Sociodemographic Effects on Onset and Recovery of ADL Disability among Chinese Oldest-old

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Abstract

By pooling the data from the three waves (1998, 2000, 2002) of the Chinese Longitudinal Health and Longevity Survey, this study examines the association of sociodemographic factors with onset and recovery of ADL disability including changes in functional status before dying. The results show that the sociodemographic factors seem to play some specific roles on disability dynamics at very high ages even after controlling for a rich set of confounders. Our results also point out that the conventional method, which excludes the information of ADL changes before dying due to unavailability of the data, overestimates the effects of age, gender, ethnicity, and living alone on disability transitions whereas underestimates the effects of SES, although the discrepancies are not very big. This finding indicates that we need to pay much more attention to collect ADL dynamic information between survey intervals among both surviving and deceased interviewees and thus to better understand the correlations between sociodemographic factors and dynamics of disability.

1. Introduction

Understanding disability dynamic mechanism could lead to better targeting of efforts to reduce or postpone disabilities at older ages (Melzer et al. 2001). A growing number of studies have shown strong associations of sociodemographic factors with the dynamic changes of disability in elderly (e.g., Crimmins, Hayward, and Saito 1994; 1996; Gill, Robison and Tinetti 1997; Land, Guralnik, and Blazer 1994; Manton, Stallard, and Corder 1995). With few exceptions (e.g., Crimmins and Saito 1993), almost all prior studies consistently find that incidence rate of disability increases with age, whereas the probability of getting better decreases with age (e.g., Crimmins et al. 1996; Gill et al 1997; Hayward, Crimmins, and Saito 1998; Laditka and Wolf 1998; Land et al.

1994; Manton 1988; Rogers, Rogers, and Belanger 1992). Gender difference in the dynamics of ADL disability is inconclusive. Some studies have reported that older males have an advantage in disability dynamics over older females (Crimmins et al. 1996; Hayward et al. 1998; Jagger, Arthur, Spiers et al. 2001), while some other studies provide an opposite result that the elderly women are in advantages (e.g., Crimmins and Saito 1993; Land et al 1994), and even others find that there is no significant gender difference in disability dynamics (Ferrucci et al. 1996; Guralnik et al. 1997; Rogers et al. 1992). Contradictory results of racial and ethnic difference in disability dynamics among elders are also frequently reported (Boult, Kane, Louis et al. 1994; Crimmins et al. 1996; Land et al. 1994; Mendes de Leone et al. 1997). Although most studies have shown that the higher SES could reduce the risk of the onset of disability and increase the likelihood to regain functioning at late ages (Crimmins et al. 1996; Land et al. 1994; Seeman et al. 1994), there is small number of studies find such protective effects are not significant or weak (Melzer et al. 2001; van Groenou, Deeg, and Penninx 2001; Geroldi et al. 1996). Despite the challenges from several recent studies (e.g., Arber and Cooper 1999), the protective effects of marriage on disability at late ages have been widely recognized (Goldman, Korenman, and Weistein 1995; Murphy, Glaser, and Grundy 1997; Rogers et al. 1992). The effect of living arrangement on disability dynamics in older ages is somewhat less studied and the results are largely divided (e.g., Grundy 2001; Hebert Brayne, and Spiegelhalter 1999).

The primary limitation of previous studies on sociodemographic effect on dynamics of disability is, however, underestimation of disability. Recent research has indicated that the underestimation of disability transition between survey intervals is one of the major problems in research on population aging (Gill, Hardy, and Williams 2002; Guralnik and Ferrucci 2002). The rate of onset of disability in the old ages is substantially underestimated in longitudinal studies, especially with the follow-up interval more than two years (Gill et al. 2002). Most previous studies focused on disability transition normally assume that there is a single transition between two adjacent surveys for those survivors and have not covered the information of disability dynamics for those deceased person, however. So far, six approaches to deal with the disability of the decedents between survey interval in the longitudinal study on disability transitions have been employed: (a) excluding decedents' data from the analyses (e.g., Harris et al. 1989) (Note 1); (b) combining death and functional limitation into a single category (e.g., Roos and Havens 1991); (c) considering death and functional limitation as separate categories but no information of disability for the decedent (e.g., Crimmins et al. 1996; Hayward et al. 1998); (d) assuming that the decedents' probabilities of disability transitions are the same as those for survivors with the same sex, age, health status, and some other characteristics (Manton and Land 2000); (e) estimating simulated monthly transition probabilities of disability using microsimulation approach (Laditka and Wolf 1998); and (f) including the disability information of the decedent before dying by proxies in a retrospective way and including such information in estimates of disabled life expectancy through an extended multi-state life table method (Zeng, Gu, and Land 2004). By comparing between 24 monthly assessments of functional disability with a single assessment over 24-month interval, Gill et al. (2002) found that the underestimation of disability was considerably high, and increased progressively as the length of assessment interval increased. Zeng et al. (2004) found that the disabled life expectancy was significantly underestimated if excluding information of changes of disability status before death.

The second limitation of previous studies is that the oldest-old subjects have not yet been received sufficient attentions when studying correlates of disability. Over the past few decades the oldest-old have been a group of subpopulation with the highest increase rate both in absolute terms and as a percentage of the total population worldwide (UN 2002). However, insufficient attention has been paid to this group of people even though studies on the disability of the oldest-old have grown rapidly since 1990s due to improvement of availability of data sets (Andersen-Ranberg et al. 1999; Evert et al. 2003; Femia, Zarit, and Johansson 1997; Soldo et al. 1997; Suzman, Willis, and Manton 1992; Zeng et al. 2001; 2002). The prevalence rate of disability for the community-dwelling oldest-old has been reported as high as around 40-50% (e.g., Cornoni-Huntley et al. 1992), and the two-year incidence rate of onset of disability is around 25% for females and 10% for males (e.g., Melzer et al. 2001). However, a substantial percentage of the oldest-old who, once disabled, could regain independence in their ADL function in most longitudinal studies. For example, the two-year recovery rate is as high as 10-20% (Melzer et al. 2001). One study even finds that nearly 20% of centenarians didn't have onset of a disease or have not yet been diagnosed with any disease except osteroarthritis (Evert et al. 2003) (Note 2). Another study indicates that 20% female centenarians and 45% male centenarians could carry out ADL independently (Andersen-Ranberg et al. 1999). These studies provide evidence that the heterogeneity of disability dynamics in very high ages does exist. Awareness of the heterogeneity of functional ability, variations in rates of changes in functioning, and their correlates among the oldest-old population is very important in study of healthy longevity. The disability dynamics among the oldest-old is still not systematically examined. Thus, improvement in knowledge of dynamic patterns of disability of the oldest-old would lead to better predict their future disability transitions, develop strategies, conduct intervention programs, and formulate sound policies.

The third limitation of previous studies is that most of them have been based on populations in Western developed nations, particularly in the Unites States and Europe, and research on the elderly disability in developing countries has been rare, although several recent studies had dealt with a few Asian and African countries (e.g., Lamb 1997; Liu et al. 1995; Zachary, Linda, and Chang 2002; Zimmer et al. 1998), but none of them focused on the oldest-old. China, a developing county, has the largest number of the oldest-old in the world. The number of the oldest-old in China in 2000 hit 13 million, and will climb to 23 million, 100 million in 2020 and 2050, respectively under medium scenario projection (UN 2002; Zeng and George 2000). Such an astonish trend raises questions about functional ability of the oldest-old, quality of life in their late age and the sustainability of the current health system of China. However, very little was known about disability dynamics of this subpopulation in China. Given that China differs substantially from Western developed societies in living arrangement, health practice, cultural setting, and sociopolitical system including health care policy, studies on Chinese oldest-old population could provide a better understanding of the underlying mechanisms of prevalence and dynamics of disability.

Based on above considerations, the main purposes of this study are: (1) to explore sociodemographic effects on onset of disability and recovery from disabled status; and (2) to examine difference of effects of sociodemographic variables between including and not including information of ADL dynamics before dying. Our analyses are conducted within a comprehensive multivariate framework focusing on the sociodemographic factors including age, gender, residential type, SES, marital status, and living arrangement.

