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Trends in late-life disability in Taiwan: The roles of education, environment, and technology

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Abstract

This analysis offers the first strong evidence of trends in late-life disability in an emerging economy. Consistent measures of limitations in seeing, hearing, physical functions, instrumental activities of daily living (IADLs), and activities of daily living (ADLs) were available for three to six survey waves, depending on the outcome, from 1989 to 2007 for the population of Taiwan aged 65 and older. Limitations in seeing, hearing, and IADLs declined substantially, but trends were mixed for physical functions and flat for ADLs. The remarkable reduction in difficulty phoning, an IADL, may reflect changes in telecommunications infrastructure and highlights the roles of environment and technology in disability outcomes. Trends for urban residents were more advantageous than those for rural residents for seeing and hearing, but less so for physical functions and IADLs. Were it not for the substantial increase in educational attainment, trends in all outcomes would have been less favorable.

Keywords

trends; health; disability; education; technology; Taiwan; Asia; aging

Introduction

As people live longer, whether or not their additional years of life are spent in good or bad health has important implications for individual well-being, as well as health and social policy (Gruenberg 1977; Fries 1980; Manton 1982). Thus, monitoring trends over time in late-life health is a priority for many governments. There is a wide array of indicators of health, but for people at older ages, measures of functioning such as those that assess limitations in daily activities have been most commonly used. Such measures are not necessarily pure measures of health, since they also may reflect how and in what environment activities are carried out, but they have been found to be good predictors of mortality, functional decline, institutionalization, and use of health care services (Reuben et al. 2004; Trupin et al. 1996).

Self-reports of disability are frequently collected in large-scale health and social surveys, but there are challenges in using these data to assess how disability changes over time at the population level. It is important to have at least three data points spanning six or more years, so that conclusions do not rely on short-term variations (Freedman et al. 2002). Ideally, the data for this purpose also are based on the same survey (or census) design and identical questionnaires. Using this standard, there is strong evidence of downward trends in limitations in late-life functioning in recent decades for Finland (Sulander et al. 2006), Japan (Schoeni et al. 2006), the Netherlands (Picavet and Hoeymans 2002), Sweden (Parker et al. 2008), and the United States (e.g., Manton et al. 1997; Freedman et al. 2002; and Freedman et al. 2004). The evidence for countries whose socioeconomic development and epidemiological transitions occurred later is much weaker and is based on datasets with limited observations, those whose survey administration changed over time, or whose analysis yields implausible rates of change (e.g., Zimmer et al. 2002; Ofstedal et al. 2007; Gu et al. 2009; and Jang et al. 2010). Thus, whether or not trends in late-life functioning in recent decades in such countries also have been improving remains an open question.

The growing availability of high-quality survey data in Taiwan, whose population of 23 million is aging rapidly, provides a unique opportunity to investigate trends in an emerging economy. In the second half of the twentieth century and continuing into the twenty-first, Taiwan achieved extraordinary economic growth led by exports, especially from the technology sector (Maddison 2001; Maddison 2010; CIA 2011). This economic progress benefited a wide range of the population, and per capita GDP grew from $916 in 1950 to $20,962 in 2007 (both in 1990 international dollars; Maddison 2010).

Socioeconomic development and a strong family planning program resulted in a decline in total fertility from 5.6 children per woman in 1961 to 1.0 in 2009 (Chang et al. 1981; DGBAS 2010). Life expectancy at birth increased from 61.8 years for males and 67.1 years for females in 1960 (DGBAS 1990) to 75.5 and 81.7 years, respectively, in 2007 (DGBAS 2010). The introduction of a national health insurance program in 1995 increased coverage from 57 to 98 per cent of the population and especially benefited the most vulnerable, including older people (Davis and Huang 2008).

Of course, many members of today's older population were born in the first half of the 20^{th} century. Taiwan was then a colony of Japan, which although it discriminated in favor of Japanese residents of Taiwan, did oversee a broad improvement in standards of living (Jacobs 2007). In particular, the proportion of children attending school increased from 13 per cent in 1917 to 71 per cent by 1943. There were few opportunities for higher education (Wu et al. 1989), but basic literacy was enhanced. Moreover, the early lives of about one fifth of today's older population of Taiwan began on the mainland of China. These so-called Mainlanders migrated to Taiwan between 1948 and 1951 after the Chinese revolution (Hermalin et al. 2009) and, among other differences, were better educated than the then existing Taiwan population.

In this analysis, we used data from six waves of the Survey of Health and Living Status of the Middle Aged and Elderly in Taiwan from 1989 to 2007 to assess trends in limitations among the population 65 years and older that meet the standard for strong evidence mentioned at the outset. In particular, we investigated trends in limitations in seeing and hearing (6 waves, 1989–2007), any of seven physical functions (4 waves, 1996–2007), any of nine physical functions (3 waves, 1999–2007), any of six instrumental activities of daily living (5 waves, 1993–2007), and any of six activities of daily living (3 waves, 1999–2007). In addition to estimating trends for each summary indicator, we examined trends in specific activities. Given the dramatic demographic change and rapid socioeconomic development that Taiwan underwent in recent decades, we also investigated the extent to which changes in socio-demographic composition of the population could account for the trends that we found, and we explored whether or not the trends were the same across various subgroups in the population.

