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Changes in the Prevalence of Mobility Limitations and Mobile Life Expectancy of Older Adults in Singapore, 1995-2005

Vanessa Yong,1 Yasuhiko Saito,1 and Angelique Chan2

Abstract

**Objective:** To examine changes in the prevalence of mobility limitations and mobile life expectancy of Singaporeans aged 55+. **Method:** Data came from the cross-sectional 1995 and 2005 National Survey of Senior Citizens (NSSC; n = 4,750 and n = 4,591, respectively). The prevalence-based Sullivan method was used to disaggregate total life expectancy into expected life time without and with mobility limitations. **Results:** Increases in life expectancy in the city-state were accompanied by increases in the prevalence of mobility limitations—from 3.0% to 5.7% for men and 5.1% to 9.7% for women. The impairments mostly began after age 65 and increased with age particularly at ages 85+. The proportion of life expectancy without mobility limitations declined over time, at all ages, and for both genders, with women still experiencing a higher proportion with mobility problems compared to men. **Discussion:** The overall results provided support for the expansion of morbidity hypothesis, and we discussed some possible reasons. From a policy

1Nihon University, Tokyo, Japan
2National University of Singapore, Singapore

**Corresponding Author:**
Vanessa Yong, Nihon University Population Research Institute, 12-5 Goban-cho, Chiyoda-ku, Tokyo 102-8251, Japan
E-mail: vanessa.yong@nihon-u.ac.jp
perspective, the findings could suggest a need to develop infrastructures that would enable older Singaporeans to remain mobile in a highly urban setting.

**Keywords**

mobility limitations, life expectancy, Singapore, older adults

One of the most basic yet important functions for independent living and maintaining quality of life in old age is the ability to walk and move around physically without constraints. Mobility is a major aspect of lower body function and limitations with mobility is closely associated with further functional decline, disability, and the need for assistance (Guralnik et al., 2000; Johnson & Wolinsky, 1993; Lawrence & Jette, 1996; Stuck et al., 1999). With increases in life expectancy, more people are living longer and being able to maintain mobility and live independently in old age represents one of the key health concerns of the elderly. In this article, we examined the prevalence of mobility limitations, how it has changed over a 10-year period, and estimated expected life time without and with mobility limitations for a nationally representative sample of older adults in Singapore.

Longer life expectancies have been observed in many parts of the world in tandem with population aging (United Nations, 2007). The relationship between longer life expectancy and morbidity has been guided by three main hypotheses. The first hypothesis is that longer lives are associated with improved health status. Overall, there is a delay in onset and progression of diseases and disabilities and morbidity are generally reduced (Fries, 1980, 1989). An increase in life expectancy accompanied by an increased proportion of life spent healthy can be regarded as evidence of compression of morbidity. The second hypothesis is that longer lives mean more years of life in ill health and with disabilities, involving greater suffering. The sick and frail are kept alive but with expanding morbidity (Gruenberg, 1977; Kramer, 1980). Changes in life expectancy with a decreased proportion of life healthy can be evidence of an expansion of morbidity. The last hypothesis is that there is a dynamic equilibrium between health and years of life. Longer lives could be accompanied by more health conditions that are light and moderate but do not in effect change the proportion of healthy life lived (Manton, 1982).

We examined the compression and expansion of morbidity hypotheses by focusing on a specific aspect of health—mobility status, the ability to walk safely and independently. Mobility difficulties tend to develop as age increases partly as a result of a loss of muscle mass and physical frailty. A mobility limitation is a functional impairment which limits an individual’s independent
physical movement. Many older adults are concerned about declines in mobility in large part because of the importance of mobility for performing everyday essential life functions. For instance, to perform basic activities of daily living (ADLs) such as bathing, toileting, and getting in and out of bed as well as instrumental activities of daily living (IADLs) such as shopping and taking transportation without assistance, being ambulant and mobile is a necessary precondition. Not only is mobility salient for these activities but also, as studies have shown, is a strong predictor of subsequent ADL and IADL disabilities (Hirvensalo, Rantanen, & Heikkinen, 2000; Jette, Assmann, Rooks, Harris, & Crawford, 1998; Lawrence & Jette, 1996; Stuck et al., 1999).