2. Data and methodology

2.1 Data source

Data is derived from the first three waves of Chinese Longitudinal Healthy Longevity Survey (CLHLS) in 1998, 2000, and 2002 in randomly selected half of the counties/cities in 22 provinces of China. The survey was initialized to meet the needs for scientific research on the oldest-old, a sub-population we know very little but that is growing at extraordinary speed and need the most help. The survey interviewed 8,959 voluntary participants aged 80+ in baseline survey in 1998. Among them, 2,418 were centenarians, 3,013 were nonagenarians, and 3,528 octogenarians. In the second wave in 2000, out of 8,959 baseline interviewees, 4,474 (53.0%) survived to the time of 2000 interview, 3,355 (37.4%) died before the time of 2000 interview, and 860 (9.6%) lost to follow-up. In the 2000 wave, the total sample reached 11,161 including 6,337 newly added respondents. Among those 11,161, the number of centenarians, nonagenarian, and octogenarians are 2,431, 3,812, and 4,918 respectively. In the 2002 wave, out of 11,161 respondents interviewed at the 2000 interview, 5,911 (53.0%) survived at the 2002 interview, 3,401 (30.5%) died before the 2002 interview, and 1,849 lost to follow-up (16.7%). To produce more robust results, like some previous studies (e.g., Crimmins et al. 1994), all three waves of data are pooled together in this study. It means that we deal with the number of observations/cases not the number of interviewees in this study. Each interviewee has at least two but at most three observations. Time 1 was defined to refer the start-point of each two-year interval in which a dynamics of disability may occur, whereas Time 2 refers the endpoint of each two-year interval. In other words, Time 1 in this study could be the interview time in 1998 or 2000, and Time 2 could be the interview time in 2000 or 2002. Furthermore, like previous studies (Zeng et al. 2002; Zeng and Vaupel 2004), persons who reported age 106 or higher at Time 1 are excluded from this study due to insufficient information for us to validate their reported extremely high age. The total number of observations included in this study is 19,778 (8,447 aged 80-89, 6,825 aged 90-99, and 4,506 aged 100-105).

Extensive questionnaire data was collected in the CLHLS including demographic characteristics, family and households characteristics, life styles, diet, psychological characteristics, economic resources, and family support, self-reported health, self-reported life satisfaction, low and upper extremities performance, ADLs (Katz et al. 1963), the Mini-Mental State Examination (MMSE, Folstein, Folsein, and McHugh 1975), chronic diseases suffering and their adverse impacts on daily life. All information was obtained through in-home interviews. Interviews were conducted with subjects themselves if possible. If the subject was unable to answer the questions in the interview, the interview was conducted with a proxy respondent. This is the first nation-wide longitudinal survey research project with such a large sample size on the oldest-old ever conducted in a developing country. A detailed description about the sampling design and data quality assessment of the CLHLS can be found elsewhere (Zeng et al. 2001; 2002; Gu and Zeng 2004).

Comprehensive information concerning the date of death, cause of death, ADL status and days of ADL disability before getting to die, days of bedridden before death, how many times of suffering from serious diseases (hospitalized for how many days) from last interview to death, with what kind of diseases before death, whether can get adequate medical treatment when suffering disease, how many days before death the elder did not go out of door, how many days before death the time staying in bed was longer than staying out of bed, and sociodemographic characteristics such as marital status, family income, living arrangement before dying was also obtained from a close family member of those interviewees who died prior to the next wave.

The database in this study is unique and has two important advantages over many of which previous studies based. First, the CLHLS collected the information before dying from proxy for those decedents who died before the subsequent interview. Second, this study contains a total 19,778 observations (8,447 aged 80-89, 6,825 aged 90-99, and 4,506 aged 100-105). Such a large sample size makes it more reliable to study the oldest-old population.

2.2 Measuring onset and recovery of ADL disability

ADL refers to basic personal care tasks of every day life. Consistent with previous studies (e.g., Beckett et al. 1996; Mendes de Leon, Glass, Beckett et al. 1999; Mendes de Leon, Gold, Glass et al. 2001), task-specific disability is defined as the inability to perform a task independently, without help from a person or specific equipment or device. Previous studies have also shown self-reported ADL disability to be a valid measure (Weinberger et al. 1992), and Katz's scale is most often used measure of functional disability (Wiener et al. 1990). Therefore, in this article, ADL disability is defined as self-reported difficulty with any following ADLs items: (a) bathing, (b) dressing, (c) eating, (d) indoor transferring, (e) toileting, and (f) continence (Note 3). To avoid problems of complications and small sub-sample sizes in model estimation, we simply dichotomized the ADL functional capacity into "active"(no ADL limitation) and "disabled" (at least one ADL limitation). An individual is considered having an "onset" of ADL disability if he/she moved from no ADL limitation at Time 1 to at least one ADL limitation at Time 2 or before dying. A person is classified as having a "recovery" from ADL disability if he/she moved from at least one ADL limitation at Time 1 to no ADL limitation at Time 2 or before dying (see Note 4 for definition of ADL status before dying). Such dichotomous classification includes 2 x 2 = 4 sets of rates of functional transition and remaining, which enables us to clearly focus on onset and recovery of disability although it loses much information about the ADL functional gradations of deterioration/improvement. If, for example, three ADL categories are adopted, we would have to deal with 3 x 3 = 9 sets of functional transitions and remaining, which largely complicates the models and interpretations and causes problems of small sample sizes. The strategy of such dichotomous classification was also adopted in previous studies (e.g., Land et al. 1994; Rogers et al. 1989; Zimmer et al.1998).

2.3 Accuracy and reliability of ADL disability

The reliability of self-reported ADLs has been shown to be high and to be unaffected by age, cognitive status (e.g., Smith et al. 1990). The validity of self-reported ADL has been affirmed by several studies that have demonstrated high concordance between respondents and proxy (Magaziner et al. 1996).

The reliability coefficients of ADL (Note 5) in the CLHLS and some selected studies are presented in Table A1 in the Appendix. The value of Cronbach alpha in the CLHLS is close or higher than some studies conducted in USA (e.g., Fillenbaum 1988) and Canada (e.g., Penning and Strain 1994). Therefore, we are confident about the high data quality for ADL disability in the CLHLS.

2.4 Sociodemographic factors

Age, sex, residence, ethnic group, SES in terms of education, economic independence, adequate financial resources, and primary lifetime occupation, marital status, and living arrangement are the sociodemographic variables that we expected to be associated with the dynamics of ADL statuses in this study. All these factors are measured at Time 1.

The sample is divided into two ethnic groups: Han and other minorities. Residence is classified into urban and rural category (Statistical Bureau of China 1993). For classifying educational attainment, we use reported years of schooling and merge into two levels: 0 year (illiteracy), one or more years of schooling because the general education level of the Chinese oldest-old is extremely low and other alternative coding did not make any improvement of the estimates. Although the cash or asset amount income of the oldest-old was unavailable, the main income source information is collected. We classify such source into two categories: economic independence, namely, mainly relying on pension or own financial source, and economic dependence, namely, other resources such as spouse, children or other family members, or government subside and others. And we also use another variable to measure whether the all sources are adequate to maintain the daily cost of the elderly. These two variables are a proxy of economic conditions in our study. Primary lifetime occupation of males is classified into two categories: agriculture and non-agriculture, whereas it is grouped into three categories for females: agriculture, housewife, and non-agriculture. Marital status has two categories: currently not married (including never married, divorced, and widowed) and currently married. Living arrangement is classified into living alone and not-living-alone. The distribution of above variables is listed in Table 1.

2.5 Control variables

To reduce the possibility of spurious associations, we select a set of control variables for the analysis guided by previous research in this area (e.g., Boult et al. 1994; Seeman, Bruce, and MacAvay 1996).

There is good evidence to substantiate that the quality and nature of family and social supports/connections has measurable influence on functional disability (Seeman et al. 1996; Steinbach 1992; Idler and Kasl 1997; Koenig 1995). In this study, religious activities, proximity with children, playing card, and who take care of the elder in the daily life are considered as the proxy of family and social supports/connections.

It has also been well documented that sociodemographic differences in functional status are mediated by factors of health practice such as alcoholic, smoking, diet, exercise (Hubert et al. 2002; LaCroix et al. 1993), and other health related variables such as cognitive function (Gill et al. 1997), self-reported health (Goldman et al. 1995; Liu et al. 1995), depression (Gregg et al. 2002). Chronic disease conditions (see Note 2) are strongly related to an individual's ability to carry out activities of daily living (Guralnik et al. 1993; Femia, Zarit, and Johansson 2001). Hearing impairment and visual impairment are also associated with disability (e.g., Gill et al. 1997). The low and upper extremities are associated with functional dynamics as well (Guralnik et al. 1995).

Variability in time interval between observation points for individuals requires us to add the length of observation interval into model (Note 6). Whether the respondents died or survived to the next observation point was also included in the model as a dummy variable since the dynamics patterns of disability between survivors and the decedents are largely different (e.g., Melzer et al. 2001).

The presence or absence of these factors may facilitate or impede ADL decline or recovery. Neglect of above potential confounders may lead to biases in investigating the effect of sociodemographic factors on prevalence and dynamics of disability. Therefore, the results would be more scientific and more statistically powerful if we add such variables into model as control variables (Note 7).