Methods

Data

The Survey of Health and Living Status of the Middle Aged and Elderly in Taiwan was begun in 1989 by the Taiwan Provincial Institute of Family Planning (which later became the Bureau of Health Promotion of the Taiwan Department of Health) and the University of Michigan, with support from the Taiwan government and the U.S. National Institute on Aging (1989 Survey of Health and Living Status of the Elderly in Taiwan: Questionnaire and Survey Design, 1989). The initial respondents were representative of the nine per cent of Taiwan's population in 1989 that was aged 60 and older and living in either the community or institutions. Of the 4,412 possible respondents approached for in-person interviews, 4,049 or 91.9 per cent responded. In 1993, 91.2 per cent of the surviving sample was interviewed a second time. Response rates were close to 100 per cent at subsequent waves in 1996, 1999, 2003, and 2007, when surviving baseline respondents who may have not responded in a preceding wave were found and re-interviewed. Mortality was verified using Taiwan's high-quality registration system. A second survey cohort of 2,462 people ages 50 to 67 was added in 1996 and was re-interviewed in subsequent waves, with a 90.4 per cent response rate in 1999 and rates nearing 100 per cent in later waves. Our analytic sample was based on 17,027 observations of people ages 65 and older, including 2,605 in 1989, 2,969 in 1993, 2,982 in 1996, 2,905 in 1999, 2,839 in 2003, and 2,727 in 2007.

Sample weights were provided for both survey cohorts in their baseline years. Although response rates were quite high, there is the possibility of selective attrition especially in the period between first and second interviews. Accordingly, we used logistic regression to analyze wave-to-wave attrition for each cohort as a function of baseline age, sex, ethnicity, urban/rural residence, and education, and calculated individual attrition weights for each wave that were equal to the reciprocals of the resulting predicted probabilities of attrition. We then multiplied these attrition weights by the sample weights to yield full weights.

Conceptual framework and indicators of functioning

We framed our analysis in the conceptualization of the disablement process proposed by Nagi (1965), Pope and Tarlov (1991), and Verbrugge and Jette (1994). In the stylized depiction of this process shown in Figure 1, pathologies (e.g., arthritis) may be expressed as impairments (e.g., joint stiffness), which in turn may be experienced as limitations in cognitive, physical, or sensory functioning (e.g., squatting), and ultimately as limitations associated with specific daily activities (e.g., bathing), sometimes called disabilities. Such disability in activities is a function not only of the health of the individual, but also of the demands of the particular task and the environment in which it is carried out (e.g., bathtub or shower). This conceptualization of disability as a gap between capability and the environment is also a key element of the World Health Organization's International Classification of Functioning, Disability, and Health (2002). Whether or not a functional limitation is ultimately expressed as an activity disability also may be influenced by accommodations in how the task is carried out, for example, change in behavior (e.g., frequency of bathing), use of personal assistance, or use of assistive technology (e.g., a shower stool). Thus, trends in disability may be influenced not only by trends in underlying health and functional capacity but also by changes over time in living environments and the use of assistive technologies. For this reason, trends in one element of the disablement process may differ from trends in another over the same time period (Crimmins 1996).

We were meticulous in selecting indicators of limitations that were consistently measured across survey waves. We had all survey questionnaires re-translated from Chinese to English and focused not only on question wording, but also on interviewer instructions, interviewerread preambles, and response categories. Even small differences across survey waves ruled out inclusion of the measure in our analysis.

For all six waves from 1989 to 2007, respondents were asked about their clarity of vision and hearing either with or without aids. Separate questions also were asked about the use of glasses and hearing aids. We defined seeing and hearing limitations as the two lowest of the five possible responses, namely, not so clearly or not clearly at all.

For four waves from 1996 to 2007, respondents were consistently asked about any difficulty without help or the use of aids with seven physical functions: grasping, raising both hands over head, standing 15 minutes, climbing one or two flights of stairs, lifting and carrying 11–12 kilograms, squatting, and running a short distance (20–30 meters). For three waves from 1999 to 2007, two additional physical functions—walking 200–300 meters and standing two hours—were also identically measured, so for this shorter period, we were able to investigate trends in difficulty with any of nine physical functions. Physical functions tend to be less influenced by the environment and thus better reflect underlying capacity than do activities of daily living. Also because some of these functions are quite demanding (e.g., running a short distance and standing two hours), difficulty with them is much more common than is difficulty with activities of daily living.

For five waves from 1993 to 2007, there were indicators of having any difficulty conducting by one's self six instrumental activities of daily living (IADLs): shopping, managing money, phoning, light housework, heavy housework, and riding a bus or train. For the last three waves from 1999 to 2007, respondents were asked about any difficulty, not of a temporary nature, with independently carrying out six activities of daily living (ADLs): bathing, dressing, eating, transferring from bed to chair, walking around the house, and getting to the toilet.

Responses regarding seeing and hearing were missing for about 2.5 per cent of the analytic sample. Item non-response was less than a third of a per cent for all the other outcomes. In all cases of missing outcomes, respondents were assigned the median response for their age groups.

Measures of population composition

In considering how changes in Taiwan's population composition might account for trends in prevalence of limitations, we focused on demographic and socioeconomic characteristics that are associated with limitations on a cross-sectional level and whose distribution in the older population changed over the study period. We excluded variables such as living arrangements and income that may themselves be influenced by changes in disability. We also did not attempt to model all the possible influences on health and late-life functioning, such as experiences earlier in life, access to health care, and health-related behaviors, some of which were not measured consistently over time. Rather we took a more descriptive approach that highlights broad secular shifts.

Table 1 lists the characteristics on which we decided to focus and shows their average values for the first three and last three survey waves. Age is strongly associated with limitations, and Taiwan's population is aging rapidly as a result of dramatic past fertility decline and continuing improvements in survival.

As in other populations, in Taiwan, being female is associated with higher prevalence of physical functional limitation (Zimmer et al. 2002), and over time the population has become more female. The feminization of the older Taiwan population may reflect not only sex differentials in mortality trends, but also change in ethnic composition. Mainlanders, primarily young men, migrated from mainland China between 1948 and 1951 after the Chinese revolution (Hermalin et al. 2009). Originally, they came largely from central and southeast China. In comparison to the then existing Taiwan population, they were better educated, and as they grew older, were slightly less likely to marry, but more likely to hold jobs that provided health insurance, such as those in the public sector. Previous analysis (Zimmer et al. 2002) has shown that Mainlanders are less likely to experience physical functional limitation. The cohort of Mainlanders is aging over time and dying out, as reflected in the significant decline in the proportion that this group represents in our sample.