Because of the close association with disability and increase in dependency, mobility limitations can often restrict activity and social participation, bring about isolation, anxiety and depression, and contribute to an overall poorer quality of life (Netuveli, Wiggins, Hildon, Montgomery, & Blane, 2006; Rubenstein, Powers, & MacLean, 2001). Older persons who lose independent mobility are also less likely to remain living in the community and more likely to be institutionalized (von Bonsdorff, Rantanen, Laukkanen, Suutama, & Heikkinen, 2006). Other studies have found that impaired mobility among older adults is associated with a higher risk of mortality (Hirvensalo et al., 2000; Lyyra, Leskinen, & Heikkinen, 2005). In light of these associations, maintaining mobility over time is a key concern and important goal especially for older persons who are more likely to experience functional decline and disability.

**Literature Review**

Because of the importance of mobility, numerous studies have included at least one or more mobility function measure in addition to other functional disability measures. Previous studies on changes in mobility over time provided inconsistent evidence—some studies found a decrease in mobility limitations over time whereas others found an increase or no change. In a study of older persons aged 65 to 79 in Finland, mobility limitations, measured by difficulties walking outside and using stairs, declined from 1985 to 1999 (Sulander, Rahkonen, & Uutela, 2003). A Danish longitudinal study from 1984 to 1989 for ages 70 to 75 found an increase in assistance needed for mobility functions (Avlund, Davidsen, & Schultz-Larsen, 1995). Within the same country, Sweden, a national health report stated that mobility had improved since the early 1980s (Persson et al., 2006), but studies have found a decrease in mobility limitations from 1968 to 1992 for ages 18 to 76 (Ahacic, Parker, & Thorslund, 2000) and an increase from 1992 to 2002 for ages 77 or
older (Parker et al., 2005). In the United States, Spillman (2004) found that impaired mobility remained constant from 1984 to 1999 for ages 65 or older. Freedman and her colleagues (Freedman, Martin, & Schoeni, 2002) conducted a systematic review of trends in old-age functional disability which included but were not limited to difficulties with mobility; they found inconsistencies in trends although several studies provided evidence that disability among older Americans had generally declined in the last decade.

These different evidence for mobility changes over time among and even within countries could be in part a result of differences in study design, specific measures used and analytical methods employed (Freedman et al., 2004) as well as a reflection of countries at somewhat varying stages of health transitions for different time periods. Long-term population trends aside, a prospective cohort study of 754 community-living elderly aged 70 and above who were followed-up and assessed every month for up to 5 years from 1998 to 2004 in the United States also found that mobility disability in older persons is a highly dynamic process, characterized by frequent transitions between states of independence and disability (Gill, Allore, Hardy, & Guo, 2006).

Numerous studies have provided evidence that mobility disability increased with age and women had more mobility impairments than men at older ages (Ahacic et al., 2000; Iezzoni, McCarthy, Davis, & Siebens, 2000; Melzer & Parahyba, 2004; Shumway-Cook, Ciol, Yorkston, Hoffman, & Chan, 2005). It was found that from 1968 to 1992, Swedish women’s mobility improved more than men’s, thereby closing the gap between the genders. Period changes in the social class structure, increased employment among women, changes in health behaviors in smoking and physical activity, and to a limited extent improvements in childhood living conditions contributed to the overall mobility improvements during the same period (Ahacic et al., 2000; Ahacic, Parker, & Thorslund, 2003).

The Singaporean Context

For our current study, we focused on the Singaporean context. Similar to many countries, Singapore has seen an increase in life expectancy over the past few decades. Life expectancy at birth and at age 65 has increased continuously and steadily over the past 25 years for both men and women in the city-state (Figure 1). For the duration of our present study from 1995 to 2005 and our population of interest, total life expectancy at age 65 increased from 16.0 years in 1995 to 18.7 years in 2005. Among 65-year-old men, life expectancy increased by 2.3 years from 14.6 years in 1995 to 16.9 years in 2005. For their female counterparts, life expectancy increased by 3.2 years
from 17.2 years in 1995 to 20.4 years in 2005 (Department of Statistics Singapore, 2008).