2.6 Analytic strategies

Findings from recent studies show that mortality levels off at very high ages (e.g., Horiuchi and Wilmoth 1998; Thatcher, Kannisto, Vaupel 1998; Vaupel et al. 1998) and 20% of centenarians could escape from diseases except osteroarthritis (Evert et al. 2003). This raises our concerns about that the age effect on disability dynamics may be possibly different among octogenarians, nonagenarians, and centenarians. Another fact is that Macintyre and colleagues (1996) show that gender differences in health vary according to stage of the life course. It is necessary to conduct studies of different age groups, rather than assume that the same relationships remain constant throughout the life course (Arber and Cooper 1999). Therefore, unlike most previous studies took age covariates in multivariate model in analyzing disability, we run models separately for octogenarians, nonagenarians, and centenarians. It has become commonplace to analyze men and women separately in examining gender differences in the magnitude of the relationships between socio-economic characteristics and health (Arber and Cooper 1999:62), since men and women have different lifestyle, family and social roles, health and disablement outcome (Lamb 1997). Thus, we run models for males and females separately.

Previous studies have also suggested that different functional status trajectories may exist based on age, gender and other sociodemographic variables (Maddox and Clark, 1992, Wolinsky et al. 1996), the model would be more powerful if interactions between covariates are added into the model. All possible 44 two-way interactions were tested at the presence of their parent terms and all other sociodemographic variables used in this study by gender among octogenarian, nonagenarians, and centenarians separately. It turns out that only interaction between years of schooling and urban/rural residence among male nonagenarians and interaction between economic independence and having adequate financial resource among female nonagenarians are significant. Moreover, coefficients of main effects of variables in models among male nonagenarians and among female nonagenarians with such significant interactions are almost identical to those without such interactions. Therefore, no any interaction term was included in our analysis.

To reduce the influence of number of respondents who lost to follow-up or missing value of some variables on data analysis and inference, multiple imputation approach was applied in this study (Allison 2002). Two types of models were constructed to examine the how adding controlling variables may influent the estimates of effects of sociodemographic factors on disability dynamics. The first type contains only sociodemographic factors, called sociodemographic model, while the second type contains both sociodemographic factors and other control variables mentioned above, called full model.

Binominal multivariate logistics regression is employed to run all models using STATA version 8 (STATA 2003) after correcting intra-subject correlation due to some subjects contributing two observations to the pooled data set at a specific time (Time 1 or Time 2) (e.g., Liang and Zeger 1986) (Note 8).

3. Results

3.1 Descriptive information of sociodemographic variables and ADL dynamic changes

Table 1 provides descriptive information about percentage distributions of sociodemographic variables used in this study. The prevalence rates of ADL disability are 17% and 21% for male oldest-olds and female oldest-olds respectively. The prevalence rate increases steeply with advancing age. Those who live in urban areas have a higher prevalence rate, as compared to those living in rural areas. Minority ethnic oldest-olds have a lower prevalence rate of disability than their Han counterparts. Persons with low education or not currently married have a higher prevalence rates. Those living alone suffer less from daily functioning than those living with others.

Table 2 shows that for the whole oldest-old population in China, 22% of males and nearly 25% of females who were ADL active at Time 1 could develop disability within the subsequent two years, whereas 35 % of males and 31% of females who were disabled at Time 1 regained their functioning in the next two-year interval. Females have a higher onset rate and lower recovery rate. The onset rate of disability of centenarians is two times higher than that of octogenarians, whereas recovery rate is two times lower than that of octogenarians. For those who died before Time 2, their onset rate is 4 times higher than those surviving to Time 2. The bivariate differences of the rates of disability onset and recovery of different sociodemographic groups without adjusting for any other confounding factors are also listed in Table 2. We do not discuss these bivariate cross-tabulations here since we will discuss subsequently the differentials across sociodemographic groups while controlling for other confounding factors.

----Table 1 and Table 2 are about here---

3.2 Onset of disability

Figure 1a and Figure 1b reveal that male nonagenarians and centenarians have 1.8 times and 2.7 times higher risk to develop disability over a two-year interval respectively compared to male octogenarians given the same sociodemographic conditions. Age effect on disability development is more substantial among females than among males. Moreover, such age patterns do not change even after controlling family and social supports/connections, health practice, and chronic conditions although the odds ratios were lessened. This indicates that age is a strong predictor of the onset of disability.

Results in Figure 2a and Figure 2b indicate that the gender difference in disability dynamics doesn't follow the same pattern among octogenarians, nonagenarians, and centenarians. In the full model, the gender effect on disability dynamics is the highest in nineties, indicating female oldest-olds when they are in 90s have a higher risk to experience the onset of disability on average compared to male oldest-olds. The gender difference is not significant among octogenarians and is marginally significant among centenarians. On average, female oldest-olds are in disadvantage in ADL functioning.

----- Figure 1a to Figure 2b are about here-----------

Table 3-1 and Table 3-2 illustrate the sociodemographic factors associated with onset of disability among octogenarians, nonagenarians, and centenarian by gender respectively. Odds ratios were obtained for each factor among persons who were active at Time 1. The left panels of Table 3-

1 and Table 3-2 present results obtained from the sociodemographic models, whereas the right panels provide results produced from the full models. The results in Table 3-1 and Table 3-2 show that the oldest-old have a higher probability to develop disability as they live longer for both males and females although the variation of odds ratio in centenarians becomes wider. The significant difference of urban/rural residence in the onset of disability is observed among female elders aged 90 and over, while such difference is not detected among male oldest-olds. On average, ethnicity has a lower risk to develop disability compared to Han. But the pattern of ethnic effect in disability onset between males and females is different. For female oldest-olds, ethnicity has a limited effect on disability development in eighties, but it has a significant effect after age ninety, and the ethnic effect turns to be stronger with advancement of age. On the contrary, for male oldest-olds, ethnicity has the highest effect in eighties and weakens thereafter. As expected, the disadvantage effect of no education could make persons at oldest-old ages face more risk to experience a disability, especially for males although such disadvantages are reduced after adding other confounding factors into the model. Independence in finance source reduces risk to develop disability especially among females in their nineties. But such effect was not observed for males. Unexpectedly, the adequate financial resources didn't show its beneficial effect on the onset of disability. In contrast, the results show that there is a negative association between having adequate financial resources and the capacity of daily functioning. Female oldest-olds who were housewives had a higher risk to develop disability at their oldest-old ages compared to those who worked as farmers. Although the odds of risk to have onset of disability among those who were non-agricultural workers during lifetime were higher than those who were farmers, the estimates were not significant. The protective effect of marriage on developing disability is very weak, only observed among male nonagenarians without controlling confounders. The results show that married females over age 90 had a higher likelihood to suffer ADL disability than their unmarried counterparts. Those living alone had a lower risk to witness a disability over a two-year interval than those living with others among male oldest-olds. Such effect was not found in females. The right panels of Table 3-1 and Table 3-2 suggest that the sociodemographic effects on disability development was not affected much by adding the confounding factors of family and social supports/connections, health practice and chronic conditions into the model.

----Table 3-1 and Table 3-2 are about here---

3.3 Recovering from disability

Figure 1a and Figure 1b show that the odds of recovery of nonagenarians and centenarians from disability are 40% less and 50% less than octogenarians respectively. Like its effects on the onset of disability, age has a stronger effect among females than among males, and such effect didn't change much after controlling for other confounders. This implies that age is strongly correlated with disability dynamics. In general, females have a lower likelihood to regain their daily functioning once they were disabled compared to their male peers, and it reaches highest among nonagenarians. Such gender difference was not significantly detected among octogenarians, however.

Results summarized in Table 4-1 and Table 4-2 show, although the probabilities of moving from disabled status to active status decrease with age, effect of increasing age on disability recovery is different among octogenarians, nonagenarians, and centenarians. The age effect is weaker with advancement of age group, especially for males. Urban oldest-olds have a lower likelihood to get recovered once they are disabled compared to rural peers. More interestingly, such urban-rural residential effects become stronger with advancement of age groups among both males and females. Minorities have a higher chance to recover from disability. Among male oldest-olds, the minority effect weakens with increasing of age, whereas the patterns for females are just opposite. Although illiterate oldest-olds have a disadvantage to maintain their daily functioning, they don't have such disadvantage in getting recovery once they are disabled, even they have a higher chance to recover than literate persons, especially among people aged 90 and over. Economic independence and adequate financial resource could not improve the likelihood of getting recovery from a disability in our study. Female oldest-olds whose primary lifetime occupations were housewives are less likely to regain their daily functioning if they lost such functioning compared to that of farmers. The difference in disability recovery between lifetime farmers and non-farmers is small. Beneficial effect of marriage is observed only among female octogenarians, implying marriage protective effect in very old ages is limited. For males, the odds ratios of getting recovered from disability among those living alone are around 2-3 across three age groups compared to those not living alone and they are significant except for centenarians in sociodemographic model. For females, these odds are around 1.1-1.3 and they are not significant. This suggests that the effect of living alone on dynamic changes of disability is strong in males than in females. Results in Table 4-1 and Table 4-2 also show that the effects of sociodemographic factors on recovery only had a slight change after controlling possible confounding, implying the estimates of the sociodemographic effects are valid.

