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Trajectory of functional status among older Taiwanese: Gender and age variations

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Abstract

Current findings on gender and age differences in health trajectories in later life are equivocal and largely based upon data derived from Western developed nations. This study examines gender and age variations in the trajectory of functional status among older adults in Taiwan, a non-Western newly industrialized society. Data came from a sample of some 3500 Taiwanese aged 60 and over, initially surveyed in 1989 and subsequently followed in 1993, 1996, 1999, and 2003. Hierarchical linear models with time-varying covariates were employed in depicting the dynamics of functional status across gender and age. Women and the old–old experienced higher levels of disability and rates of increase than their male and young–old counterparts. Moreover, older women bore a disproportionately larger burden of disability. There are therefore significant gender and age variations in the trajectory of functional status among older Taiwanese. These findings provide evidence for the generalizability of prior observations to a non-Western society.

Keywords

Taiwan; Functional status; Gender; Hierarchical linear models; Older adults; Longitudinal

Introduction

Extensive research has focused on gender differences in aging and health (Arber & Cooper, 1999; Macintyre, Hunt, & Sweeting, 1996; Verbrugge, Lepkowski, & Imanaka, 1989). Nonetheless, there is very limited understanding of how men and women differ in health dynamics in old age. In cross-sectional studies of health states, intrapersonal change cannot be distinguished from interpersonal differences. Studies of health transitions between two points in time have suggested that women are more likely to experience functional decline than men (e.g., Anderson, James, Miller, Worley, & Longino, 1998; Mor, Wilcox,

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Rakowski, & Hiris, 1994). However, these studies provide little information on the underlying growth curve or trajectory, which consists of multiple health transitions over time (Singer & Willet, 2003). A more complete understanding dictates an analysis of how men and women differ in the level as well as the rate of change associated with a health trajectory. This is consistent with the notion of gendered health careers, which calls for the delineation of gender differences in the nature and range of health pathways over the life course (Moen & Chermack, 2005).

Health trajectories in late life, on the other hand, may differ significantly across age groups. Health transition studies have documented that older age is associated with a greater probability of functional decline and decreased odds of stability and improvement over time (Anderson et al., 1998; Crimmins & Saito, 1993). In addition, there is emerging evidence in the U.S. that younger cohorts enjoy better health. For instance, on average functional limitations in the U.S. declined by about 40% from the early 1900s to the 1990s, attributable to reduction in the debilitating effect of chronic conditions and the reduced rates of chronic conditions (Costa, 2003).

Although there is increasing research on gender differences in the trajectory of functional health, empirical findings are equivocal. Whereas a higher level of disability among older women than men was observed by many (Newman & Brach, 2001), this was not replicated consistently (Maddox & Clark, 1992; Mendes de Leon, Barnes, Bienias, Skarupski, & Evans, 2005). Findings concerning gender differences in the rate of change are equally inconclusive. For instance, some investigators have observed that women experienced greater odds of functional decline than men (Anderson et al., 1998; Leveille, Penninx, Melzer, Izmirlian, & Guralnik, 2000; Taylor & Lynch, 2004), whereas others have reported the reverse (Maddox & Clark, 1992; Mendes de Leon et al., 2005). In addition, there is some evidence that gender differences are greater among the old–old than the young–old (Liang et al., 2008). Further research is clearly needed to clarify gender and age differences in the trajectory of functional health.

Moreover, the vast majority of studies is based on data collected in Western developed nations, particularly the United States. Because of substantial differences in demographic, epidemiological, and economic transitions, the generalizability of current findings across nations remains to be established. For instance, there is some indication that rates of disability and functional limitations across Asia and Latin America are on the rise (Ofstedal et al., 2007; Palloni & McEniry, 2007), which diverge substantially from observations of declining disability in old age in the United States (Freeman & Martin, 2000).

Replications across nations are indispensible for establishing the generality of findings and the validity of interpretations derived from single-nation studies (Kohn, 1989). In no other way can we be certain that existing empirical observations are merely the product of some limited set of historical, cultural, and political circumstances such as those existed in the Western developed nations. In addition, replications are very valuable in motivating the investigators to revise their interpretations to take into account of differences or inconsistencies that could never be uncovered in research done in a single nation.

In this regard, Taiwan serves as an ideal setting for further research on gender and age differences in health dynamics. Since the early 1950s, Taiwan has evolved from a poor agricultural economy to a newly industrialized society, with a gross domestic product (GDP) per capita of $31,900 (adjusted for purchasing power parity) in 2007 (Central Intelligence Agency [CIA], 2009). Largely because of substantial declines in fertility, Taiwan is aging very rapidly. Those aged 65 and older accounted for 10.2% of the total population in 2007, and it is expected to grow to 21.7% by 2027 (Council for Economic Planning and

Development, 2008). Life expectancy at birth in Taiwan was 77.9 years in 2009, similar to that of the United States (CIA, 2009).

In comparison with older people in the Western developed countries, older Taiwanese are significantly less educated. As of 2008, 14.7% of the 65 and over population in Taiwan was illiterate (Ministry of Education, 2008). This is further exacerbated by substantial gender disparities, with 25.1% and 3.7% of older women and men being illiterate respectively (Ministry of Education, 2008). In addition, older men outnumbered older women in Taiwan until 2004, a legacy of the massive migration including a large number of troops brought by the Nationalist government during the civil war in 1949 (National Statistics, 2009; Ofstedal et al., 2007).

The current cohort of older Taiwanese have more children and are far more likely to reside with their children than their counterparts in Western developed nations. In 2005, 60% of those 65 of age and over lived with their children (Tsai, 2008). As old age pension programs are still not well developed, there is greater poverty among older persons in Taiwan than Western developed nations, with many of them depending on their children for significant financial assistance (Jesuit & Smeeding, 2003).