Despite the increases in life expectancy, little is known about the relationship between the longer lives and the health status of older Singaporeans. To date, only a few studies have examined functional disability prevalence among elderly Singaporeans. Using mainly difficulties with ADLs and IADLs as measures, the prevalence of functional disability among older Singaporeans varied widely depending on the definition of disability used, the number of ADLs and IADLs considered, and the sample population studied. One study of Chinese Singaporeans reported that 8.9% and 23.9% of elderly aged 75 to 79 and 80+, respectively, needed assistance everyday with some ADLs and IADLs (Kua, 1991). In another study, Chan and his colleagues (Chan, Pang, Ee, Ding, & Choo, 1999) found that 17% of 401 respondents aged 60 and above in 1993 were dependent in at least one of ten ADL items. A more recent study indicated that 6.6% of 1,079 Singaporeans aged 65 and older in 2003 had at least one of five ADL difficulties (Ng, Niti, Chiam, & Kua, 2006). Only one study examined disability prevalence over time (Lee & Tan, 1997); it was found that among 283 adults aged 60 and older, there was an increase in difficulties with dressing, using the toilet, bathing, and higher functional activities from 1982 to 1992. The proportion confined to bed most of the time also increased from 1.0% to 2.8% over the decade.
The findings in most of these studies were, however, limited by nonrepresentative samples, poor response rates, and/or small sample size. In addition, with the exception of the study by Lee and Tan, the disability prevalence rates were examined at only one time-point and thus unable to shed light on changes over time. Comparisons of disability prevalence among these studies are also not valid because of differences in definitions, measures, and samples used. To our knowledge, no previous studies had specifically investigated changes in the mobility status and expected life time in different mobility states of older Singaporeans. We thus begin a first attempt at understanding the relationship between increased longevity and morbidity as measured by mobility limitations for older Singaporeans.

Singapore is also of particular interest given its location in Southeast Asia. As one of the more economically developed countries in the region with a multiethnic population of about 4 million people comprising the Chinese, Malays, and Indians, Singapore can be thought of as a microcosm of how Asian societies could adapt to population aging. The results of various issues that can potentially be studied in Singapore, such as the effects of socioeconomic development, ethnicity, and other factors on health outcomes as well as the financing of long-term care in a setting where the family has traditionally been the main provider for older adults can be used as a window onto the rest of its Asian neighbors in dealing with population aging.

We first examined the prevalence of mobility limitations and changes over time among older Singaporeans. Following that, we sought to answer these questions by computing mobile life expectancy: (a) What is the expected average life time without and with mobility limitations? (b) What is the proportion of life lived in each of these health states? (c) How have the number of years and proportion of life lived without and with mobility limitations changed over time? and (d) Has there been a compression or expansion of morbidity? The answers to these questions would provide important insights and evidence for policy makers to formulate policies for the health care needs of a quickly growing segment of the Singaporean population and to address possibly unique concerns in an Asian setting. We analyzed the data, which we provided details below, by age and gender.¹

**Data and Method**

Two sources of data were used for the analyses. The first was gender-specific period life tables which were needed for the mortality data. In particular, data on the number of people living at each age (1x) and years lived in the age interval (Lx) were required in the computation of mobile life expectancy. We
obtained published life table data for 1995 and 2005 from the Department of Statistics (DOS) in Singapore.

The second data source was from nationally representative surveys which contained the prevalence rates of interest. The data on prevalence rates were combined with life table data to compute mobile life expectancy. The prevalence rates of interest in this study, mobility status, were obtained from the 1995 and 2005 National Survey of Senior Citizens (NSSC), both commissioned by Singapore’s Ministry of Community Development, Youth and Sports (MCYS). The 1995 and 2005 NSSC are nationally representative cross-sectional household surveys of adults aged 55 and older in Singapore.

In both surveys, the sampling frame used was the National Database on Dwelling which was obtained from DOS. Only households with at least one person aged 55 and above who is a Singapore citizen or permanent resident were included in the sampling frame. The surveys were restricted to older adults living in the community and those in institutions, which comprised less than 5% of the older population, were excluded. Since the institutionalized population might have different mobility patterns compared with the community living population, we discussed the implications of excluding the institutionalized from our study at the end of this article.

For a selected household with more than one person aged 55 and above, a computer-generated random number was provided in the list, to enable the interviewer to select the person to be interviewed. Both the 1995 and 2005 surveys oversampled for ages 75 and above to ensure sufficient numbers of respondents at higher ages. To obtain the prevalence rates for mobility status, the disproportionate distribution was weighted back to the actual population configuration by individual age group, ethnicity group, and gender using weights based on the 1990 and 2000 Census of Population for the respective surveys.