Earlier research in Taiwan that covered a shorter time period suggested no relation between urban/rural residence and physical functioning (Zimmer et al. 2002), but the significant increase in the proportion of the older population living in urban areas and preliminary analysis suggested that urban residence might be positively associated with better functioning, so we included an indicator of urban versus rural residence in our models.

Studies of both onset and prevalence of limitation in Taiwan have found a strong negative association with education attainment (Zimmer et al. 1998; Zimmer et al. 2002; Chiu et al. 2005). As shown in Table 1, the educational distribution of our sample changed dramatically over time. The proportion with no education declined from 50.6 to 37.9 per cent between the first three and the last three survey waves. In our models of trends, we explored specifying education in the four groups shown in Table 1 and as a continuous variable indicating number of years of education. Results were substantively similar, so we decided to use the continuous specification.

Zimmer and colleagues (1998) found that not being married was associated with increased risk of onset of physical functional limitations, but Zimmer and colleagues (2002) found no association of marital status with prevalence. In preliminary models of trends in prevalence of limitations, we found no significant effects of marital status, so decided not to include this characteristic in the models presented here.

The final variable in Table 1 and in our models is not a compositional variable, but rather indicates whether or not the survey interview was conducted in part or in full using a proxy respondent. In other populations, there is evidence that proxies tend to report more limitations than respondents do themselves (e.g., Magaziner et al. 1997), and as shown in Table 1, the proportion of interviews involving proxy respondents increased from 7.2 to 9.0 per cent over the study period.

Statistical analyses

We pooled observations for all years and fit logit models of limitations in seeing, hearing, any of seven physical functions, any of nine physical functions, any of six IADLs, and any of six ADLs. To allow for the variety of trends observed across outcomes and to enhance comparability across outcomes, we specified the trend in terms of dummy variables for each survey year. The first year of observation served as the reference category. Results of initial models including only the year dummy variables indicate unadjusted trends for the 65 and over population as a whole. These results may be of interest to those concerned about changes in limitations at the overall population level.

More reflective of trends in individual well-being are models that, in addition to the year dummy variables, control for age, sex, and proxy—our so-called basic models. We then added Mainlander, urban/rural residence, and education to the basic models individually to see the extent to which changes in each of these three variables affected the estimated trends, as reflected in changes in the estimated average annual per cent change in the outcome. We also fit full models that included all of the variables.

For each outcome and model, we calculated estimated average annual per cent change on the basis of the predicted prevalence for each of the survey years. We linearly interpolated predicted prevalence between survey years to obtain predicted prevalence for all years in the study period for each outcome. For example, the values for 1990, 1991, and 1992 for seeing limitation were based on linear interpolation between the predicted values for 1989 and 1993. We then calculated year-to-year per cent change, and took the average to obtain the estimated average annual per cent change in the outcome. Although this averaging process obscures any non-linearity, it does allow us to summarize in one number the overall trend for each of the many models and to investigate the extent to which changes in specific population composition variables account for the changes in outcomes over time.

To see if trends in particular tasks (e.g., climbing, shopping, bathing) were driving the trends in the summary measures, we also fit models for the individual physical functions, IADLs, and ADLs. To probe differences in trends by subgroups, we fit models of summary outcomes in which the year dummy variables were interacted with each of the population composition variables (age, sex, Mainlander, urban/rural residence, education) and used an adjusted Wald test to ascertain significance of the interactions all together for each composition variable and outcome variable pair. Finally, as warranted by the interaction results for summary outcomes, we explored selected interactions of the year dummy variables with the population composition variables for specific limitations.

For all models, robust standard errors accounted for weighting and multiple observations per individual across survey waves.

Results

The observed unadjusted prevalence rates for each major outcome measure and each year are presented in Figure 2. Because these values are unadjusted they may reflect changes in the composition of the population over time.

The two physical functioning summary measures show the highest prevalence. Sixty-eight to seventy per cent of the older population report difficulty with at least one of the nine physical functions, depending on the survey wave, whereas 54 to 67 per cent report difficulty with at least one of the seven. Running a short distance, which is included in both summary measures, is difficult for roughly half of the sample, and standing two hours, which is included in any of 9 physical functions, is difficult for almost 60 per cent (individual items not shown).

Next most common are difficulties with any of the six IADLs with a prevalence of 45 to 50 per cent. Over 40 per cent reported difficulty doing heavy housework (according to the survey question, such as cleaning windows or the ditches surrounding the house), followed by almost a quarter reporting difficulty taking transport. Seeing limitations are more common than hearing limitations. Lowest in prevalence is difficulty with any of the six ADLs, which was reported by only about 12 to 14 per cent of the population 65 and older. Of these, difficulty bathing is most common, ranging from 10 to 12 per cent.

Table 2 presents the estimated average annual per cent change for each of the summary measures based on the various models. In the year-dummies-only models, which represent the unadjusted trends, there are declines in difficulty for all outcomes except any of seven physical functions and any of six ADLs, both of which are up. But as indicated by the footnotes to the table that document significance of the effect of each of the year dummy variables relative to the omitted first year of observation, there is year-to-year variation in significance. Thus, consistent with Figure 2, the model results show that change is not monotonic.

Once age, sex, and proxy are included in the models, there is a significant change between the first year for each type of limitation and 2007, except for any of six ADLs. There is no change in ADL difficulty for either 2003 or 2007 in comparison to 1999. The estimated average annual change in difficulty with any of seven physical functions remains positive in sign in the basic model, but is reduced in size by half once age, sex, and proxy are controlled for. The estimated average annual changes for the other four outcomes are substantially more negative than in the year-dummies-only models. Because the distributions of age, sex, and proxy generally changed over time in ways that would increase limitation (i.e., older, more female, and more represented by proxies, as shown in Table 1), once they are controlled for, trends are more favorable. The only exception to this pattern is for hearing limitation, for which males are at a greater risk than females. Even so, the basic model for hearing limitation yields a significantly greater decline than does the year-dummies-only model.