The present study aims to extend current knowledge of aging and health in three respects. We first chart the trajectory of functional health by using longitudinal data from a national sample of Taiwanese over 60 years of age for a period of 10 years (1993–2003). Second, we examine how the level and rate of change associated with the trajectory of functional status differ between men and women and across age groups. Finally, we explore whether the gender gap in functional status trajectory varies by age.

Hypotheses

We offer several hypotheses grounded in the perspective of social stratification of aging and health (Crimmins & Seeman, 2001; House, Lantz, & Herd, 2005). In particular, social economic status (SES) is viewed as a function of age, gender, and ethnicity as they have profound implications for the distribution of wealth, prestige, and power. As a fundamental cause, SES shapes people’s exposure to many risk factors including social relations, health behaviors, and personality dispositions (Link & Phelan, 1995). More importantly, age, gender, and ethnic differences on health and well-being often cannot be fully explained by SES. Examples of these perspectives include age stratification (Riley, 1987) and gender stratification (Huber, 1990). Accordingly, gender and age are hypothesized to affect functional status directly and indirectly via SES, social support, and prior health. Social relations and health status are assumed to be time-varying, as they may change substantially if an extended period of observation is involved.

Hypothesis 1: Functional status worsens over time among older Taiwanese (H_1)—Most of the studies of older Taiwanese relied on cross-sectional data (Chang & Zimmer, 2006; Chiu, Hsieh, Mau, & Lee, 2005; Ofstedal et al., 2007; Wang, Sheu, & Protas, 2006). The limited number of longitudinal studies tended to focus on health transitions between two points in time, yielding little information on health trajectory (Beckett, Goldman, Weinstein, Lin, & Chuang, 2002; Zimmer, Liu, Hermalin, & Chuang, 1998). According to recent longitudinal studies in the United States, functional status in old age deteriorates over time in a linear or quadratic fashion (Kahng, Dunkle, & Jackson, 2004; Kim & Durden, 2007; Liang et al., 2008). However, parallel observations in Taiwan are lacking. Extrapolating from observations made in the U.S., we hypothesize that functional status worsens over time among older Taiwanese (H_1).

Hypothesis 2: Older Taiwanese women not only experience higher functional impairment than older Taiwanese men but also tend to decline functionally at a greater rate (H_2)—There is a fair amount of research suggesting that older Taiwanese women experience more functional disability than men (Chang & Zimmer, 2006; Ofstedal et al., 2007; Zimmer, Hermalin, & Lin, 2002). However, evidence on gender differences in changes in functional status is mixed. For instance, Hsu (2005) found older Taiwanese women more likely to develop difficulties with activities of daily living (ADL) than men over a six-year period, whereas others observed no gender differences in the risk of developing disability over time (Chiu et al., 2005; Wu, Leu, & Li, 1999). All of these studies focused on health transitions between two points in time. Little is known about how elderly Taiwanese men and women differ in the trajectory of functional status. In the U.S., findings regarding gender differences in changes in functional status are similarly equivocal (Anderson et al., 1998; Kahng et al., 2004; Mendes de Leon et al., 2005) and further research is required. We hypothesize that Taiwanese women not only experience higher functional impairment than men but also tend to decline functionally at a greater rate (H_2).

Hypotheses 3: The level of disability and its rate of change are higher among the old–old Taiwanese than the young–old Taiwanese (H_3)—Cross-sectional data suggest greater disability in Taiwanese seniors at advanced ages than the young old (Department of Statistics, 2006). Several studies of health transitions also showed that older age was associated with increased risk of functional decline and a lower likelihood of functional improvement among elderly Taiwanese (Chiu et al., 2005; Zimmer et al., 1998). Although there is some indication that the prevalence of disability is increasing among older Taiwanese (Zimmer, Martin, & Chang, 2002), there has been no direct observation of age differences in the rate of change in disability trajectory.

Age differences in the trajectories of functional impairment observed over time reflect a combination of cohort and age effects. According to Gruenberg (1977), even with increasing life expectancy, there is little change in the ages of onset of morbidity and disability. Hence there is little or no difference in disability between older cohorts and younger cohorts. In contrast, Fries (1983) proposed the notion of compression of morbidity in that the onsets of morbidity and disability have been delayed significantly in younger cohorts relative to older cohorts. Finally, even though declines in mortality may increase the prevalence of chronic diseases, the rates of progression for these diseases and thus disability may fall (Manton, 1982). Thus, there would be greater functional impairment among members of older cohorts compared to younger cohorts at the same ages. This is supported by recent research by Costa (2003) that age-specific prevalence rates of chronic diseases have declined substantially with a significant delay in the onset of chronic diseases during the 20th century.

In addition, within a given birth cohort, age plays an important role. Research on health transitions strongly suggests that age is associated positively with the risk of functional decline and negatively with functional improvement (Anderson et al., 1998; Crimmins & Saito, 1993; Mor et al., 1994). Accordingly, we hypothesize that compared to the young–old, old–old persons have greater functional impairment and experience more rapid functional decline over time (H_3).

Hypothesis 4: Gender differences in both the level and rate of change in disability are greater among the old–old in Taiwan than the young–old (H_4)—A key factor underlying the gender gap in disability is that women have more comorbidity and chronic health problems than men (Newman & Brach, 2001; Verbrugge et al., 1989). However, Crimmins and Saito (2000) found a significantly greater increase in most of the diseases among men than women in the United States. In addition, there is evidence that the impact of chronic diseases on disability has been reduced over the years (Freeman & Martin, 2000), suggesting a decreased gender gap among members of younger cohorts than older cohorts. This is supported by recent research in the U.S. that gender differences in functional decline were more substantial among the old–old than the young–old (Liang et al., 2008). This may be a result of improved education, occupation, and income among women in recent decades (Guralnik, Land, Blazer, Fillenbaum, & Branch, 1993; House et al., 2005). There, however, has been no parallel research on older people in Taiwan. Extrapolating from observations from the U.S., we hypothesize that gender differences in both the level and rate of change in disability are greater among the old–old in Taiwan than the young–old (H_4).