Using structured questionnaires that were translated into the four official languages in Singapore (English, Mandarin Chinese, Malay, and Tamil), the surveys were conducted by face-to-face interviews in the homes of the respondents. The interviewers, whose ethnicity and/or languages ability were matched with that of the respondents, were trained and provided with instructions for the fieldwork. Up to three visits at different times of the day and day of the week were made before a selected household was treated as a nonresponse case. In cases where the respondent had difficulties in understanding and answering the interviewers, a proxy closely related to the respondent such as a caregiver or a family member was used. Data were collected on basic socioeconomic and demographic characteristics and the topics covered included health status, active ageing, employment and retirement, financial status, household composition and family structure, social support, and use
of community services. Prior to the survey, a pretest was conducted on a convenience sample of 1% to 2% of the final sample; refinements were made to the questionnaire where necessary. Fieldwork took approximately 7 months for each of the surveys.

A total of 4,750 older adults aged 55 and above were interviewed in 1995, whereas a total of 4,591 older adults aged 55 and above were interviewed in 2005. This represented a response rate of 60% and 64% for 1995 and 2005, respectively. The number of interviews completed by proxy in 2005 was very small—69 cases or 1.5% of the total interviews. Similar information for the 1995 survey were unavailable, although it is likely that proxies were not used. Of the nonresponse in 1995, 70% was due to failure to contact or locate the older person at the given address, and 30% was due to refusal to be interviewed. The specific breakdown of the nonresponses in 2005 is unavailable. We discussed the implications of the nonresponse on the study’s findings in the discussion section.

The completed questionnaires were checked for completeness, accuracy, and consistency. To ensure the quality of data collected, telephone call-backs were made on about 10% and 30% of the completed interviews in 1995 and 2005, respectively. More details on the survey method and design can be found in the reports by MCYS (1996, 2006).

We used this specific question on mobility status from the surveys: “Are you able to move around physically without any help?” There were five response categories: (a) ambulant and physically independent; (b) ambulant and physically independent but requires walking aids; (c) requires some physical assistance to move around and needs supervision while using assistive devices; (d) not bedridden but requires total physical assistance for transfers and movement; and (e) bedridden and requires regular turning in bed. In our analyses, we dichotomized the five response categories into “ambulant and mobile” for the first two categories and “with mobility limitations” for the last three categories. We recoded the categories as such to distinguish between those who needed physical assistance from another person from those who did not as well as to take into account the severity of mobility limitations. In addition, our recoding also considered the slight difference in the questions between the two surveys although the response categories were identical. In 1995, the responses were based on self-reports and the observations of interviewers. In 2005, the responses were based on self-reports only. Because respondents who needed physical mobility assistance from another person can be directly observed by the interviewers, combining the first two and last three response categories would minimize any differences that might have arose from the slight variation in the question. A study by Shumway-Cook,
Patla, et al. (2005) that compared self-reported versus observed community mobility further showed the two measures to be highly correlated.

Observations with missing data for age, gender, and mobility status were deleted. There were no missing data on these three variables in 1995 and all 4,750 observations were used. In 2005, 79 observations with missing data on age and 8 observations with missing data on mobility status were excluded from the analyses. A total of 4,505 observations were used in the analyses for 2005. The sample characteristics for age and gender were similar between the two surveys. The median age was 65.8 years for the 1995 sample, and 52.6% were women. For the 2005 sample, the median age was 66.0 years, and 52.3% were women.

We used a prevalence-based method devised by Sullivan (1971) to compute the mobile life expectancy of older Singaporeans. This method combines age- and gender-specific life table functions and age- and gender-specific morbidity prevalence rates from national surveys at a single point in time to partition total life expectancy into healthy (without mobility limitations) and unhealthy (with mobility limitations) states. The prevalence rates were used to calculate person-years of life lived in a specific mobility state for the age intervals using given life table population. The person-years of mobility for each age interval were summed from age \times forward to the end of the table to obtain the total person-years that are mobile. The mobile life expectancy values were obtained by dividing the total mobile person-years at each age interval by the survivors at the beginning of that age interval from the life table. Using this method thus reflects the current mobility health structure of a population adjusted for mortality levels. We computed the variances of the mobile life expectancy estimates with weighted prevalence rates and unweighted number of persons in the age interval using the formula provided in Jagger, Cox, Le Roy, and EHEMU (2006). The confidence intervals were computed, and the significance levels are shown in the tables.