----Table 4-1 and Table 4-2 are about here---

3.4 Difference between the estimates including and not including the ADL changes before dying

Results in Figure 3a to Figure 3d indicate that the magnitude of differences of the estimates of effects of sociodemographic factors on ADL disability dynamics between models including and not including ADL dynamics before dying is not negligible, although the patterns of effects are close (Note 9). The results suggest that the effect of age on disability onset is higher in the models not including ADL dynamic changes of the deceased persons before dying compared to models including ADL dynamic changes before dying. The effect of age on disability recovery in conventional approach without information of ADL changes before dying is lower than models including ADL transition before dying (Note 10). Conventional approach overestimated the age effect on disability dynamics. This is because the difference in ADL dynamics across ages for survivors is larger than that for the deceased persons. Our multivariate analyses based on the full model show that the odds ratios of having an onset of disability across three age groups with age 80-89 as the reference group are 1.74 ($p<0.000$) for age 90-99 and 2.90 ($p<0.000$) for age 100-105 among male survivors, and 1.06 ($p>0.1$) for age 90-99 and 1.03 ($p>0.1$) for age 100-105 among the deceased male oldest-olds. Correspondingly, the odds ratios of getting recovery across these three age groups with age 80-89 as the reference group are 0.55 ($p<0.000$) and 0.36 ($p<0.000$) for male survivors and 1.12 ($p>0.1$) and 0.94 ($p>0.1$) for the deceased males (Note 11). Such age differential effect between survivors and the deceased persons among females is also found.

Furthermore, the conventional method overestimates the gender difference in disability dynamics. The odds ratios of the onset of disability and the recovery from disability between genders with males as reference group in the full models including ADL changes before dying are 1.061 ($p>0.1$) and 0.784 ($p<0.01$) respectively. The corresponding figures in the full model not including ADL changes before dying are 1.175 ($p<0.05$) and 0.695 ($p<0.001$) respectively. This is also because gender difference in ADL dynamics is large among survivors while it is small among deceased persons. The gender odd ratios with males as the reference for transition from active to disabled and transition from disabled to active among survivors are 1.18 ($p<0.05$) and 0.69 ($p<0.01$), while the corresponding figures among the deceased persons are 1.07 ($p>0.1$) and 0.78 ($p<0.05$). The conventional method also overestimates the effects of ethnicity and living alone on disability dynamics. On the contrary, conventional method underestimates the effect of SES. Differences in effects of marital status and urban/rural residence between two methods are trivial, however.

---- Figure 3a to Figure 3d are about here----

4. Discussion

This study is innovative in its development of measurement and model to include change of functional status before dying incorporating basic sociodemographic factors under a more comprehensively multivariate framework. Our innovation has its important potential implications both theoretically and practically. Our results point out that the general patterns of sociodemographic effects on disability dynamics in the conventional method, which excludes the information of ADL changes before dying, is similar to those in our model including ADL changes before dying. The conventional method, however, overestimates the influences of age, gender, ethnicity, and living alone on disability transitions whereas somewhat underestimates the effects of SES, based on the CLHLS data. This is the most striking result in this study. The major reason is the difference in patterns of disability dynamics between survivors and the deceased persons. Since it is unlikely for survivors and the deceased persons to share the same or even similar pattern of ADL dynamics, the level of mortality also plays a critical role. If the mortality rate is very low, it will offset the difference between these two methods even though the difference in ADL dynamics between survivors and the deceased persons is substantial. It is worthwhile to note that small discrepancies in effects of sociodemographic factors on ADL dynamics between these two methods could lead to significant biases in estimation of probability of disability and the ADL status-specific life expectancy as reported by Zeng et al. (2004). Although such overestimation and underestimation of sociodemographic factors on ADL dynamics caused by the conventional method revealed in the present study might not be a general phenomenon and far from conclusive, our finding indicates that we need to pay much more attention to collect ADL dynamic information between survey intervals among both surviving and deceased interviewees and thus to better understand the correlations between sociodemographic factors and dynamics of disability. It may provide better guidance for formulation of more feasible long-term care policies as well.

Consistent with previous reports (Manton 1988; Wolinsky et al. 1996), our study show that the prevalence rates of ADL disability among Chinese oldest-olds are 17% and 21% for males and females, respectively, and increase steeply with advancement of age. More than 20% of the oldest-old who were active developed an onset of disability in the next two years, while about 30% of the oldest-old who were disabled regained their daily functioning over a two-year period. This suggests that the oldest-old are a frail group of people on average. Such figures also provide evidence to support the ideas that getting recovery was almost as common as onset of disability (Clark, Stump, and Hui 1998), and disability among older persons and even oldest-old persons is a highly dynamic process and is not an irreversible but often recurrent event (Gill and Kurland 2003).

As potential correlates, we have not only evaluated the effects on disability dynamics of those traditional sociodemographic variables, such as age, gender, urban/rural residence type, SES, marital status, and living arrangement, but also investigated their correlates under context of controlling for various confounding factors. Our analysis provides insight into difference in the risk of onset of disability, and rate of recovery by sociodemographic characteristics in a more comprehensive context.

Our results show age is strongly linked to disability dynamics. Increasing age decreases the chance of remaining active. It also increases the chances of moving from active to disable status, and decreases the chance that disabled individuals recover to active status. This is reaffirms most others' reports (e.g., Crimmins et al. 1996; Hayward et al. 1998; Laditka and Wolf 1998; Rogers et al. 1992). One of the most striking findings in relation between age and disability dynamics is that for males after age 90 and for females after age 100, increasing an additional year of age will not decelerate the chance to get recovery. This is supportive evidence to the argument that older age, per se, may not impede recovery but, rather, may act as a proxy for other unmeasured factors, which in turn decrease the capacity of disabled persons to recover (Gill et al. 1997: 760).

Although there is a growing evidence to challenge the hypothesis that women have a poor self-reported health, most studies still show that women have a lower level of functioning (Arber and Cooper 1999; Zimmer et al. 2002). In accordance with other studies (e.g., Crimmins et al. 1996; Fuchs, Blumstein, Novikov et al. 1998; Hayward et al. 1998; Land et al., 1994), our finding shows that males have a lower probability to develop disability and a higher probability to get recovery, suggesting oldest-old woman are significantly disadvantaged. The gender difference in our study, however, doesn't follow the same pattern among octogenarians, nonagenarians, and centenarians. It reaches the highest in nineties, and it is not significant among octogenarians. Such insignificance is possibly due to length of assessment interval. Hebert et al. (1997) also reported that the interval between surveys could affect the gender difference in functional decline or improvement. Gender pattern still needs further investigation.

The rural and urban difference is less salient in developed countries than in developing countries. Hence, few studies are available to date to examine the urban/rural residential relations with disability. The majority of these studies mainly focus on cross-sectional analysis and the results are not consistent (e.g., Barberger-Gateau et al. 1992; Mainous and Kohers 1995; Gupta and Sankar 2003). For example, Mainous and Kohers (1995) find rural elders have a higher disability prevalence rate and conformed by Gupta and Sankar (2003). On the other hand, some studies find that there is no significant association between urban/rural residence and disability (Barberger-Gateau et al. 1992). In out study, urban oldest-olds exhibited a higher probability to have the onset of disability and lower probability to get recovery than their rural counterparts (No significant residential difference in the onset of disability was found among male oldest-olds). The potential explanations for such urban-rural patterns in China are (1) the harder life and higher mortality at younger ages in rural areas, which has resulted in that rural oldest-olds are more selected than urban oldest-olds; (2) less availability of facilities to assist oldest-old persons in their daily life in rural areas may force them to perform daily life thus enable them maintain functioning; (3) the frequency of daily activities performed by urban oldest-olds is less than rural oldest-olds due to housing structure; (4) rural has a better physical environment than urban areas (Zeng et al. 2001). The first two explanations may also help us to understand the fact that the elderly in some developing countries are more active than the elderly in developed countries (Chen and Jone 1989; Lamb 1999).