Methods

Data

Data for this research came from the Health and Living Status of the Elderly in Taiwan (HLSET) survey. Initiated in 1989, it involved a nationally representative 3-stage equal probability sample of 4049 Taiwanese 60 years of age or older (response rate = 91.8%). The respondents were followed in 1993, 1996, 1999, and 2003 with a response rate ranging from 87% to 92%. Whenever possible, proxy interviews were conducted for individuals who were unable to complete the survey themselves. Deaths occurred during the period of observation were verified by using the Death Registration from the Ministry of the Interior in Taiwan.

Because of the specification of lagged time-varying covariates and change scores in our models, measures of the dependent variable (i.e., functional status) could only be derived from data collected in 1993 and thereafter. As a result, those who were interviewed in 1989 but died or dropped out before 1993 could not be included in our analysis. There were a total of 3488 respondents in the 1993–2003 HLSET surveys. In order to assess the effects of ethnicity, we further deleted 73 respondents who identified themselves as other than Fukienese, Haka, or Mainlanders, the three main ethnic groups in Taiwan. The final analytical sample included 3415 individuals, contributing a total of 10,786 observations.

Measures

Functional status was measured by one ADL item (i.e., bathing), four instrumental activities of daily living (IADL) items (i.e., shopping for personal items, managing money, using telephone, and taking a bus or train by oneself), and one mobility item (i.e., walking about 200–300 m). Each item was scored with a four-point scale (0 = no difficulty at all, 1 = some difficulty, 2 = very difficult, and 3 = cannot do it). The sum of these six items ranged from 0 to 18, with a higher score representing greater disability. Spector and Fleishman (1998) showed that ADL and IADL items could be combined to measure functional status with enhanced range and sensitivity. In addition, our composite correlates highly with the conventional 6-item ADL measure (i.e., eating, dressing, transferring, bathing, using toilet, and walking indoor) (r = 0.88–0.90 across different survey waves) and 5-item IADL measure (i.e., light housework, heavy housework, shopping for groceries, manage financial matters, using telephone) (r = 0.95–0.97 across different survey waves).

Several measures of social stratification were included. Gender was indexed by a dummy variable, whereas age differences were indicated by age in 1993 (centered at age 70). Socioeconomic status was indexed by the number of years of schooling (capped at 17 for individuals with 17 or more years of education). Education is the key to one’s place in the social stratification system as it shapes employment opportunity, income, and wealth (Mirowsky & Ross, 2003). Because income was not consistently measured across different waves of HLSET, we used education as a proxy for an individual’s SES because of the high correlations among education, income, wealth, and occupation.

Two dummy variables were created to reflect three major ethnic groups (i.e., Fuchienese, Hakka, and Mainlander). Fuchienese and Hakka migrated to Taiwan many generations ago, primarily from Fukien and Kwantung, two provinces in southern China, whereas the mainlanders arrived in Taiwan in the late 1940s during the civil war. These groups differ in their migratory histories, socioeconomic status, and social networks. For instance, Mainlanders tend to be the younger elderly, male, urban residents, less likely to be married, and enjoy higher education and income (Hermalin, Ofstedal, & Chang, 1992).

Three indicators of social relations were measured. Marital status was constructed as a dummy variable (1 if the individual was married at the time of the interview, and 0 otherwise). Emotional support was assessed by three items (i.e., how well someone listened to him/her, how well he/she was cared for, and satisfaction with care received). Because these three items were measured with different scales involving 3–5 points respectively, each item was recalibrated to a zero-to-one scale so that equal weights were given to all three items. The final emotional support variable was calculated as the average of the rescaled three items (score range: 0–1). Instrumental support was measured by the respondent's reported level of assistance received during sickness. It was significantly correlated with financial assistance received ($r = 0.57$). This measure was also recalibrated to a zero-to-one scale. A higher score on the emotional or instrumental support measure indicated lower social support.

Several measures of health status were obtained. Self-rated health was measured by two items: (a) a rating of overall health status (1 = excellent, 2 = very good, 3 = good, 4 = fair, and 5 = poor), and (b) a comparison of current health with health a year ago (1 = better, 2 = about the same, and 3 = worse). Both items were recalibrated to a zero-to-one scale. A composite of self-rated heath was constructed as the summation of these two rescaled scores (range: 0–2). Diseases were a count of health conditions reported (range: 0–10), including diabetes, heart disease, hypertension, stroke, arthritis, cataract, respiratory tract diseases, gastrointestinal disorders, liver or gall bladder problems, and kidney diseases. Depressive symptoms were represented by an abbreviated 10-item Center for Epidemiological Studies Depression Scale (CES-D), including: (a) poor appetite, (b) bad mood, (c) everything was an effort, (d) happy, (e) lonely, (f) people were unfriendly, (g) life was good, (h) sad, (i) could not get going, and (j) could not sleep well. Each item was coded with a four-point scale, indicating how often one experienced a given symptom (i.e., 0 = never, 1 = rarely, 2 = sometimes, or 3 = often or chronically). Positive affect items were reverse coded such that a higher score reflected greater depressive symptoms (range: 0–30). Cronbach's alpha for the 10-item CES-D in the 1996,1999, and 2003 surveys ranged between 0.84 and 0.86 (Seplaki, Goldman, Weinstein, & Lin, 2006).