### Results

The prevalence of mobility limitations by gender in 1995 and 2005 is shown in Table 1. The vast majority (more than 90%) of both men and women aged 55 and above were completely ambulant and physically independent. Over the decade, however, the proportion with mobility limitations has increased. The largest increases were from older persons with mild mobility limitations that required only walking aids—the proportion more than doubled, from 1.6% to 3.7% for men and from 2.9% to 6.6% for women. There were also some increases in more severe mobility limitations that required physical assistance.
Using the recoded dichotomized categories (ambulant and mobile vs. with mobility limitations), Table 2 shows the prevalence rates by 5-year age groups. The proportion with mobility limitations at younger ages was small; the impairments mostly began after age 65 and increased with age particularly at ages 85 and above. From 1995 to 2005, the prevalence of mobility limitations has declined for men below age 60 and for women below age 65, but there were substantial increases at higher ages over time, with a larger proportion of women experiencing mobility limitations compared to men.

Table 3 shows total life expectancy, expected number of years lived ambulant and mobile, and expected number of years lived with mobility limitations for 55-, 65-, 75-, and 85-year-old Singaporean men and women for 1995 and
Table 2. Prevalence of Mobility Limitations, by 5-Year Age Groups and Gender

<table>
<thead>
<tr>
<th>Age group</th>
<th>1995</th>
<th></th>
<th></th>
<th>2005</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ambulant and mobile</td>
<td>With mobility limitations</td>
<td></td>
<td>Ambulant and mobile</td>
<td>With mobility limitations</td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55-59</td>
<td>367</td>
<td>99.2</td>
<td>0.8</td>
<td>515</td>
<td>99.5</td>
<td>0.5</td>
</tr>
<tr>
<td>60-64</td>
<td>375</td>
<td>99.7</td>
<td>0.3</td>
<td>414</td>
<td>99.2</td>
<td>0.8</td>
</tr>
<tr>
<td>65-69</td>
<td>274</td>
<td>99.0</td>
<td>1.0</td>
<td>419</td>
<td>97.8</td>
<td>2.2</td>
</tr>
<tr>
<td>70-74</td>
<td>201</td>
<td>97.8</td>
<td>2.2</td>
<td>295</td>
<td>98.0</td>
<td>2.0</td>
</tr>
<tr>
<td>75-79</td>
<td>375</td>
<td>96.7</td>
<td>3.3</td>
<td>262</td>
<td>95.5</td>
<td>4.5</td>
</tr>
<tr>
<td>80-84</td>
<td>329</td>
<td>96.3</td>
<td>3.7</td>
<td>126</td>
<td>93.8</td>
<td>6.2</td>
</tr>
<tr>
<td>85+</td>
<td>137</td>
<td>93.3*</td>
<td>6.7*</td>
<td>78</td>
<td>84.5*</td>
<td>15.5*</td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55-59</td>
<td>382</td>
<td>99.0</td>
<td>1.1</td>
<td>532</td>
<td>99.8</td>
<td>0.2</td>
</tr>
<tr>
<td>60-64</td>
<td>432</td>
<td>99.2</td>
<td>0.8</td>
<td>387</td>
<td>99.7</td>
<td>0.3</td>
</tr>
<tr>
<td>65-69</td>
<td>400</td>
<td>98.3</td>
<td>1.7</td>
<td>463</td>
<td>98.2</td>
<td>1.8</td>
</tr>
<tr>
<td>70-74</td>
<td>321</td>
<td>97.3</td>
<td>2.7</td>
<td>322</td>
<td>95.9</td>
<td>4.1</td>
</tr>
<tr>
<td>75-79</td>
<td>501</td>
<td>96.0</td>
<td>4.0</td>
<td>330</td>
<td>94.5</td>
<td>5.5</td>
</tr>
<tr>
<td>80-84</td>
<td>412</td>
<td>94.0*</td>
<td>6.0*</td>
<td>197</td>
<td>87.3*</td>
<td>12.8*</td>
</tr>
<tr>
<td>85+</td>
<td>244</td>
<td>88.5*</td>
<td>11.6*</td>
<td>165</td>
<td>77.5*</td>
<td>22.5*</td>
</tr>
</tbody>
</table>

Note: Computed from 1995 and 2005 NSSC. Table shows weighted data. Percentages might not add up to exactly 100% due to rounding.