The addition of either ethnicity or urban/rural residence to the basic models had essentially no effect on the estimated average annual per cent changes, although the main effects of these variables on some of the limitations are significant and in the expected directions with being a Mainlander or living in an urban area associated with fewer limitations in seeing, hearing, and IADLs. In contrast, the effects of the addition of education to the models were substantial. Education is negatively associated with all indicators of limitation, and its inclusion in the models results in considerably less favorable estimated trends. These results suggest that had educational attainment not increased as much as it did (what is being controlled for by adding education to the basic models), the trends in functioning would have been much less favorable. In comparison to the basic model, the education model reduces the downward trend by 47 per cent for seeing ($100*(1-(-.76/-1.44))$), 36 per cent for hearing, 16 per cent for any of nine physical functions, and 20 per cent for IADLs. For any of seven physical functions, the addition of education to the basic model raises the positive trend by 21 per cent. As shown in the final column for the full model, the addition of all the other variables to the basic plus education model provides little additional explanation of the trends.

Related to seeing and hearing, respondents were asked about their use of glasses (including reading glasses and contact lenses) and hearing aids. Wearing glasses was quite common with 51 per cent of the 65 and older population doing so by 2007. Moreover, seeing limitations were at least twice as common among those who did not wear glasses as among those who did for all survey years (e.g., 56% vs. 24% in 2007), and the estimated average annual change in seeing limitations from basic models was −2.25 per cent among those who wore glasses and only −0.58% among those who did not. Using a hearing aid was much rarer with fewer than four per cent doing so by 2007. Those who did not wear hearing aids were much less likely to report not being able to hear clearly than those who did (e.g., 28% vs. 48% in 2007), and the estimated average annual decline in hearing limitations was similar for the two groups. Results from basic models for 1989 to 2007 indicate that the average annual per cent increases in using these aids were 1.23 and 3.35 per cent, respectively. After controlling for education, the average annual per cent increase in using glasses was reduced to 0.30 per cent, but that for using hearing aids was unchanged.

Table 3 indicates that the individual physical functions most likely underlying the increase in difficulty with any of seven of them are (in order of from low to high of estimated increase from the basic models): grasping, lifting and carrying, running a short distance, climbing stairs, and squatting. For the first three, the overall increase obscures an inverted U-shape pattern of change, as indicated by the coefficients on the year dummy variables in the basic models (not shown). For climbing and squatting, the pattern is more generally upward. The remaining two of the seven, difficulty raising hands and standing 15 minutes declined, although the coefficients on the year dummies for later years are not significantly different from those for 1996. For the shorter period from 1999 to 2007, difficulty with walking 200–300 meters and standing two hours both declined significantly. Thus, the reason that the overall pattern for the seven physical functions from 1996 to 2007 was upward, but the overall pattern for the nine functions from 1999 to 2007 was downward, was that for five of the functions measured for the longer period (all except climbing and squatting), any increases in the early years were reversed later. Once those five were combined in the any-of-nine indicator with walking 200–300 meters and standing two hours, the prevailing trend was downward.

Among individual IADLs, the declines in difficulty with managing money, heavy housework, and especially phoning in the basic models are the largest. For managing money, the decline in comparison to 1993 is significant only for 2007. The trends for difficulty with the other three activities—shopping, light housework, and riding the bus or train—are essentially flat.

In the case of both individual physical functions and individual IADLs, the inclusion of education in the models substantially affected the estimated trends in comparison to the basic models. The individual ADL results do not provide additional insight; coefficients on all of the year dummy variables are statistically insignificant in the both the basic and basic plus education models.

Investigation of interactions of trends with the population composition variables yielded several statistically significant results, as shown in Table 4. There are disparities by age in trends in seeing and hearing limitations with decline for ages 70–74, 75–79, and 80–84 being the greatest. For both sensory limitations, rural residents did not experience as much reduction as did urban residents. In contrast, the upward trend in difficulty with any of seven physical functions was greater among urban than among rural residents, driven in particular by differences for grasping and lifting and carrying.

Mainlanders, urban residents, and those with more education experienced relatively less decline in IADL difficulties than non-Mainlanders, rural residents, and those with the least education, respectively. These three differentials are consistent with each other since being a Mainlander, living in an urban area, and being more educated are all positively correlated. Among individual IADLs, difficulties managing money and phoning declined more among non-Mainlanders than Mainlanders, but the opposite was true for difficulty with heavy housework. The education differential was significant only for phoning difficulty with the least educated experiencing the most improvement.

Perhaps most interesting are the interaction results for IADLs and urban residence. Shown in Table 5 are the model coefficients and estimated average annual changes for basic plus urban models and models with urban and year dummy variables interacted for any of six IADLs and for the three specific activities for which including the interactions significantly improved model fit, namely, phoning, light housework, and heavy housework. The results for light housework (as indicated in the survey question, such as sweeping, washing dishes, taking out garbage, and other light tasks) are the weakest with statistically insignificant coefficients for three of the four interaction terms. Basic models of difficulty with light housework run separately for the urban and rural samples indicate that, unlike for the other outcomes in the table, rural residents experienced a worse trend than urban residents. The urban trend was flat, but the rural trend was upward at an average rate of 1.04 per cent per year, although the coefficients on the year dummy variables for 2003 and 2007 were not statistically significant, suggesting that the increase occurred early in the 1993–2007 period.