Contrary to several previous studies in the U.S. that find minority ethnicic groups' functional capacity is at lower levels, on average, than the majority (e.g., Crimmins et al. 1996; Land et al. 1994; Schoenbaum and Waidman 1997; Smith and Kington 1997), our study shows that minority ethnic oldest-olds in China have a lower chance to develop disability and higher probability to get recovery if they were disabled. Zimmer and colleagues (2002) also found that those Mainlander in Taiwan (most of them are Han Chinese) have a higher functional limitations compared with those minorities in Taiwan. Furthermore, it is interesting to note that the ethnicity differences in disability dynamics in this study among males and females are also different. The patterns of the ethnic difference in disability dynamics across age among males turn to be weaker with the increasing age, while the patterns for females are just opposite. This is new finding but it deserves further research. Some previous research has attributed race/ethnic difference in disability to the low SES of minorities (e.g., Boult et al. 1994). But it is not clearer whether the ethnic difference between Chinese Han and minorities is mainly due to mortality selection or other unobserved heterogeneities. More elucidation on this topic could gain better understanding of ethnic difference in disability dynamics.

Most previous studies in western societies, which dealt with entire elderly population aged 65+ and did not have large sub-sample size for the oldest-old as we have, find that education has a protective effect on disability in old ages (Crimmins et al. 1996; Land et al. 1994; Rogers et al. 1992). Our study that focuses on the oldest-old in China with a large sample size found that the education is not strongly associated with dynamics of disability among Chinese oldest-olds. This is partially in line with those findings in Taiwan (Zimmer et al. 1998; Lee and Chuang 2003) and Japan (Liu et al. 1995). All of them find that education could decrease the likelihood of onset of ADL disability but has no significant protective effect on recovery. We agree with Zimmer and colleagues (1998:271-273) that the effect of education on transitions of ADL disability involves a complicated framework including culture background given that Mainland China has similar historical background with Taiwan. The dissimilarity of effect of education on onset of ADL disability between the present study and those in Taiwan and Japan might be because of difference in age range of subjects and length of observation interval. Like most western studies, all three studies in Taiwan and Japan dealt with entire elderly population aged 65+ and didn't focus the oldest old. The observation intervals of these three studies are three-year (Liu et al. 1995), four-year (Zimmer et al. 1998), and seven-year (Lee and Chuang 2003). The mechanism of the relationship between education and function at oldest-old ages in China deserves further investigation.

With advancement of age, the income of the elders declines, while at the same time the elders have a greater likelihood of disability (Ginn and Arber 1991). The poor elders do not have the adequate financial resources to compensate for their disabilities. This leads people to speculate that elders with better economic conditions should be healthier. Unexpectedly, however, economic conditions in the late life were not significant factors to retard from developing disability and reduce the risk of maintaining disability in our analyses on Chinese oldest-olds. Although this finding provides additional evidence to support the results reported by Arber and Ginn (1991), it differs from most others that do not focus on the oldest-old (e.g., Maddox and Clark 1992; Rogers et al. 1992; Seeman et al. 1994; Van Groenou et al. 2001). Additional research would be help to shed further light on association of economic status with disability dynamics at the oldest-old ages.

It is noteworthy that those female oldest-olds who were housewives in their lifetime experienced a higher risk of the onset of disability and a lower likelihood of regaining of functioning compared to those farmers. This may because farmers usually started to work at childhood and often continued to work well beyond the age of 65 and such labour activities served as physical exercises, which may make them being more active than the housewives. Another possible explanation is majority (2/3) of previous farmers are still residing in rural areas; and the rural environment also made them relatively abler in daily life activities as we discussed earlier in explaining the urban/rural residential differentials .

It is commonly stated that marriage demonstrated a beneficial effect on functional capacity (e.g., House, Landis, and Umberson 1988). Marriage provides individuals with a sense of meaning and importance that promotes health (Rogers et al., 1992). Although marriage provides health benefits for both husbands and wives, marriage confers a greater health benefit upon husbands than upon wives because wives often monitor their husband’s health, but husbands usually do not provide the same service to their wives (Goldman et al. 1995; Umberson 1992; Rogers et al. 1992). Such beneficial effect of marriage is not fully replicated in this study. We find marriage doesn’t have significantly protective effect on disability dynamic transitions, indicating the protective effect of marriage on disability dynamics is limited, or weak in the oldest-old ages in the two-year interval (Note 12). We offer following explanations for this finding. First, mortality selection makes those not married individuals and frail individuals drop out of the before they reach oldest-old ages; In other words, those currently not married oldest-olds are possibly at least as robust as those married oldest old. Second, we didn’t examine the quality of marriage, remarriage, the length of marriage, and recent changes of marital status on the disability dynamics in the present study. These factors probably affect the results. Third, the observation interval may not be enough for us to detect such effect in the oldest-old. Fourth, in the oldest-old ages, factors other than marital status may have stronger influence on disability, such as chronic disease conditions or genetic factors. Further research on marital effect on disability is warranted.

An increasing strand of research has demonstrated that living arrangement may exert effect on health (Grundy 2001; Hebert et al. 1999). Our findings show living arrangement did have significant effects on the dynamic changes of disability among male oldest-olds, reaffirming other studies which did not focus on the oldest-old (e.g., Hebert et al. 1999). In our sample, those living alone are more independent in daily activities compared to those living in other settings. Furthermore, our study reveals that such effect of living alone is smaller among female oldest-olds than among male oldest-olds. Hebert et al. (1999) interpreted that living alone could act as a proxy for good health at very old ages rather than as a risk factor. This could possibly explain the phenomenon found in the present study. More than what Hebert et al. (1999) found, however, our study also show that those living alone had a higher chance to regain their daily functioning among those disabled persons.

Unlike most of other studies, our study focuses on the oldest-old to whom we know very little about but need most care than others. The data set includes large simple size, and is the first largest longitudinal survey for the oldest-old in the developing countries. Although there are considerable number of studies focusing on the functional ability among nonagenarians and centenarians (e.g., Andersen-Ranberg et al. 1999; Nybo et al. 2001), the sociodemographic effects on dynamic changes in disability are still not fully examined. The large sample size among octogenarians, nonagenarians, and centenarians enables us to examine the effects of sociodemographic factors on onset or recovery of disability separately in this study under control of various confounding effects. Results of this study provide new knowledge about general patterns of disability dynamics of the oldest-old in developing countries, and make it possible to compare with those in developed countries. Our finding contributes to a better understanding of some of the social and demographic factors associated with transitions between disabled and active statuses. Our analysis has illustrated which sociodemographic factors are the most important ones in reducing transitions to disability, and in increasing the rate of recovery.

One limitation of the present study is that information on ADL status for dead persons between two waves is obtained from proxy, which may involve some bias, although previous studies reveal that the use of proxy responses from family members is appropriate in quality of dying research (George 2002). And we only collected one episode data about ADL dynamics before dying, which may also suffer some limitations. How to get the more accurate information of ADL dynamics over survey interval without increasing frequency of survey is still a challenge for epidemological study. Another limitation is that information was not available on whether participants received interventions, such as physical or occupational therapy, after the onset of their disability. Therefore, we could not evaluate (or adjust for) the effect of these rehabilitative efforts on the likelihood of ADL recovery.

In short, the present study shows that the sociodemographic factors seem to play some specific roles on disability dynamics even after controlling for a variety of confounders. It is worth noting that the relationships between sociodemographic factors and disability dynamics are much more complex and far from conclusive. We are fully aware of the fact that not only diversity of conceptual measures of functioning and interval between evaluations will result in different answers (Hebert et al. 1999), but also the analytical strategies will produce different pictures as well. One of our purposes is to draw attention on underestimation of disability in existing literature. Although we have included ADL dynamics information before dying, the answer is far beyond satisfied given that we lack of the full information of ADL transitions between assessments. There is still a long way to go to capture the whole picture of ADL dynamics. Given current projections that the number of Chinese oldest-olds could be reach more than 100 million by 2050 (UN 2002; Zeng and George 2000), further research on the mechanisms of ADL disability and recovery in the oldest-old population is clearly warranted.