*Statistically significant difference at the .05 level between 1995 and 2005 proportions.

2005. At age 55 in 1995, men can expect to live for another 22.1 years of which 21.7 years are mobile and independent, and 0.4 years are with mobility limitations. In 2005, while total life expectancy has increased to 24.9 years, the number of years spent mobile and with mobility limitations has also increased to 24.1 years and 0.8 years, respectively. Of the 2.8 years increase in life expectancy from 1995 to 2005, 2.4 years are expected to be lived in an ambulant and mobile state and 0.4 years are expected to be lived with mobility limitations. At age 65, between 1995 and 2005, men can expect an increase of 2.3 years in life time, of which 1.9 years are mobile and 0.4 years are with mobility limitations. At ages 55 and 65, of the increases in life expectancy over the decade, over four fifths (between 83% and 86%) are expected years of life in ambulant and mobile state. The estimates for expected years of life with mobility limitations for men at older ages were not statistically significant most likely because of the small number of cases in the sample.

For women at age 55 in 1995, the expectation of remaining life is 25.6 years of which 24.8 years are lived without mobility limitations and 0.8 years are
lived with mobility limitations. In 2005, life expectancy has increased to 29.0 years, with corresponding increases of 27.4 and 1.7 years of life lived mobile and with mobility limitations, respectively. Of the 3.4 years gained in life time, 2.5 years are lived without mobility limitations and 0.9 years are lived with mobility limitations. At age 65, of the 3.2 years increase in life expectancy, 2.1 years are lived without mobility limitations and 1.1 years are lived with mobility limitations. At older ages, women can expect almost 60% of the increase in life expectancy to be life without mobility limitations. All the

Table 3. Life Expectancy (in Years) in Different Mobility States, by Age and Gender

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th></th>
<th>Females</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>At age 55</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>22.1</td>
<td>24.9</td>
<td>2.8</td>
<td>25.6</td>
</tr>
<tr>
<td>Ambulant and mobile</td>
<td>21.7</td>
<td>24.1</td>
<td>2.4**</td>
<td>24.8</td>
</tr>
<tr>
<td>With mobility limitations</td>
<td>0.4</td>
<td>0.8</td>
<td>0.4*</td>
<td>0.8</td>
</tr>
<tr>
<td>At age 65</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14.6</td>
<td>16.9</td>
<td>2.3</td>
<td>17.2</td>
</tr>
<tr>
<td>Ambulant and mobile</td>
<td>14.2</td>
<td>16.1</td>
<td>1.9**</td>
<td>16.5</td>
</tr>
<tr>
<td>With mobility limitations</td>
<td>0.4</td>
<td>0.8</td>
<td>0.4*</td>
<td>0.7</td>
</tr>
<tr>
<td>At age 75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8.8</td>
<td>10.4</td>
<td>1.6</td>
<td>10.4</td>
</tr>
<tr>
<td>Ambulant and mobile</td>
<td>8.4</td>
<td>9.6</td>
<td>1.2**</td>
<td>9.7</td>
</tr>
<tr>
<td>With mobility limitations</td>
<td>0.4</td>
<td>0.8</td>
<td>0.4</td>
<td>0.7</td>
</tr>
<tr>
<td>At age 85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4.4</td>
<td>5.9</td>
<td>1.5</td>
<td>4.6</td>
</tr>
<tr>
<td>Ambulant and mobile</td>
<td>4.1</td>
<td>5.0</td>
<td>0.9*</td>
<td>4.1</td>
</tr>
<tr>
<td>With mobility limitations</td>
<td>0.3</td>
<td>0.9</td>
<td>0.6</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Note: Sum of life expectancy in states sometimes do not add to total life expectancy due to rounding.

*Significant at .05 level. **Significant at .01 level.
estimates for mobile life expectancy for women at all ages were significant at .01 level.