For any of six IADLs, heavy housework, and phoning, a pattern of greater declines over time in difficulty in rural areas in comparison to urban areas was found. For all three, rural residents started the period at a disadvantage, but by 2007 reported relatively less difficulty. In 1993, the unadjusted prevalence of difficulty with the three outcomes were for urban residents 46.5, 42.1, and 16.0 per cent, respectively, versus for rural residents 55.6, 48.5, and 23.7 per cent. By 2007, the unadjusted levels of difficulty were for urban residents 47.2, 45.3, and 14.9 per cent versus for rural residents 44.9, 42.3, and 12.4 per cent. This pattern of relative change is substantiated by the positive and mostly significant coefficients for the four urban*year dummy variables (after controlling for age, sex, and proxy) in Table 5 for any of six IADLs and heavy housework. For phoning, the pattern of the coefficients for the urban*year dummy variables indicates that the decline in difficulty benefited urban residents most initially, but by late in the period rural residents experienced relatively more progress. The differences in the estimated average annual change for each of the three outcomes when the urban*year dummy interactions were added to the models also indicate that if there had not been an urban/rural difference in the rate of change (what we are controlling for in the interaction models), the declines in difficulty would have been greater.

Discussion

Our aim was to examine trends in late-life functioning in Taiwan, an emerging economy with a rapidly aging population, over a relatively long period of observation. The trends found varied by indicator of functioning and subgroup of the population. Such variation is not unexpected given that our measures reflect different elements of the disablement process (Crimmins 1996). Nevertheless, for the older population of Taiwan as a whole, many aspects of functioning improved over the last two decades.

Limitations in seeing and hearing declined substantially. For seeing, this decline appears to be related in part to the increase in using glasses that we found. Moreover, a 2002 Taiwan-wide study of vision problems among the 65 and older population reported that cataract was the most common eye-related disease with a prevalence of 60 per cent, but that national health insurance program data indicated a dramatic increase in cataract surgery and positive outcomes in recent years (Tsai, C.Y. et al. 2005). Another study of the older population in 1999–2000 in a district of Taipei, the capital, found a similar prevalence of cataracts and noted that the rate of surgery increased with age and with the implementation of the universal health insurance in 1995 (Tsai, S.Y. et al. 2003).

The decline in hearing limitation was not related to the increased use of hearing aids, which remains rare in Taiwan. There are many potential causes of hearing loss including infection, which likely declined over time, but evidence from several countries suggests that work-related noise is a major factor (e.g., Wallhagen et al. 1997; Mizoue et al. 2003). In the United States, occupational exposure has declined as a result of both increased regulation of noise and greater use of protective devices (Zhan et al. 2010). For Taiwan, we have no evidence of trends in noise exposure at work, especially during the earlier work years of the survey’s older respondents, but in 1995 the government established a surveillance system for noise-induced hearing loss among workers (Wu et al. 1998), suggesting formal recognition of the problem.

Limitation in any of six IADLs also declined for the older population as a whole, but the decline was greater among non-Mainlanders, rural residents, and those with the least education. As noted at the outset, disability represents a gap between the capabilities of an individual and the demands of the task being carried out in a particular environment. Accommodations including behavior change, receipt of personal assistance, and use of assistive technology may influence the extent to which underlying functional limitations are ultimately manifested as difficulty with daily activities. Moreover, the effects of technology may not be limited to those of devices designed specifically to reduce disability, but may extend to those of innovations developed for use throughout a population (Spillman 2004).

In the case of difficulty phoning, the changes in the telecommunication infrastructure in Taiwan may have played an important role in the large decline that we found. In 1996, the passage of three telecommunication reform laws ended the government monopoly and allowed the provision of services by both domestic and international firms (Liu 2003). The number of fixed telephone lines per 100 inhabitants grew from 52.4 in 1988 to 62.4 in 2008, a 19 per cent increase. Even more impressive was the fivefold increase in the number of mobile cellular subscriptions per 100 habitants from 21.6 to 110.3 over the same period (International Telecommunication Union 2010), indicating one of the greatest market penetrations in the world. Of course, improvements in vision, hearing, and grasping (at least in the later years) may have played a role in the decline in difficulty phoning. We do not have trend data on cognitive function, which may also have contributed to the decline. But, the magnitude of the phoning improvement suggests that a major factor may well have been the widespread increase in the availability of phones. Such changes in telecommunication in addition to the growth of online banking, use of automated teller machines, and cash cards also may have contributed to the decline in limitations managing money that we found (Tan and Chen 2008; Ou et al. 2009).

The trend in difficulty with heavy housework is also possibly related to changes in infrastructure. The survey question about this activity gives examples of cleaning windows or the ditches surrounding the house (also translated as gutters or drains). Although Taiwan has experienced rapid economic growth led by technology exports, it has been slow to develop a comprehensive sewage treatment system (Government Information Office, Republic of China 2011), and problems with sewers and street gutters have been regularly mentioned in the popular press and by political leaders (see, e.g., Office of the President, Republic of China 2003; Central News Agency 2010; and Taipei Times 2010). In the 1990s, public investment in sewers grew dramatically, which might help explain the decline in difficulty with heavy housework that we found. Nevertheless, by the end of 2006, public sewer connections were still not in place for 57 per cent and 20 per cent of households in Taiwan’s two largest cities, Kaohsiung and Taipei, respectively (Gao 2006). We do not have information on the relative growth of sewers in urban versus rural areas over our study period, but the ramifications of lack of such infrastructure for people’s daily lives may be greater in densely populated urban areas. If so, this infrastructure issue may be related to the lower rate of decline in difficulty doing heavy housework among urban versus rural residents that we found. Even if improvements in health enhanced the physical functioning necessary to carry out this activity, the environmental challenges might have limited change.