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Notes:

1. Majority of existing studies follow this approach, and we call it as the conventional method in this paper.
2. According to previous research (e.g., Pope and Tarlov 1991; Verbrugge and Jette 1994; Jette 1999) and WHO (1980), the main pathway in the disablement process is as follows: presence of disease leads to impairments, which in turn lead to functioning limitations, which then lead to disability (difficulty doing ADL). Therefore, the onset of disease is normally a necessary precursor of disability (except in the case of trauma).
3. If one receives assistance in at least one item, we define he/she has difficult in ADLs. Although some studies have mentioned that continence may exist without physical limitations and it is therefore no longer included in ADL disability estimates (Jagger et al. 2001: 404; Guralnik et al. 1993), we still include it in our analysis.
4. It is difficult practically to distinguish between an onset of disability in the time period before death and a disability emerging in the dying process in some cases since there is a good chance that, at some point in the dying process, a person might lose the ability to perform some tasks of ADL, say, bathing. In our CLHLS survey, we instructed the interviewers to inquire the deceased subjects' general ADL status during a few weeks before dying, rather than the status at the moment of death.
5. Reliability coefficient is define as follows: $\alpha = \frac{K(\bar{r})}{1+(K-1)\bar{r}}$, where, $\bar{r} = \frac{K}{K-1}(1-\frac{\sum_{i=1}^{K} S_i^2}{S_{sum}^2})$, and K is the total number of items; S_i^2 denotes the variances for the k th item; S_{sum}^2 denotes the variance for the scale (i.e., sum of all items). (See, http://www.spss.com/tech/stat/Algorithms/11.5/reliability.pdf.
6. Normally, such data is called unequally spaced or unbalanced data set in longitudinal study (e.g., Willett 1988).
7. The definition of each control variable, its distribution and odds ratio are not presented in this paper but available upon request.
8. We have run the random effect logit model. The result is identical to that in logistic model after correcting the intra-subject correlation. Population–averaged logit model based on generalized estimation equation (GEE), an extension of the theory of generalized linear model (GLM), is also tried, and the result turns out to be almost the same as those in logistic and random-effect logit model above.
9. Figure 3a to Figure 3d are based on the full model with males and females separated. The results in the full model with males and females combined are very close to those listed in Figure 3a to Figure 3d, and hence, they are not presented in this paper but available upon request.
10. Comparisons are made among age-combined models to avoid problems of small sample size of some covariates.
11. Table 2 also provides a brief result about the different patterns of ADL dynamics across age groups between survivors and the deceased persons in terms of the percentage of making ADL transitions.
12. It doesn't necessarily mean that our this finding supports Arber and Cooper (1999) who find that marriage doesn't have protective effect on ADL functioning based on a cross-sectional data set. We have run the model using cross-sectional data and found that the marriage protective effect on ADL functioning is significant for females although such protective effect for males is not significant.

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Appendix A:

Table A1 Distributions of reliability coefficients of ADL

	Time 1		Time 2			
			Survivors		Decedents	
	Males	Females	Males	Females	Males	Females
Age 80-89	0.8597	0.8650	0.8680	0.8695	0.9535	0.9552
Age 90-99	0.8705	0.8679	0.8553	0.8736	0.9459	0.9399
Age 100-105	0.9390	0.8804	0.8826	0.8818	0.9335	0.9325

Note: (1) ADL includes six items: bathing, dressing, inside transferring, toileting, continence, and feeding.
(2) Results are based on not imputed data.

Table 1 Percentage distributions of socio-demographic variables by gender

Variables	Males			Females		
	# of obs.	% [a]	% disabled [b]	# of obs.	% [a]	% disabled [b]
Total	8142	100.00	16.63	11636	100.00	20.88
Age						
80-89	4255	52.26	16.33	4192	36.03	19.39
90-99	2944	36.16	30.04	3881	33.35	39.85
100-105	943	11.58	52.70	3563	30.62	62.00
Residence						
Rural	3841	47.18	15.21	5841	50.2	19.58
Urban	4301	52.82	19.28	5795	49.8	23.32
Ethnic group						
Han group	7644	93.88	16.91	10840	93.16	20.87
Minority group	498	6.12	12.03	796	6.84	22.01
Economic independence						
No	2893	35.53	15.92	868	7.46	17.34
Yes	5249	64.47	17.87	10768	92.54	21.33
Adequate financial resources						
No	1937	23.79	17.27	3225	27.72	20.33
Yes	6205	76.21	16.44	8411	72.28	21.07
Years of schooling						
0	2889	35.48	15.02	9977	85.74	21.31
1+	5253	64.52	17.44	1659	14.26	18.91
Primary lifetime occupation						
Agriculture	4332	53.21	14.46	6255	53.76	19.30
Housekeeper	NA	NA	NA	3732	32.07	24.72
Non-agriculture	3810	46.89	19.50	1649	14.17	19.81
Marital status						
Currently without spouse	5261	64.62	16.46	10908	93.74	21.62
Currently with spouse	2881	35.38	16.83	728	6.26	16.51
Living alone						
No	7323	89.94	17.72	10251	88.1	22.72
Yes	819	10.06	7.69	1385	11.9	11.09

Note: (1) a, unweighted distribution; b weighted based on distribution of age-sex-urban/rural residence of whole population of the oldest olds in sampled provinces at Time 1 except age weighted by distribution of age-sex-urban/rural residence within each corresponding age group; NA, not applicable. (2) All variables are measured at Time 1 including distribution of ADL disability.

Table 2 Dynamic changes of ADL functioning by gender

	Males						Females					
	% ADL disabled at Time 2 or before dying among those who were active at Time 1			% ADL active at Time 2 or before dying among those who were disabled at Time 1			% ADL disabled at Time 2 or before dying among those who were active at Time 1			% ADL active at Time 2 or before dying among those who were disabled at Time 1		
	S	D	S+D	S	D	S+D	S	D	S+D	S	D	S+D
Number of observations	4379	1539	5915	1002	1225	2227	5132	1673	6805	2166	2665	4831
Total	14.21	58.07	22.17	40.82	20.04	34.39	18.26	60.83	24.47	34.62	22.51	30.66
Age												
80-89	13.62	57.40	21.01	42.92	19.92	34.39	17.13	62.00	23.11	34.95	20.85	30.87
90-99	22.08	60.66	34.55	26.55	24.07	25.20	33.72	64.40	41.65	21.71	19.42	20.58
100-105	38.07	59.21	48.88	21.05	20.88	20.93	47.52	70.02	56.94	18.45	16.73	17.29
Residence												
Rural	14.73	57.29	22.96	48.83	19.93	36.75	18.51	57.72	24.46	37.03	24.20	32.70
Urban	13.22	59.94	20.63	37.11	20.22	30.94	17.78	67.72	24.48	30.98	19.61	27.46
Ethnic group												
Han group	14.54	59.57	22.56	42.57	19.20	33.14	18.46	62.09	24.85	33.21	22.34	29.67
Minority group	8.74	40.23	16.09	69.44	46.67	61.54	15.62	43.16	19.44	52.34	24.62	43.01
Economic independence												
No	15.07	58.02	24.51	47.38	20.18	35.48	19.19	59.21	25.28	34.93	22.74	30.79
Yes	12.86	58.04	18.03	39.01	19.75	32.58	11.68	79.65	18.35	31.96	18.75	29.17
Adequate financial resources												
No	15.92	54.04	23.53	51.45	23.90	36.79	18.39	52.86	24.08	38.69	25.18	33.14
Yes	13.70	59.40	21.74	42.05	18.18	33.62	18.22	64.34	24.61	33.38	21.20	29.79
Years of schooling												
0	15.40	60.29	25.58	53.40	21.82	39.35	19.29	61.00	25.79	34.01	21.79	29.90
1+	13.64	56.35	20.41	40.04	19.14	32.17	14.00	59.68	18.66	37.46	26.89	34.35
Primary lifetime occupation												
Agriculture	14.36	56.88	23.31	47.98	19.85	35.73	17.13	58.47	23.08	38.45	23.54	33.70
Housekeeper	NA	NA	NA	NA	NA	NA	23.85	62.07	30.32	29.48	18.83	25.59
Non-agriculture	14.01	61.61	20.52	40.30	19.91	32.96	13.59	68.68	19.91	31.69	28.97	31.12
Marital status												
Currently without spouse	14.10	57.14	23.44	50.29	19.67	36.11	18.59	60.37	24.93	31.97	20.35	28.20
Currently with spouse	14.32	59.56	20.71	37.97	20.63	32.36	16.55	64.29	21.91	55.67	38.24	49.66
Living alone												
No	14.98	59.04	22.91	42.82	20.04	33.56	19.13	60.72	25.30	33.12	22.42	29.53
Yes	8.49	51.41	16.69	59.57	20.00	49.18	14.32	61.37	20.59	48.52	24.49	42.66

Note: (1) S, surviving at Time 2; D, died before Time 2; NA, not applicable. (2) Percentages are weighted based on distribution of age-sex-urban/rural residence of whole population of the oldest olds at Time 1 except age weighted by distribution of age-sex-urban/rural residence within each corresponding age group.