To ensure that a clear time sequence was defined between the time-varying covariates and functional status outcome, our model included the lagged measure (i.e., observation from the last interview, X_{t-1}) and the change term (i.e., change in the value of the variable between the last interview and the present interview, $\Delta X_{t-1,t} = X_t - X_{t-1}$) for each of the time-varying covariates. As shown in Table 1, chronic diseases, functional disability increased along with self-rated poor health and depressive symptoms between 1993 and 2003. In addition, nearly 45% of the respondents died during the same period of time. Finally, older Taiwanese were characterized by a smaller proportion of women (43%), limited education (average years of schooling = 4.6), and a fair degree of ethnic heterogeneity.

Data analysis

Hierarchical Linear Modeling was used to describe how functional status changes over time (Raudenbush & Bryk, 2002) as follows (level-1 or repeated-observation model):

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$$Y_{it}=\pi_{0i}+\pi_{1i}\text{Time}+\Sigma\mathscr{B}_k X_{kit}+\varepsilon_{it} \quad (1)$$

swhere Y_{it} is functional status for individual *i* at time *t* (e.g.,1993). π_{0i} is the intercept of functional status for individual *i*. π_{1i} is the rate of change (slope) in functional status for individual *i* over time. *Time* refers to the year of assessment and was centered at 1996 (i.e., the middle point of the observation period, 1989–2003). Hence the intercept represents the level of functional impairment in 1996.

X_{kit} is the *k*th time-varying covariate (e.g., lagged marital status and its corresponding change term) associated with individual *i* at time *t*. β_k represents the effect of X_k on functional status. ε_{it} represents random error in functional status for individual *i* at time *t*.

To examine age and gender differences in the changes of functional status, we included them as predictors in the level-2 (or person-level) equation in the multi-level analysis:

$$\pi_{pi}=\gamma_{p0}+\Sigma\gamma_{pq}X_{qi}+\zeta_{pi} \quad (2)$$

where X_{qi} is the *q*th time-constant covariate (e.g., gender) associated with individual *i*. γ_{pq} represents the effect of X_q on the *p*th growth parameter (π_p), such as intercept (π_0) and linear slope (π_1). ζ_{pi} is a random effect with a mean of 0. No random effects were modeled for β_k. A SAS procedure, Proc Mixed, was used to estimate Equations (1) and (2). To determine the mediation effects of various covariates (e.g., social stratification, social support, and health status), we followed the approach outlined by Baron and Kenny (1986) in conjunction with the procedure proposed by Clogg, Petkova, and Haritou (1995).

Because centering or anchoring time at various years (i.e., 1993, 1996, 1999, or 2003) leads to the test of a different set of hypotheses, the parameter estimates and the results of significance tests would vary as well. In particular, with a certain centering constant, the resultant estimates describe the trajectory's behavior at that specific point in time (Singer & Willet, 2003, pp. 181–188). Thus, in addition to centering *Time* at 1996, we undertook additional analyses by varying the anchor of the *Time* variable.

Item missing, mortality and attrition

To minimize the loss of data due to item missing or missing of certain interviews by some respondents (i.e., if a subject missed one or more early waves but responded to a later one), multiple imputation was undertaken using IVEware (Raghunathan, Solenberger, & Van Hoewyk, 2002). Parameter estimates and their standard errors were derived by averaging across five imputed datasets and by adjusting for their variances.

Subjects whose data were provided by a proxy respondent at a given interview were specified by means of a time-varying covariate in the level-1 equation. In addition, following the approach of "pattern mixture models" (Hedeker & Gibbons, 1997; Raudenbush & Bryk, 2002), two binary variables were constructed to identify those who died or dropped out of the study during the period of observation and were included in the level-2 equation. These measures were treated as confounding variables instead of predictors in our model to control for selection bias.

Results

To evaluate the hypotheses, we took the following steps. First, we charted the trajectory of disability over time (H_1) without any covariates (M_0 in Table 2). Second, we examined the disability trajectory by adjusting for proxy interview, mortality, and attrition as confounding variables (M_1). Third, we added measures of social stratification including age differences, gender, age by gender interaction, and ethnicity (M_2). The intent was to evaluate their effects on disability trajectory as stated in H_2 through H_4. Finally, we added education and time-varying social relations as covariates in M_3 and disability at the baseline and time-varying measures of prior health in M_4, respectively, to assess their roles in mediating the observed gender and age differences in disability.

Change in disability over time

Both linear and quadratic models were evaluated for the trajectory of functional status (Equation 1). Because of the statistically significant quadratic slope and a better fit (based on the-Bayesian Information Criterion), we chose the quadratic model in our final analysis. Consistent with H_1, the functional disability score was 2.867 out of a total of 18 points in 1996 ($p < 0.001$, M_0 in Table 2), and it increased over time at an increasing rate (linear slope = 0.322, $p < 0.001$, quadratic slope = 0.019, $p < 0.001$, M_0 in Table 2). Adjusting for proxy interview, mortality, attrition, and social stratification, the level of disability and its linear slope became diminished substantially (intercept = 0.057, p > 0.05; linear slope = 0.073, $p < 0.05$, M_2 in Table 2), while the curvature remained essentially the same (quadratic slope = 0.025, $p < 0.001$, M_2 in Table 2) (Fig. 1a).

Gender differences in disability trajectory

Women were not only more functionally impaired than men ($b = 1.265$, $p < 0.001$, M_2 in Table 2), but also experiencing greater increase in disability over time ($b = 0.100$, $p < 0.01$, M_2 in Table 2). After adjusting for population heterogeneity in social stratification, social support and prior health, gender differences in the level of disability attenuated by 74.9% [(1.265−0.317)/1.265 = 0.749, $p < 0.01$] (Clogg et al.,1995). However, the greater rate of increase in disability in women remained ($b = 0.083$, $p < 0.05$, M_4 in Table 2). Together, these findings lend support to H_2 that women are more functionally impaired and experience a more rapid deterioration than men. This was indicated by the steadily widening gender gap in functional impairment over time (Fig. 1a).

