusted model. Female gender and non-Han minority status reduced three-year mortality risks by 28.0% and 11.0%, respectively. Every additional year increased the mortality risk by 6.0%. Although not statistically significant, counterintuitive point estimates were seen in the increased hazards of mortality with greater education and income. People living in towns or rural areas, in comparison with the urban residence, were more likely to die in the later three years by about 16.0%. Institutionalized Chinese elderly had a 50.0% higher risk of death in comparison with people living with their household members.

Cognitive impairment, self-rated health, and comorbidity were all associated with three-year mortality as expected. Heavier people and those underweight were more likely to die in the later three years. History of smoking increased the risk by 7.0% compared to non-smokers, while drinking and regular exercises were both protective and respectively reduced the mortality risk by 8.0% and 15.0%. Participation in religious activities significantly reduced the three-year mortality rate by 12.0%.

Discussion

This paper reports several key results. First, these results clearly demonstrate that jointly classifying disability according to both self-reported activities of daily living and observed physical performance is required in order to differentially predict death in a large cohort of Chinese older adults. Surprisingly, neither ADL dependency alone nor performance-based

limitations alone distinguished substantially different survival rate compared to the average rate in the overall population. However, this should not imply that identifying those mutually distinct populations with subtle disability is unimportant. The prevalence of performance-based limitations alone is much higher in the Chinese population than ADL dependency alone (13.0% versus 3.0%), and the clinical needs of the two populations may differ greatly. For example, persons who have physical performance limitations but do not yet have ADL dependency may benefit from interventions such as exercise to improve their rate of survival. From a policy perspective, persons without ADL limitations don't require availability of human help to reside in the community and so require less support from government or informal services. For predicting mortality, however, it is clear that combined use of both types of disability measures is optimal. When used alone, neither self-reported nor performance tests adequately discriminated survival rates from the average whereas the joint measures identified groups with 30% lower or 50% higher risk of dying over a three year period. This finding is novel and has important clinical and health policy implications. Future work is needed to examine the economic implications and health outcomes of policies targeted at these distinct disablement groups.

Little prior research has been done on the complimentary use of self reported and performance based tools. In contrast to one prior study,¹⁸ our results show that the added value of performance-based tests is not only important for the highest functioning, ADL-free group, but also for ADL-limited people. This finding is novel as previous work had largely combined both groups into a single category or suggested that the less severe subtype might be clinically irrelevant.

The older adults who are limited in ADL but not in PP comprise a meaningful disability subtype. Theoretical models for the disablement process propose that various factors may influence the process, such as organ system impairments and both personal and environmental factors.^{23,24} The existence of the multiple mechanisms toward ADL dependency well justifies subtype 2. For example, impairment in cardiopulmonary function might limit endurance and affect the ability to carry out ADLs even though the endurance limitation does not manifest in brief performance tests. Subtype 2 may also reveal contextual factors in the disablement process. For instance, elderly people who are lacking electricity and lighting and are without personal shower facilities may tend to report difficulties with indoor transferring and bathing, even though they perform well on performance tests. In addition, Persons with access to social support may also be more likely to report dependency in ADLs with modest limitations in physical abilities, simply because those resources are more available or easier to access. That is, self-report of disability can sometimes reflect use of assistance and not necessarily need per se.

This report also examines the relationship between disability and mortality in a developing country - most prior research was carried out in western/developed countries. Our results showed that the role of disability in mortality prediction in a developing country with wide disparities in socioeconomic characteristics is similar to findings from more developed countries. The presence of disability among Chinese aged adults, be it self-reported or observed, conjoint or in isolation, among the many covariates in our model, always was the strongest predictor of old-age mortality. Although more work is needed to establish the causal linkages between disability and mortality in the context of developing countries, we surmise that the limited health care services available for disabled elderly in China may help to explain the magnitude of the association we observed between disability and death.²⁵ In follow-up analyses, we found a statistically significant positive association between disability subtypes and lack of access to health care. Our work thus suggests a need for improved screening of disability in Chinese elderly people and/or enhanced social programs and medical services targeted to the prevention and treatment of disability. The size and rate

of growth of China's older population, the prevalence of disability in China, and the known impact of old-age disability on health status, health care costs and social burden, all imply an urgent need for medical reforms in China.