Table 3-1 Odds ratios of the onset of ADL disability by socio-demographic variables, Males

	Socio-demographic variable only			Full model		
	Age 80-89	Age 90-99	Age 100-105	Age 80-89	Age 90-99	Age 100-105
Single age	1.096***	1.077***	1.181*	1.080***	1.061**	1.180*
Urban (rural)	1.011	1.067	0.912	0.941	1.130	0.933
Minorities (Han)	0.573**	0.709#	0.799	0.408***	0.691#	0.680
1+ year (s) schoolings (no schooling)	0.799*	0.841#	0.691#	0.861	0.845	0.758
Economic independence (dependence)	0.776*	0.891	1.843#	0.965	0.980	1.672
Adequate financial resources (no)	0.924	0.952	1.206	0.990	1.109	1.484
Non-agriculture (agriculture)	1.014	1.068	0.950	1.071	1.197	1.125
Currently married (not married)	0.869	0.766*	1.006	1.055	0.857	1.026
Living alone (not living alone)	0.732*	0.676**	0.537*	0.694*	0.682*	0.421*
- Log Likelihood	1852.8***	1275.0***	301.2	1590.1***	1150.9***	277.3**
Df	9	9	9	30	30	30
Nagelkerke R^2	0.022	0.016	0.025	0.160	0.111	0.103
Number of observations	3501	1968	446	3501	1968	446

Notes: (1) Reference group of each covariate is listed in the parentheses. (2) All variables are measured at the beginning of each two-year interval. (3) Full mode means all other controlling variables are in the model in addition to socio-demographic variables. (4) Odds ratios and their significant level were corrected by intra-subject correlations due to some subjects contributing two observations to the pooled data set at a specific time (Time 1or Time 2). (5) #, p<0.1; *, p<0.05; **, p<0.01; ***, p<0.001.

Table 3-2 Odds ratios of the onset of ADL disability by socio-demographic variables, Females

	Socio-demographic variable only			Full model		
	Age 80-89	Age 90-99	Age 100-105	Age 80-89	Age 90-99	Age 100-105
Single age	1.078***	1.082***	1.069#	1.058**	1.058**	1.028
Urban (rural)	0.950	1.209*	1.293*	1.043	1.284*	1.382*
Minorities (Han)	0.881	0.694*	0.377***	0.883	0.613**	0.389***
1+ year (s) schoolings (no schooling)	0.741**	1.102	0.780	0.838	1.170	0.886
Economic independence (dependence)	0.988	0.550*	0.668	1.005	0.580*	0.704
Adequate financial resources (no)	1.059	0.937	1.236#	1.216#	1.094	1.198
Primary lifetime occupation before age 60						
Housekeeper (agriculture)	1.407**	1.249*	1.088	1.382**	1.310*	1.095
Non-agriculture (agriculture)	1.122	1.240	0.768	1.142	1.189	0.808
Currently married (not married)	0.925	1.667*	1.087	0.954	1.838*	1.192
Living alone (not living alone)	0.825#	0.969	0.793	0.900	0.929	0.746
- Log Likelihood	1815.8***	1457.5***	900.9***	1782.3***	1358.4***	847.7***
Df	10	10	10	31	31	31
Nagelkerke R^2	0.015	0.017	0.027	0.115	0.084	0.081
Number of observations	3294	2157	1354	3294	2157	1354

Notes: (1) Reference group of each covariate is listed in the parentheses. (2) All variables are measured at the beginning of each two-year interval. (3) Full mode means all other controlling variables are in the model in addition to socio-demographic variables. (4) Odds ratios and their significant level were corrected by intra-subject correlations due to some subjects contributing two observations to the pooled data set at a specific time (Time 1or Time 2). (5) #, p<0.1; *, p<0.05; **, p<0.01; ***, p<0.001.

Table 4-1 Odds ratios of the recovery from ADL disability by socio-demographic variables, Males

	Socio-demographic variable only			Full model		
	Age 80-89	Age 90-99	Age 100-105	Age 80-89	Age 90-99	Age 100-105
Single age	0.884***	0.980	1.014	0.897**	0.978	1.054
Urban (rural)	0.726#	0.620**	0.506*	0.728	0.578**	0.522*
Minorities (Han)	2.841*	1.993*	1.445	2.867*	1.966*	1.627
1+ year (s) schoolings (no schooling)	0.925	0.763#	0.849	0.933	0.751*	0.734
Economic independence (dependence)	0.881	0.834	0.881	0.785	0.843	0.794
Adequate financial resources (no)	0.931	1.107	0.879	0.693	1.012	0.849
Non-agriculture (agriculture)	1.033	0.926	0.791	1.009	0.983	0.760
Currently married (not married)	0.927	1.113	0.855	0.921	0.998	0.926
Living alone (not living alone)	2.590*	2.284**	1.935	2.828*	2.855**	2.238#
- Log Likelihood	454.3***	532.2***	245.3*	411.7***	510.8***	233.6*
Df	9	9	9	30	30	30
Nagelkerke R^2	0.040	0.032	0.038	0.130	0.069	0.078
Number of observations	754	976	497	754	976	497

Notes: (1) Reference group of each covariate is listed in the parentheses. (2) All variables are measured at the beginning of each two-year interval. (3) Full mode means all other controlling variables are in the model in addition to socio-demographic variables. (4) Odds ratios and their significant level were corrected by intra-subject correlations due to some subjects contributing two observations to the pooled data set at a specific time (Time 1or Time 2). (5) #, p<0.1; *, p<0.05; **, p<0.01; ***, p<0.001.

Table 4-2 Odds ratios of the recovery from ADL disability by socio-demographic variables, Females

	Socio-demographic variable only			Full model		
	Age 80-89	Age 90-99	Age 100-105	Age 80-89	Age 90-99	Age 100-105
Single age	0.942*	0.928***	0.993	0.950#	0.942**	1.022
Urban (rural)	0.757	0.692**	0.597***	0.724#	0.653**	0.588***
Minorities (Han)	1.223	1.673*	2.122**	1.545	1.675*	1.945***
1+ year (s) schoolings (no schooling)	1.219	0.699	0.736	1.057	0.660#	0.735
Economic independence (dependence)	0.741	0.834	0.663	0.669	0.839	0.679
Adequate financial resources (no)	0.915	0.968	0.839	0.863	0.903	0.826
Primary lifetime occupation before age 60						
Housekeeper (agriculture)	0.796	0.696	0.687**	0.836	0.693*	0.710*
Non-agriculture (agriculture)	0.979	1.108	1.332	1.091	1.168	1.265
Currently married (not married)	1.947**	0.963	---	2.271**	0.945	---
Living alone (not living alone)	1.648#	1.234	1.360	1.278	1.122	1.524
- Log Likelihood	527.0***	800.1***	983.6***	490.8***	777.8***	954.8***
Df	10	10	10	31	31	31
Nagelkerke R^2	0.025	0.024	0.032	0.090	0.051	0.060
Number of observations	898	1724	2209	898	1724	2209

Notes: (1) Reference group of each covariate is listed in the parentheses. (2) All variables are measured at the beginning of each two-year interval. (3) Full mode means all other controlling variables are in the model in addition to socio-demographic variables. (4) Odds ratios and their significant level were corrected by inter-subject correlations due to some subjects contributing two observations to the pooled data set at a specific time (Time 1or Time 2). (5) #, p<0.1; *, p<0.05; **, p<0.01; ***, p<0.001. (6) '---', The number of observations is less than 5 in one of categories.

Figure 1a Age effect on dynamic changes of disability, Socio-demographic model

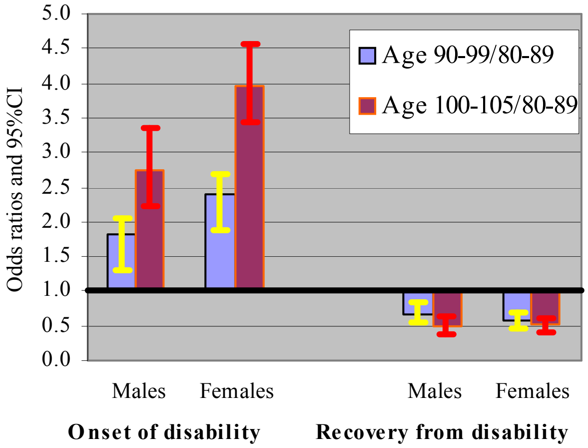


Figure 1b Age effect on dynamic changes of disability, Full model

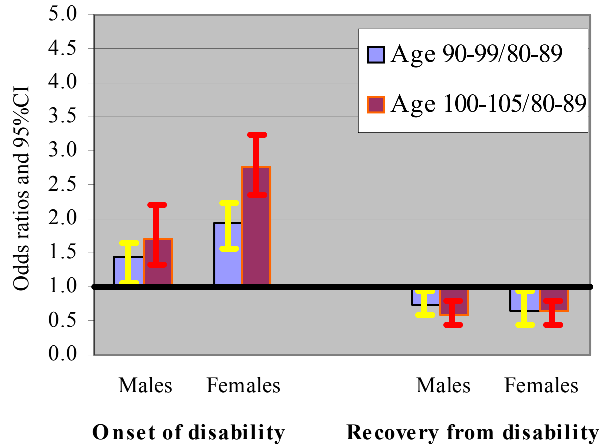


Figure 2a Gender effects (Female/Males) on dynamic changes of disability, Socio-demgraphic model