Age differences in disability trajectory

Baseline age was significantly associated with both the intercept ($b = 0.081$, $p < 0.001$) and linear slope ($b = 0.009$, $p < 0.01$) of the functional status trajectory (M_2 in Table 2). However, this was not the case with the quadratic slope. The introduction of education and social relations (M_3) reduced the age effects by 37.0% compared to model M_2 [(0.081−0.051)/0.081 = 0.370, $p < 0.001$]. Changing health status accounted for some of this age difference as shown by the reduced age effect on the intercept in M_4 ($b = 0.051$, $p < 0.01$, M_4 in Table 2). However, adjustment of population heterogeneity did not change the age impact on linear slope ($b = 0.009$, $p < 0.01$, M_4 in Table 2). These data lend support to H_3 that older persons have greater functional disability as well as a greater rate of increase in functional impairment relative to their younger counterparts. This was shown by the gradually increasing functional status gap between the old–old and the young old over time (Fig. 1b).

Gender by age interaction in disability

There was evidence for a significant gender by age interaction effect on the intercept of the disability trajectory in that older women were disproportionately more disabled ($b = 0.089$, $p < 0.01$, M_2 in Table 2). It remained significant, even after baseline and time-varying covariates were adjusted ($b = 0.062$, $p < 0.01$, M_4 in Table 2). However, no such effect was observed on the linear or quadratic slope. Hence, H_4 is supported with reference to the intercept of the disability trajectory but not in terms of its rate of change (Fig. 1c).

Effects of other covariates

Higher education was associated with less disability ($b = -0.060$, $p < 0.01$, M_3 in Table 2), but this relationship appeared to be explained by changes in the person's health status (M_4 in Table 2). Likewise, greater disability among Fuchienese ($b = 0.374$, $p < 0.05$, M_2 in Table 2) was accounted for by heterogeneity in education and social support (M_3 in Table 2).

Lower emotional support and reduced emotional support over time were associated with greater disability ($b = 1.402$, $p < 0.01$; $b = 1.136$, $p < 0.01$; M_3 in Table 2). Such effects, however, were explained by the person's changing health status. On the other hand, lower instrumental support at and decreased instrumental support over time were associated with better functional health ($b = -1.029$, $p < 0.01$, and $b = -0.623$, $p < 0.01$, M_4 in Table 2).

Poor functional status at baseline was associated with a higher level of disability subsequently ($b = 0.420$, $p < 0.001$, M_4 in Table 2). Time-varying health covariates were all highly correlated with functional status. Specifically, poor self-rated health, more diseases, greater depressive symptoms, and recent deterioration in these health measures all resulted in elevated disability (M_4 in Table 2).

Difference in the variance components of the intercept between M_1 and M_2 [(8.859−7.685)/8.859 = 0.133] suggests that 13.3% of the variation of the intercept is associated with age, gender, and ethnicity. Comparing M_2 with M_4 in which social relations and health status measures were controlled, the residual variance is further reduced by 32.6% [(7.685−5.180)/7.685 = 0.326]. In contrast, 6% of the variation in the linear time slope was explained by age, gender, and ethnicity, whereas 27% was accounted by changing social relations and health status.

We can quantify the effect size by assessing the estimated gender and age differences in ADL/IADL as a fraction of the standard deviation of ADL/IADL (Cohen, 1988). For example, the predicted gender difference in ADL/IADL in 1993 was 1.157 (Fig. 1) with a standard deviation of 4.038 (Table 1). Therefore, the gender difference is equivalent to 0.29 standard deviations. Similarly, we can calculate the Cohen's effect size for gender difference in 2003 (i.e., 2.332/5.622 = 0.41), and age difference in 1993 (i.e., 1.192/4.038 = 0.30) and 2003 (i.e., 2.776/5.622 = 0.49). Hence, both gender and age differences in disability trajectory are greater than a small effect (i.e., 0.2) at the baseline and increased over time, approaching a medium effect (i.e., 0.5) (Cohen, 1988).

Mortality, attrition, and proxy interview

Mortality, attrition, and the use of proxy interview were all significant confounding factors when disability was examined. For example, even after adjusting for changing health status, mortality during the follow up period was significantly correlated with both the intercept and linear slope of the functional health trajectory ($b = 1.428$, $p < 0.001$, and $b = 0.302$, $p < 0.001$, respectively, M_4 in Table 2). Proxy interviews (both in terms of the lagged measure and change score) were associated with poor functional status ($b = 5.591$, $p < 0.001$, and $b = 4.528$, $p < 0.001$, M_4 in Table 2). These results suggest that estimates of growth parameters for the functional health trajectory would be biased if mortality, attrition and proxy interview status were not accounted for.

Parameter estimates and time centering

Results presented so far were based on the analysis with the time variable centered at 1996 (Table 2). As noted previously, parameter estimates and significance tests could vary, depending on where the time variable is anchored (Singer & Willet, 2003). To further explore gender and age differences in the disability trajectory, we conducted additional analyses by varying the year used for centering time (Table 3). In particular, there were significant gender differences in the level of disability in 1993, 1996, 1999, and 2003, increasing from 1.002 to 2.160. Likewise, age differences in the intercept of disability increased from 0.070 in 1993−0.223 in 2003. With reference to the linear slope, gender difference increased from 0.076 in 1993−0.156 in 2003, while age differences ranged from −0.001 to 0.032 between 1993 and 2003. Similar to the results based on centering time at 1996, there were significant age by gender interaction effects in 1993, 1999, and 2003. These results are consistent with the hypothesized gender and age variations in the trajectory of functional status.