Several covariates in addition to disability were observed to have associations with mortality that are worth mentioning here. First, the medical service system in China is much more advanced in the urban areas in comparison with the rural areas, which have greatly reduced the mortality risks of urban residents and our results suggest a protective effect on mortality from urban residence. Another interesting finding was that neither living alone nor with others substantially altered the risk of mortality, although residential status in institutions markedly decreased survival as expected. We anticipated a positive role of social support on late life health via household members; however, those effects may be confounded by other mechanisms. For example, previous work showed that living alone promoted independence in Chinese elderly, even when performance-based limitations were present.¹⁹ Similarly, other recent analyses showed Chinese elderly people with family-oriented networks, compared with aged people living alone, were significantly disadvantaged in disability onset and subsequent survival.²⁶

Some of our findings, while not significant, seem counterintuitive. Specifically, the hazard of mortality was slightly, although not significantly, higher for Chinese elders with greater education or greater wealth. Higher socioeconomic status is generally associated with lower mortality risk in western countries, and even in China improved income was associated with significant mortality declines in the 1980s.²⁷ However, recent studies suggest an epidemiologic transition in China with rapid increases in the “diseases of the wealthy,” including hypertension, diabetes, and obesity closely related to economic development in developing countries, for which people of higher socioeconomic status could be vulnerable.^{28,29}

This study had several important limitations. First, the observation period for subsequent death in our study was only three years. Although the relatively close proximity in time of the baseline measures of disability to the mortality assessments helps to support a potentially causal relationship, longer follow-up and repeated measures of physical function might bring more meaningful and interesting results, as is exactly what we expect for future studies. Second, the three measurements we used in the PP tests primarily target motor skills. It is possible that performance-based tests that target function of other organ systems would provide additional predictive value. Other impairments not reflected in these three performance-based measures may include impaired cardiopulmonary functions and sensory limitations such as blindness. The strength of the current study is use of a large, national survey of the older population of a developing country with a very rapidly aging population.

In conclusion, we believe this is the first time that mutually distinct disability subtypes were created using a combination of the two established types of disability measurements and applied to mortality prediction in a large population of a developing country. Since the physical performance tests we used here were neither expensive nor complicated, their joint usage with self-reported ADL dependency could be very feasible for future clinical and policy research in disability.

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Figure 1. Survival Curves of the Four Disablement Subtypes over a Three-year Period

Table 1
Baseline Data from the 2002 Wave of the Chinese Longitudinal Healthy Longevity Survey
(n=16,020)

Variables	Percentage/Mean(SD)
Sociodemographics	
Women (%)	53.0
Age (year)	72.5 (6.1)
Non-Han minority (%)	5.8
Education received (%)	48.8
Income per capita (Yuan)	6399.4 (17466.3)
Living environment	
<i>Living in urban (%)</i>	19.2
<i>Living in town (%)</i>	15.8
<i>Living in rural (%)</i>	65.0
Living arrangement	
<i>Living with family (%)</i>	85.0
<i>Institutionalized (%)</i>	2.4
<i>Living alone (%)</i>	12.6
Mean social support score (score: 0-12)	11.0 (1.9)
Access to medical service (%)	91.4
Health	
Mean MMSE score (score: 0-29)	21.3 (3.9)
Mean depression symptoms score (score: 0-5)	0.7 (0.9)
Having one of the four major illnesses (%)	25.3
Self-reported health	
<i>Good or very good (%)</i>	49.1
<i>Fair (%)</i>	35.1
<i>Poor or very poor (%)</i>	14.8
<i>Do not know (%)</i>	1.0
Mean weight (kilogram)	52.6 (10.4)
Mean knee high (cm)	46.7 (5.4)
Smoking in the past (%)	37.5
Drinking at present (%)	23.3
Exercising at present (%)	36.8
Religious participation at present (%)	22.7
Disability Subtypes	
Self-reported ADL Dependency	
<i>Bathing (%)</i>	6.7
<i>Dressing (%)</i>	2.3
<i>Toileting (%)</i>	2.3
<i>Transfer (%)</i>	1.8
<i>Continence (%)</i>	1.5