Difficulty with any of seven physical functions increased from 1996 to 2007, but declined from 1999 to 2007. Because physical functioning is more proximally related to pathologies in the disablement process, changes in environment and technology are generally less likely to have influenced these changes. However, squatting showed by far the largest increase in reports of difficulty, and it could be that older people have increasingly less lifetime experience with this particular function, as standards of living have risen and household furnishings have changed. But more likely the explanations for trends in physical functional limitations lie in changes in the prevalence or severity of particularly limiting diseases. The Survey of Health and Living Status of the Middle Aged and Elderly in Taiwan, whose data we used, collected self-reports of having a limited number of conditions, but question wording changed over time in some cases, plus self-reports of diseases may be influenced by many factors besides health, including changes in access to care, diagnosis thresholds, health literacy, as well as survival The institution of universal health insurance in 1995 may have especially influenced trends in disease prevalence over our study period. Two studies (Zimmer et al. 2002; Wen et al. 2008) have found that survival improvements after 1995 benefited relatively more those who had the most severe physical functional limitations or poorest health prior to 1995. Thus, part of the increase in difficulty with physical functioning that we found early in our study period may be associated with such selective survival. As time passed and the benefits of universal care moved beyond acute care and more broadly to management of chronic conditions (in some cases, through physician payment being linked to performance in managing conditions such as diabetes and hypertension; Cheng 2009), the disabling effects of disease may have declined.

The trend in difficulty with any of six ADLs, the most severe and least common type of limitation, was flat overall from 1999 to 2007. This result indicates relatively good news given the pattern of survival change after 1995. Nevertheless, given the rapid growth of the older population in Taiwan, even if prevalence rates did not change, the number of people with ADL limitations undoubtedly increased. Improvements in home environments may have played a role in holding ADL rates steady, but we have no evidence. However, a 2002 cross-sectional survey of the 65 and older population in Taiwan (Lan et al. 2008) found that over 80 per cent of their homes had no grab bars or protection against slipping in the bath. Given that difficulty bathing is the most commonly cited ADL limitation in Taiwan and given that it is a strong predictor of the need for long-term care in other populations (Gill et al. 2006), such relatively low-cost home improvements may have potential for reducing ADL limitations and associated costs in the future.

Our investigation of the extent to which changes in population composition account for trends in late-life functioning highlighted the major role of education. This result is similar to that found for the United States (Freedman and Martin 1999; Schoeni et al. 2008; Martin et al. 2010). In Taiwan, education accounted at a minimum for 16 per cent of the trend in any of nine physical functions and at a maximum for 47 per cent of the trend in vision limitation. There are many possible mechanisms through which education might influence functioning. For example, more education is likely associated with less hazardous occupations, which in turn might be associated with better late-life hearing and physical functioning. Those with more education may expect to live longer and may invest in late-life health through healthier behaviors. The better educated may have had access to better health care throughout their lives, been more adept at navigating the health care system, and been better able to understand and adhere to medical advice. Education is also an indicator of social standing, so the higher status and possibly lower stress of the better educated may benefit late-life functioning. Finally, education may be associated with access to and willingness to use assistive technologies (such as the case for glasses, as we found) and environmental modifications that enhance functioning.

There are several limitations to our study. First, time-series data on all aspects of the disablement process were not available for analysis. Ideally, we would have included trend data on underlying health conditions and changes in environment. Instead, we were able only to estimate the association of changes in various indicators of population composition with the trends in functioning that we found. Second, we relied on self-reports of functioning. Such reports have been found to be predictive of functional decline, institutionalization, and mortality in diverse populations (Reuben et al. 2004). However, in the rapidly developing setting of Taiwan with increased access to health care and online health information, changing attitudes and expectations about health and functioning may have influenced trends in self-reports. Third, the trends that we found are sensitive to the base year of the analysis. We highlighted this issue for physical functional limitations and the potential role of selective survival after the establishment of universal health insurance in accounting for first increases and then declines. But estimated trends for sensory and IADL limitations are also sensitive to base year. Sensitivity analyses that omitted the start year and subsequent years sequentially up to 1999 indicate that for seeing the average annual per cent change varies from −1.44 (1989–2007) to 0.01 (1993–2007), 0.30 (1996–2007), and −0.44 per cent (1999–2007). For hearing, the results are −1.37, −0.17, 0.50, and −1.66 per cent, respectively, and for IADLs, −1.48 (1993–2007), −0.63 (1996–2007), and −0.62 (1999–2007). Such year-to-year variation in prevalence is not uncommon for the outcomes and the age group being studied and is one of the reasons that the longest possible time series with as many observations as possible is desirable (Freedman et al. 2002).

Indeed, a high-quality dataset that consistently measures multiple indicators is a major strength of this analysis, which provides the best evidence to date of trends in functioning in an emerging economy. We have not been able to document trends in health per se. Rather we have shown improvements in sensory functioning and ease of conducting instrumental activities of daily living that have likely been influenced by assistive technology and infrastructure, as well as by underlying health. These trends in functioning suggest that several dimensions of the lives older people in Taiwan have changed for the better over the study period. Past trends do not necessarily predict the future, but the fact that educational attainment of older people in Taiwan will continue to increase in coming decades is encouraging (Hermalin et al. 2006), and no doubt there will be technological innovations that will benefit the daily lives of the older population.