The substantive findings on other covariates are quite robust, regardless of how time was centered. Similar patterns were observed for M_3 and M_4 when we changed the choice of centering for the time variable (results from these analyses are available from authors upon request).

Discussion

A key contribution of this research lies in its focus on the dynamics of functional status in old age in Taiwan, a non-Western society. Approximated by a quadratic function, disability increases over time with an accelerated rate among older Taiwanese. Women and the old–old experience not only greater disability but also more rapid functional decline. Moreover, old–old women bear a disproportionately larger burden of disability. Finally, gender and age differences in the trajectory of functional health are partially mediated by education, social relations, and health conditions.

To the best of our knowledge, this study is the first in analyzing the long term trajectory of functional status among older Taiwanese. Relative to prior studies based on cross-sectional data or analysis of changes between two points in time, the present research employs a more dynamic approach involving longitudinal data with up to five repeated observations over 14 years. In particular, it offers quantitative estimates of the gender and age differences in the parameters of the growth curve (i.e., intercept and rate of change) for functional status.

This research also contributes to our knowledge of age stratification in the health dynamics in old age. Most of prior research focused on how health disparities in terms of socioeconomic status interact with age (House et al., 2005). Our findings reinforce the importance of gender in this context. Using data derived from the U.S., Liang et al. (2008) found that women and the old–old experienced not only greater disability but also more elevated rates of increase. Furthermore, women in the old–old age group tended to have disproportionately higher disability. In view of the substantial social and cultural differences between the U.S. and Taiwan, similarities in the patterns of gender and age variations in disability trajectory between these two countries are remarkable. Hence there is increasing support for the hypothesized gender by age interaction effect on disability trajectory.

By incorporating time-varying covariates, we are also able to show that disability is dynamically linked with social relations and health conditions. In particular, disability is significantly correlated with the lagged values as well as the change scores of these time-varying covariates. Whereas more emotional support is correlated with less disability, greater instrumental support is associated with greater disability. These findings provide additional evidence regarding the important role of social support in affecting health status in later life.

Our observation of the positive linkage between emotional support and functional status is consistent with current knowledge of the beneficial effects of social support on health (Reblin & Uchino, 2008). On the other hand, the negative association between instrumental support and functional health is less intuitive. Nonetheless, similar findings were reported previously (Mendes de Leon, Gold, Glass, Kaplan, & George, 2001; Taal, Rasker, Seydel, & Wiegman, 1993). Receiving help with daily activities may foster a sense of dependency and reduced confidence or self-efficacy to perform these daily tasks, which is shown to be an important mechanism in the disabling consequences of declining physical health (Mendes de Leon et al., 2001). Hence, an excessive amount of instrumental support could weaken an older person's ability to perform these tasks and related physical functions.

Conventional measures of health outcomes (e.g., ADL or IADL) are often limited to health state at one point in time. Health trajectories can significantly complement the conventional measures by providing information related to how health evolves over time. They can aid the identification of individuals who are at risk for disability and these individuals (e.g., women and the old–old) could be targeted for timely intervention. Moreover, health trajectories may serve as additional outcome measures in evaluating the performance of various programs designed for health promotion and the prevention and management of chronic diseases and frailty. Because of the substantial variations in health and aging across nations, estimated growth parameters and their predicators found in the U.S. have to be cross-validated and calibrated by using data from non-Western developing nations.

The present study can be improved in several aspects with particular relevance for future research. First, functional status is but one of the multiple dimensions of health and well-being (e.g., diseases, emotional and cognitive functioning). Conceivably, trajectories in terms of all these dimensions can be charted, and more importantly how they vary across gender and age groups needs to be examined. Although the structural linkages among various dimensions of health and well-being have been a long standing interest among researchers (e.g., Stump, Clark, Johnson, & Wolinsky, 1997), they have not been analyzed within a dynamic framework.

Second, there might be significant heterogeneity in how functional status changes over time, which is not explored in this research. For instance, recent analysis of data from the Health and Retirement Study has shown that underlying the average trajectory of disability, there are five distinct courses of change including (a) excellent functional health, (b) good functional health with small increasing disability, (c) accelerated increase in disability, (d) high but stable disability, and (e) persistent severe disability (Liang, Xu, Bennett, Ye, & Quiñones, 2010). In addition, Chen, Wang, and Huang (2008) identified three distinct trajectory groups of recovery in functional status (good function, moderate function, and poor function) among 286 surgical patients admitted to a large medical center in Northern Taiwan. These findings suggest the need to examine not only the average health change with age in a given population but also its underlying heterogeneity in terms of distinct trajectories.

Finally, significant gaps remain in our knowledge concerning gender differences in health. A promising strategy would be incorporating additional psychosocial variables in conjunction with biomarkers in future research. These may include health behaviors, body mass index, and muscular skeletal conditions (Wray & Blaum, 2001). In particular, the roles of health behaviors as mediating variables deserve further research. Up to one third of the variations in human life expectancy can be explained by genetic factors. Moreover, overall functioning, muscle strength, and gait speed have shown substantial heritability, suggesting genetic variations in the timing of the development of physical impairments (Melzer, Hurst, & Frayling, 2007). Neither biological nor social research alone can explain the complexity of gender differences in health. Only an integration of these perspectives can lead to the interdisciplinary dialogue and investigations required to fill the gaps in our current knowledge (Rieker & Bird, 2005).

In sum, similar to prior observations in the U.S. (Liang et al., 2008), disability among older Taiwanese increased over time with acceleration. Women and the old–old experienced not only higher levels of disability but also greater rates of deterioration. Moreover, women in the older age groups suffered from disproportionately greater disability. Future research examining the heterogeneity in functional health changes, employing alternative health and well-being measures, and integrating biomedical factors with psychosocial variables is warranted.