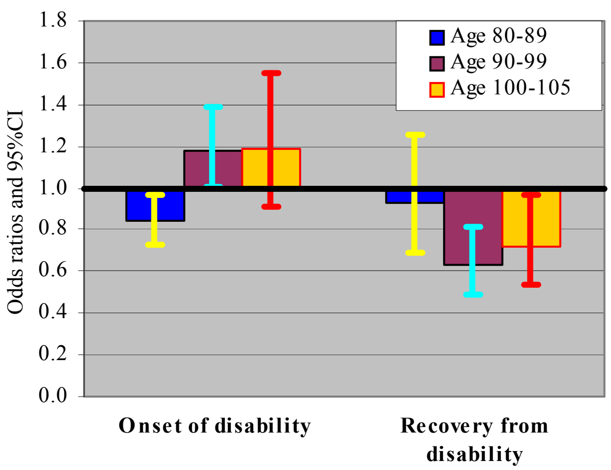


Figure 2b Gender effects (Females/Males) on dynamic changes of disability, Full model

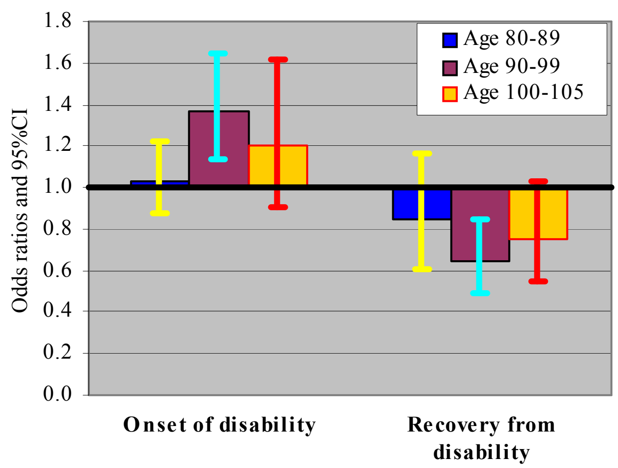


Figure 3a Comparison of odds ratios between models including and not including ADL disability transitions before dying, from active to disabled, Full Model, Males

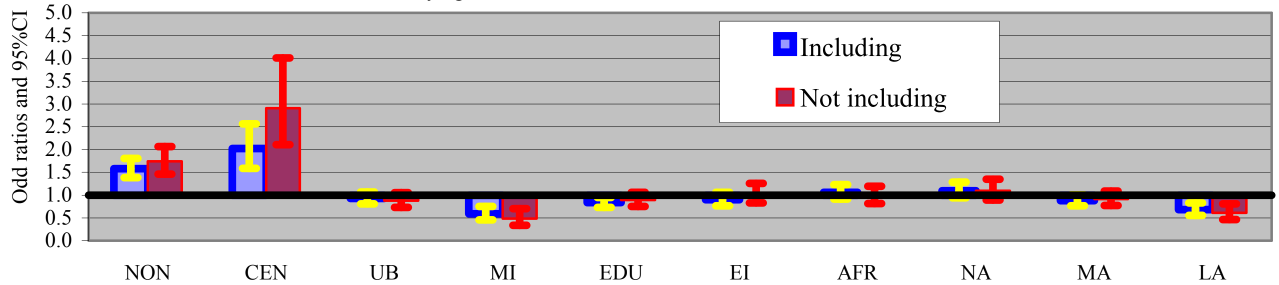


Figure 3b Comparison of odds ratios between models including and not including ADL disability transitions before dying, from disabled to active, Full Model, Males

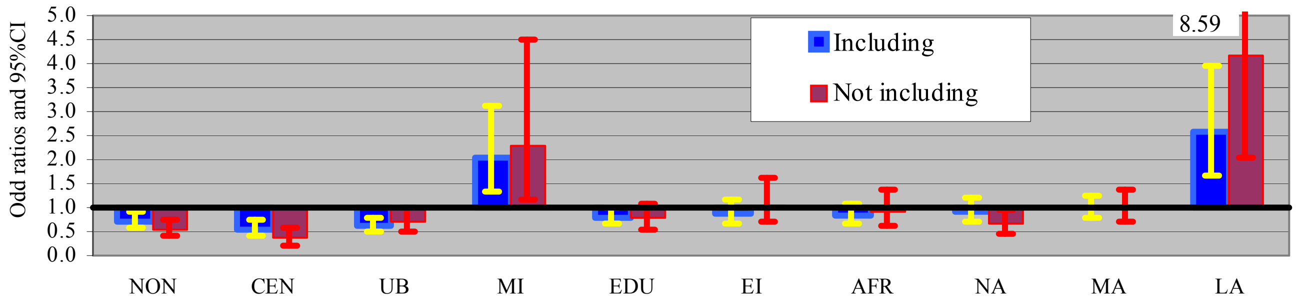


Figure 3c Comparison of odds ratios between models including and not including ADL disability transitions before dying, from active to disabled, Full Model, Females

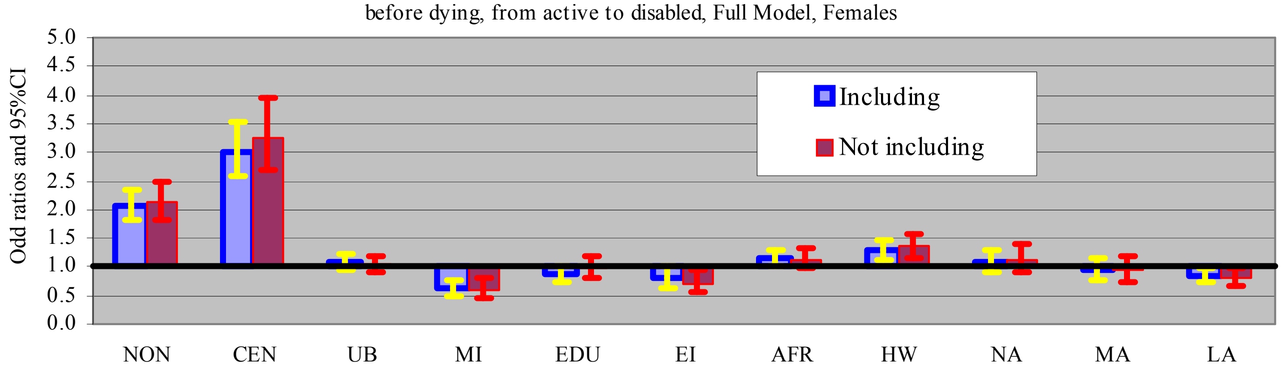
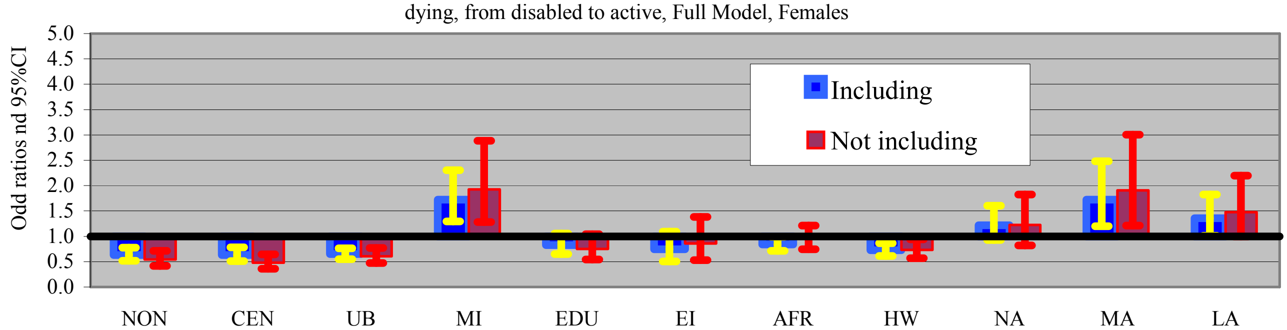


Figure 3d Comparison of odds ratios between models including and not including ADL disability transitions before dying, from disabled to active, Full Model, Females



Note: NON-nonagenarians vs octogenarians; CEN-centenarians vs octogenarians; UB-urban vs rural; MI-minority vs Han; EDU-no schooling vs 1+ schooling; EI-economic independence vs dependence; AFR- adequate financial resources yes vs no adequate financial resources; HW-housewife vs agriculture; NA-non-agriculture vs agriculture; MA-currently married vs not married; LA-living alone vs not-living alone