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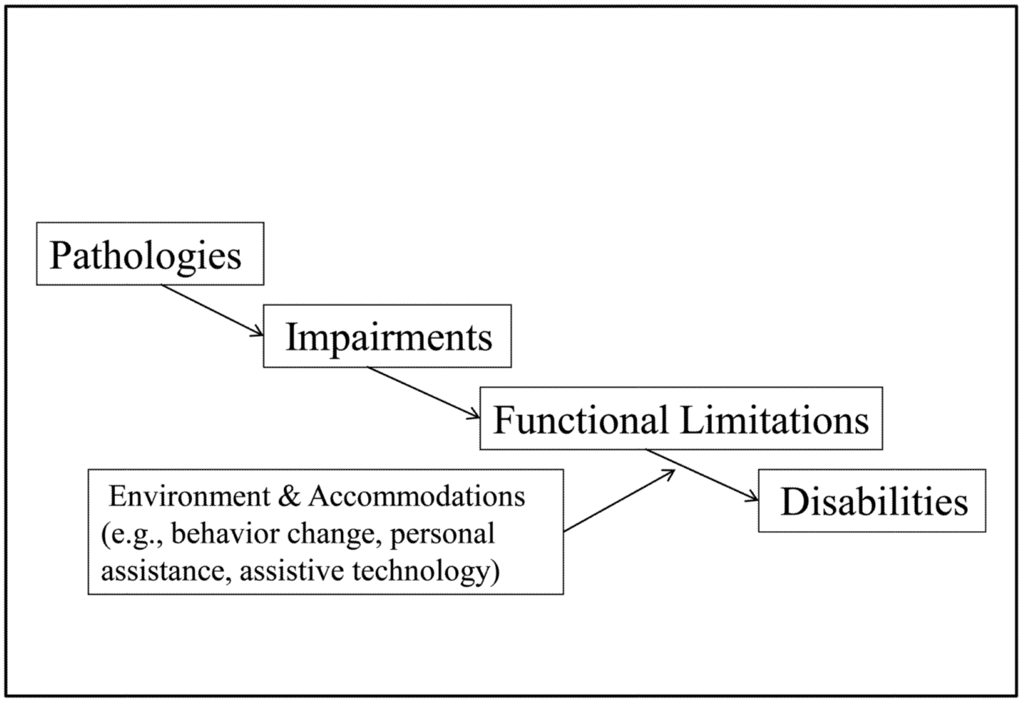

Figure 1. Disablement Process
Source: Based on Nagi (1965), Pope and Tarlov (1991), and Verbrugge and Jette (1994).

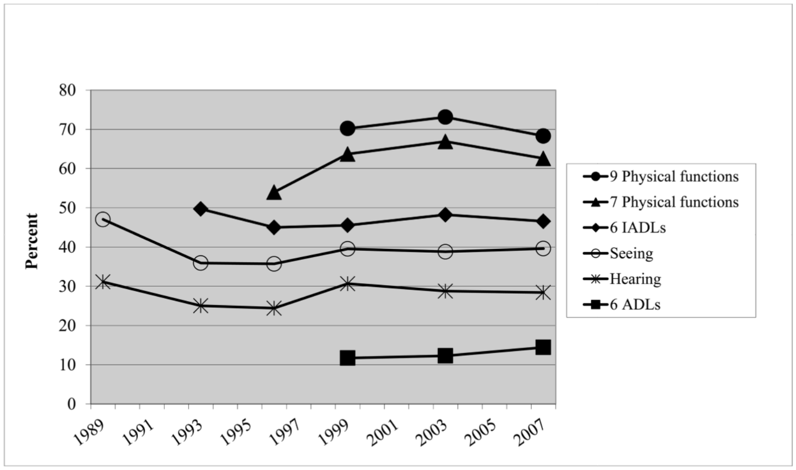

Figure 2. Observed Unadjusted Prevalence of Limitations
Source: Survey of Health and Living Status of the Middle Aged and Elderly in Taiwan

Table 1

Characteristics of the Population Ages 65 and Older (weighted %), 1989–1996 and 1999–2007

	Average 1989–1996	Average 1999–2007	p[a]
N	**8,556**	**8,471**	
Age			
65–69	42.0	33.9	0.000
70–74	29.3	28.2	0.019
75–79	16.6	20.5	0.000
80–84	8.6	11.1	0.000
85+	3.5	6.3	0.000
Male	55.6	52.0	0.000
Mainlander	22.3	17.5	0.000
Urban	65.7	70.0	0.000
Education			
0 years	50.6	37.9	0.000
1–6 years	30.4	39.3	0.000
7–11 years	8.6	10.5	0.000
12+ years	10.4	12.3	0.000
Proxy	7.2	9.0	0.000

[a] *p* values for trend coefficient in logit regression of characteristic using all data 1989 to 2007. Source: Survey of Health and Living Status of the Middle Aged and Elderly in Taiwan

Table 2

Estimated Average Annual Percent Change Calculated from Results of Logit Models of Limitation

			Estimated Average Annual Percent Change					
Limitation	**Years**	**N**	**Year dummies only**	**Basic: Year dummies, age, sex, & proxy**	**Basic + Mainlander**	**Basic + urban**	**Basic + education**	**Full model**
Seeing	1989–2007	17,027	−0.95	−1.44	−1.50	−1.38	−0.76	−0.80
Hearing	1989–2007	17,027	−0.51[cd]	−1.37	−1.40	−1.33	−0.87[c]	−0.91[c]
Any of 7 Physical Functions	1996–2007	11,453	1.34	0.67	0.67	0.67	0.81	0.88
Any of 9 Physical Functions	1999–2007	8,471	−0.35[e]	−0.73[d]	−0.72[d]	−0.73[d]	−0.61	−0.52
Any of 6 IADLs	1993–2007	14,422	−0.47[d]	−1.48	−1.53	−1.46	−1.18	−1.19
Any of 6 ADLs	1999–2007	8,471	2.60[d]	0.89[de]	0.87[de]	0.88[de]	1.15[de]	1.17[de]

[a] year dummy for 1993 not significantly different from start year at the p < .05 level

[b] year dummy for 1996 not significantly different from start year at the p < .05 level

[c] year dummy for 1999 not significantly different from start year at the p < .05 level

[d] year dummy for 2003 not significantly different from start year at the p < .05 level

[e] year dummy for 2007 not significantly different from start year at the p < .05 level

Source: Survey of Health and Living Status of the Middle Aged and Elderly in Taiwan

Table 3

Estimated Average Annual Percent Change Calculated from Results of Logit Models of Limitations in Specific Physical Functions, IADLs, and ADLs