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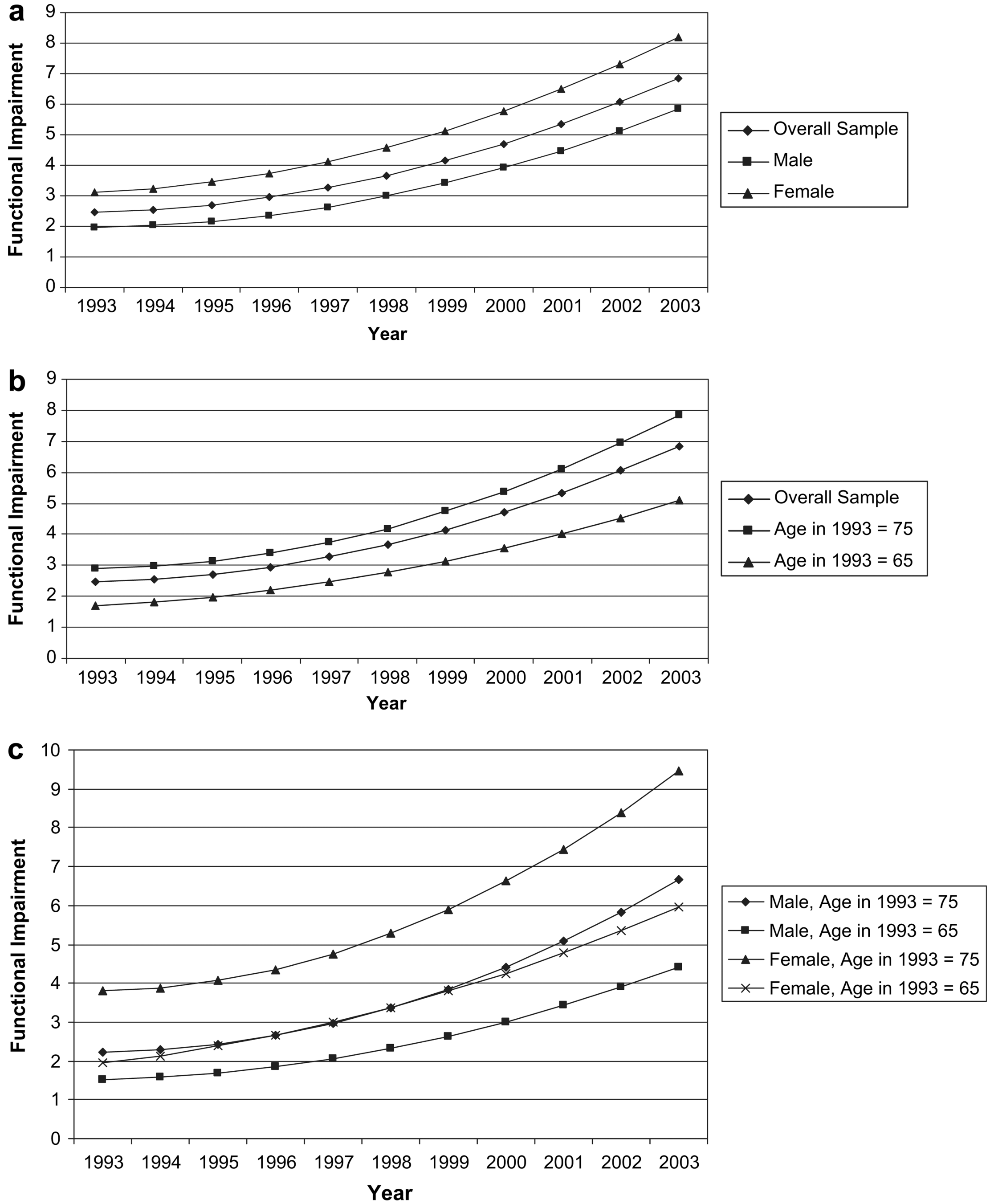

Fig. 1.

Trajectories of Functional Impairment in Older Taiwanese Adults. (a) Trajectories of functional impairment for the overall sample and by gender (based on model M_2 in Table 2). (b) Trajectories of functional impairment by age in 1993 (based on model M_2 in Table 2). (c) Trajectories of functional impairment by gender and age in 1993 (based on model M_2 in Table 2).

Table 1

Descriptive statistics.

Measures	1993	1996	1999	2003
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Time varying covariates	*n* = 3415	*n* = 2960	*n* = 2519	*n* = 1892
Functional status	2.069 (4.038)	2.441 (4.450)	3.129 (4.880)	4.076 (5.622)
Proxy status $_{t-1}$	3.1%	6.2%	10.0%	10.9%
ΔProxy status $_{t-1,t}$	0.031 (0.253)	0.063 (0.276)	0.031 (0.308)	0.095 (0.354)
Marital status $_{t-1}$	66.8%	60.9%	56.8%	53.8%
ΔMarital status $_{t-1,t}$	−0.059 (0.266)	−0.060 (0.255)	−0.047 (0.267)	−0.085 (0.307)
Self-rated health $_{t-1}$	1.065 (0.482)	1.127 (0.471)	1.207 (0.466)	1.256 (0.475)
ΔSelf-rated health $_{t-1,t}$	0.062 (0.557)	0.106 (0.564)	0.070 (0.562)	0.098 (0.576)
Diseases $_{t-1}$	1.057 (1.289)	1.659 (1.430)	1.713 (1.484)	1.714 (1.426)
ΔDiseases $_{t-1,t}$	0.601 (1.505)	0.119 (1.441)	0.055 (1.474)	0.329 (1.529)
Depressive symptoms $_{t-1}$	6.419 (5.143)	7.282 (6.092)	6.807 (6.512)	7.309 (6.791)
ΔDepressive symptoms $_{t-1,t}$	0.863 (6.200)	−0.008 (6.959)	0.906 (6.707)	0.572 (6.653)
Emotional support $_{t-1}$	0.387 (0.191)	0.251 (0.251)	0.282 (0.208)	0.272 (0.208)
ΔEmotional support $_{t-1,t}$	−0.136 (0.271)	0.039 (0.271)	−0.005 (0.250)	0.016 (0.242)
Instrumental support $_{t-1}$	0.449 (0.222)	0.178 (0.294)	0.265 (0.250)	0.232 (0.235)
ΔInstrumental support $_{t-1,t}$	−0.271 (0.316)	0.092 (0.318)	−0.030 (0.289)	0.018 (0.285)
Baseline characteristics	*n* = 3415			
Age in 1993	71.372 (5.911)			
Female	43.1%			
Fuchienese	61.2%			
Hakka	15.4%			
Education	4.560 (4.661)			
Functional status in 1989	1.105 (2.788)			
Died (1993 and 2006)	44.9%			
Ever attrited (between 1993 and 2006)	22.1%			