Variables	Percentage/Mean(SD)
<i>Feeding (%)</i>	1.4
<i>Any ADL limitation (%)</i>	8.1
Proxy report in ADL Dependency (%)	5.5
Observed Physical Performance	
<i>Standing up from chair (%)</i>	11.6
<i>Picking up a book from floor (%)</i>	9.4
<i>Turning around 360 degrees (%)</i>	7.8
<i>Any PP limitation (%)</i>	18.1
Disability subtypes	
<i>Subtype 0 (Neither ADL nor PP limited) (%)</i>	78.9 (Female: 75.6; Male: 83.4)
<i>Subtype 1 (Limited in PP, but not in ADL) (%)</i>	13.0 (Female: 15.4; Male: 10.3)
<i>Subtype 2 (Limited in ADL, but not in PP) (%)</i>	3.0 (Female: 3.4; Male: 2.4)
<i>Subtype 3 (Both ADL and PP limited) (%)</i>	5.1 (Female: 5.6; Male: 3.9)

Table 2
The Cox Model of the Three-year Mortality

Variables	HR	P value	95% CI
Disability: (Subtype 0: Neither ADL nor PP limited)			
<i>Subtype 1: Limited in PP, but not in ADL</i>	1.31	P<0.001	[1.20, 1.42]
<i>Subtype 2: Limited in ADL, but not in PP</i>	1.39	P<0.001	[1.23, 1.59]
<i>Subtype 3: Both ADL and PP limited</i>	1.88	P<0.001	[1.72, 2.05]
Proxy report	1.16	P<0.001	[1.08, 1.25]
Women	0.72	P<0.001	[0.66, 0.78]
Age (year)	1.06	P<0.001	[1.05, 1.06]
Non-Han minorities	0.89	0.054	[0.79, 1.00]
Education received (yes/no)	1.07	0.074	[0.99, 1.15]
Income/10000 (Yuan)	1.09	0.060	[1.00, 1.19]
Living environment: (Living in urban area)			
<i>Living in town area</i>	1.17	0.001	[1.07, 1.28]
<i>Living in rural area</i>	1.15	0.001	[1.06, 1.25]
Living arrangement: (Living with family)			
<i>Institutionalized</i>	1.50	P<0.001	[1.28, 1.75]
<i>Living alone</i>	1.07	0.161	[0.97, 1.17]
Social support	1.01	0.163	[1.00, 1.03]
Availability of medical service (yes/no)	1.13	0.007	[1.03, 1.23]
MMSE	0.98	P<0.001	[0.98, 0.99]
Depression symptoms	1.02	0.391	[0.98, 1.05]
Having one of the four major illnesses (yes/no)	1.12	0.002	[1.04, 1.19]
Self-reported health: (Fair)			
<i>Good or very good</i>	0.86	P<0.001	[0.81, 0.92]
<i>Poor or very poor</i>	1.12	0.010	[1.03, 1.22]
<i>Do not know</i>	0.93	0.247	[0.82, 1.05]
Weight/10 (kilogram)	0.69	P<0.001	[0.58, 0.82]
Square of weight/10	1.03	0.001	[1.01, 1.04]
Knee height (cm)	1.00	0.467	[1.00, 1.01]
Smoking in the past (yes/no)	1.07	0.052	[1.00, 1.15]
Drinking at present (yes/no)	0.92	0.025	[0.85, 0.99]
Regular exercise at present (yes/no)	0.85	P<0.001	[0.79, 0.91]
Religious activity at present (yes/no)	0.88	0.004	[0.81, 0.96]