Limitation	Years	N	Estimated Average Annual Percent Change: Year dummies only	Basic: Year dummies, age, sex, & proxy	Basic + education
Physical Function					
Raise hands	1996–2007	11,453	0.25^{de}	-0.98^{de}	-0.58^{de}
Grasp	1996–2007	11,453	1.55	0.36^{e}	0.72^{e}
Stand 15 minutes	1996–2007	11,453	0.79^{e}	-0.33^{cde}	0.19^{e}
Climb stairs	1996–2007	11,453	1.95	1.04	1.43
Lift and carry	1996–2007	11,453	1.51	0.47^{e}	0.61
Squat	1996–2007	11,453	2.69	1.89	2.12
Run short distance	1996–2007	11,453	1.37	0.57	0.78
Walk 200–300 meters	1999–2007	8,471	-0.76^{de}	-1.77^{d}	-1.39^{d}
Stand 2 hours	1999–2007	8,471	-0.28^{de}	-0.77^{d}	-0.59^{d}
IADL					
Shop	1993–2007	14,422	2.01^{b}	-0.05^{bcde}	0.44^{bcde}
Manage money	1993–2007	14,422	0.79^{d}	-1.71^{bcd}	-1.08^{bcd}
Phone	1993–2007	14,422	−2.00	−4.14	−2.91
Light housework	1993–2007	14,422	2.43	0.47^{bde}	0.85^{b}
Heavy housework	1993–2007	14,422	0.03^{de}	−1.01	-0.78^{d}
Ride bus or train	1993–2007	14,422	1.43^{b}	-0.25^{bcde}	0.30^{bcde}
ADL					
Bathe	1999–2007	8,471	2.87^{d}	0.88^{de}	1.08^{de}
Dress	1999–2007	8,471	1.83^{de}	-0.19^{de}	0.03^{de}
Eat	1999–2007	8,471	2.30^{de}	-0.09^{de}	0.14^{de}
Transfer	1999–2007	8,471	3.31^{d}	1.38^{de}	1.62^{de}
Move inside house	1999–2007	8,471	3.33^{d}	1.39^{de}	1.70^{de}

Limitation	Years	N	Estimated Average Annual Percent Change		
			Year dummies only	Basic: Year dummies, age, sex, & proxy	Basic + education
Toilet	1999–2007	8,471	3.08 [d]	1.02 [de]	1.24 [de]

[a] year dummy for 1993 not significantly different from start year at the $p < .05$ level

[b] year dummy for 1996 not significantly different from start year at the $p < .05$ level

[c] year dummy for 1999 not significantly different from start year at the $p < .05$ level

[d] year dummy for 2003 not significantly different from start year at the $p < .05$ level

[e] year dummy for 2007 not significantly different from start year at the $p < .05$ level

Source: Survey of Health and Living Status of the Middle Aged and Elderly in Taiwan

Table 4

Significant Interactions of Year Dummy Variables with Population Composition Variables

Limitation	Variable	Finding
Seeing	Age	Decline for ages 65–69 less than declines for ages 70–74, 75–79, and 80–84. No decline for 85+.
	Urban	Decline for rural less than decline for urban.
Hearing	Age	Decline for 70–74, 75–79, and 80–84, but not for 65–69 or 85+.
	Urban	Decline for rural less than decline for urban.
Any of 7 physical functions	Urban	Increase for urban greater than increase for rural.
Any of 6 IADLs	Mainlander	Decline for Mainlanders less than decline for non-Mainlanders.
	Urban	Decline for urban less than decline for rural.
	Education	Decline for more educated less than decline for least educated.

Table 5

Results of Logit Models Testing Urban-Year Interactions for Difficulty with Any IADL, Phoning, and Heavy Housework, 1993–2007

	Any of 6 IADLs		Phoning		Light Housework		Heavy Housework	
	Weighted Coefficients	Weighted Coefficients	Weighted Coefficients	Weighted Coefficients	Weighted Coefficients	Weighted Coefficients	Weighted Coefficients	Weighted Coefficients
Proxy	2.195	2.196	3.023	3.036	2.407	2.410	1.864	1.864
Male	−1.148	−1.153	−1.201	−1.209	−0.662	−0.662	−0.985	−0.988
Urban	−0.136	−0.424	−0.637	−0.637	−0.116 ns	0.068 ns	−0.034 ns	−0.288
Ages 70–74	0.508	0.512	0.449	0.455	0.483	0.481	0.495	0.497
Ages 75–79	1.100	1.097	1.104	1.110	0.927	0.928	1.043	1.040
Ages 80–84	1.769	1.769	1.697	1.692	1.572	1.570	1.679	1.682
Ages 85 plus	2.719	2.716	2.336	2.330	2.155	2.153	2.485	2.485
Year 1996	−0.341	−0.464	−0.458	−0.186 ns	0.110 ns	0.411	−0.278	−0.440
Year 1999	−0.399	−0.757	−0.469	−0.287	0.173	0.312	−0.331	−0.684
Year 2003	−0.318	−0.558	−0.861	−0.997	0.133 ns	0.203 ns	−0.145	−0.305
Year 2007	−0.498	−0.817	−0.953	−1.442	0.108 ns	0.216 ns	−0.311	−0.555
Urban * Year 1996		0.190 ns		−0.493		−0.474		0.250
Urban * Year 1999		0.529		−0.291 ns		−0.212 ns		0.518
Urban * Year 2003		0.367		0.221 ns		−0.110 ns		0.247 ns
Urban * Year 2007		0.476		0.713		−0.167 ns		0.367
Constant	0.095 ns	0.285	−1.452	−1.452	−2.353	−2.471	−0.292	−0.127
Estimated average annual change	−1.46%	−2.35%	−3.97%	−6.03%	0.50%	1.00%	−1.01%	−1.75%
p value for adjusted Wald tests		0.0001		0.0000		0.0328		0.0009
N	14,422		14,422		14,422		14,422	

ns not significantly significant at the p < .05 level

Source: Survey of Health and Living Status of the Middle Aged and Elderly in Taiwan