Note: Time varying covariates are those associated with repeated observations within individuals. Data based on the 1989–2003 Health and Living Status of the Elderly in Taiwan (HLSET) survey. Data are reported as mean (standard deviation) for continuous measures and % for dichotomous measures.

Table 2

Sequential models for the trajectory of functional status (time variable centered at 1996).

Covariates	M_0	M_1	M_2	M_3	M_4
Time varying covariates					
Proxy interview $_{t-1}$		7.854***	7.436***	7.382***	5.591
Δ Proxy interview $_{t-1,t}$		5.570***	5.353***	5.305***	4.528
Married $_{t-1}$				−0.206	−0.189
Δ Marital status $_{t-1,t}$				−0.092	0.056
Emotional support $_{t-1}$				1.402**	−0.071
Δ Emotional support $_{t-1,t}$				1.136	0.059
Instrumental support $_{t-1}$				−0.685*	−1.029**
ΔInstrumental support $_{t-1,t}$				−0.325	−0.623**
Self-rated health $_{t-1}$					0.987***
Δ Self-rated health $_{t-1,t}$					0.850***
Diseasest-1					0.146**
Δ Diseases $_{t-1,t}$					0.120***
Depressive symptoms $_{t-1}$					0.151***
Δ Depressive symptoms $_{t-1,t}$					0.136***
For intercept, π_0					
Intercept	2.867***	0.844***	0.057	0.547*	−1.453***
Dead		2.631***	2.192***	2.104***	1.428***
Ever attrited		0.496*	0.596**	0.592**	0.440*
Age in 1993			0.081***	0.073***	0.051**
Female			1.265***	1.012***	0.317
Age in 1993 × female			0.089**	0.085**	0.062**
Fuchienese			0.374*	0.161	0.253
Hakka			0.212	0.068	0.252
Education				−0.060**	−0.007

Covariates	M_0	M_1	M_2	M_3	M_4
Functional status in 1989					0.420***
For linear slope, π_1					
Intercept	0.322***	0.114***	0.073*	0.089	0.070
Dead		0.360***	0.347***	0.347***	0.302***
Ever attrited		−0.011	−0.008	−0.004	−0.007
Age in 1993			0.009**	0.008**	0.009**
Female			0.100**	0.086*	0.083*
Age in 1993 × female			−0.004	−0.004	−0.002
Fuchienese			−0.004	−0.020	−0.004
Hakka			0.027	0.018	0.035
Education				−0.003	−0.002
Functional status in 1989					−0.009
For quadratic slope, π_2					
Intercept	0.019***	0.026***	0.025***	0.032**	0.031**
Dead		0.027	0.018	0.021	0.011
Ever attrited		0.004	0.003	0.002	0.005
Age in 1993			0.002	0.002	0.001
Female			0.004	0.003	0.004
Age in 1993 × female			0.001	0.001	0.001
Fuchienese			0.000	−0.002	−0.006
Hakka			0.007	0.004	0.003
Education				−0.001	−0.001
Functional status in 1989					0.002
Random effect	Variance	Variance	Variance	Variance	Variance
Intercept	17.608	8.859	7.685	7.607	5.180
Linear time slope	0.130	0.063	0.059	0.059	0.043
Quadratic time slope	0.004	0.003	0.003	0.003	0.003
Level-1, R	6.535	6.277	6.259	6.226	5.837
AIC fit index	60,061	57,383	56,835	56,767	54,916
BIC	60,123	57,493	57,038	57,025	55,229

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AIC = Akaike's information criterion. BIC = Bayesian information criterion.

* $p < 0.05$,

** $p < 0.01$,

*** $p < 0.001$.

Table 3

Summary of key estimated parameters when varying the year used for centering the time variable in model M_2.

Key Parameters	Year used for centering the time variable in M_2			
	1993	1996	1999	2003
For intercept, π_0				
Intercept	0.062	0.057	0.501**	1.791***
Age in 1993	0.070***	0.081***	0.122***	0.223***
Female	1.002***	1.265***	1.600***	2.160***
Age in 1993 × female	0.114***	0.089**	0.089**	0.126*
For linear slope, π_1				
Intercept	−0.077	0.073*	0.223***	0.422***
Age in 1993	−0.001	0.009**	0.019**	0.032*
Female	0.076	0.100**	0.124***	0.156*
Age in 1993 × female	−0.012	−0.004	0.004	0.015

Model also adjusted for mortality, attrition, proxy interview status, and ethnicity.

* $p < 0.05$,

** $p < 0.01$,

*** $p < 0.001$.