Comparing between the genders, at the same age, women can expect to live longer than men. The increase in life expectancy over the 10-year period was also greater for women than for men at all ages. For instance, at age 65, men gained an additional 2.3 years while women gained an additional 3.2 years over the same period. With the increases in life expectancy, both men and women can expect more years of life both without mobility limitations and with mobility limitations. However, because women live longer, they can expect to spend more years than men in both mobility states. In particular, women at all ages can expect to live about twice or more the number of years with mobility limitations compared to men.

We also computed the proportion of lifetime spent in different mobility states to examine whether the compression or expansion of morbidity or the dynamic equilibrium hypotheses hold for the Singaporean case from 1995 to 2005. As Table 4 shows, for both men and women aged 55 and above, well over 90% can expect a remaining lifetime without mobility limitations. The exceptions are women aged 75 and above and men aged 85 and above. For instance, in 1995, a 55-year-old man can expect to live 98% of his remaining life without mobility limitations. His female counterpart can expect an almost equally high proportion, 97%. However, as age increases, this proportion decreases. By age 85, the corresponding proportions for men and women dropped to 93% and 89% in 1995, respectively.

Over time from 1995 to 2005, the proportion of life without mobility limitations has also declined for both men and women and at all ages. For men at age 65, the proportion of life without mobility limitations dropped from 97% in 1995 to 95% in 2005. For women at age 65, that proportion dropped from 96% to 91% from 1995 to 2005. Compared with men of the same age and over time, women can expect a smaller proportion of their lives to be without mobility limitations and a larger proportion with mobility limitations.

**Discussion**

This study has examined changes in the prevalence of mobility limitations and mobile life expectancy of Singaporean men and women aged 55 and older from 1995 to 2005. Although the vast majority of older Singaporeans are ambulant and mobile, the prevalence of mobility limitations has increased over the decade. Mobility limitations mostly started after age 65 and increased with age particularly at ages 85 and older. A larger proportion of women experienced mobility limitations compared with men at same ages.
Table 4. Proportion of Lifetime in Different Mobility States, by Age and Gender

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>At age 55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100.0 100.0</td>
<td>100.0 100.0</td>
</tr>
<tr>
<td>Ambulant and mobile</td>
<td>98.2 96.8</td>
<td>96.9 94.2</td>
</tr>
<tr>
<td>With mobility limitations</td>
<td>1.8 3.2</td>
<td>3.1 5.8</td>
</tr>
<tr>
<td>At age 65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100.0 100.0</td>
<td>100.0 100.0</td>
</tr>
<tr>
<td>Ambulant and mobile</td>
<td>97.3 95.3</td>
<td>95.9 91.2</td>
</tr>
<tr>
<td>With mobility limitations</td>
<td>2.7 4.7</td>
<td>4.1 8.8</td>
</tr>
<tr>
<td>At age 75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100.0 100.0</td>
<td>100.0 100.0</td>
</tr>
<tr>
<td>Ambulant and mobile</td>
<td>95.5 92.3</td>
<td>93.3 86.7</td>
</tr>
<tr>
<td>With mobility limitations</td>
<td>4.5 7.7</td>
<td>6.7 13.3</td>
</tr>
<tr>
<td>At age 85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100.0 100.0</td>
<td>100.0 100.0</td>
</tr>
<tr>
<td>Ambulant and mobile</td>
<td>93.2 84.7</td>
<td>89.1 77.8</td>
</tr>
<tr>
<td>With mobility limitations</td>
<td>6.8 15.3</td>
<td>10.9 22.2</td>
</tr>
</tbody>
</table>

Computations to disaggregate total life expectancy into expected life time without and with mobility limitations showed that the number of years of life in both mobility states has increased over time, with women living longer in both mobility states than men because of their longer lives. The proportion of life time without mobility limitations declined with age and over time for both men and women. At same ages, women can expect to spend a smaller proportion of life without mobility limitations compared to men. Overall, the number of years and proportion of life with mobility limitations increased with age for both genders over time.

Our results on gender differences in mobility limitation prevalence and mobile life expectancy were in line with the findings of a study in Singapore by Chan and Jatrana (2007) that older women were significantly more likely than older men to report having functional disabilities even after controlling for socioeconomic characteristics, health-risk behaviors, and social support. The substantial increase in the prevalence of functional disability at higher ages among older Singaporeans was also found in a study by Ng et al. (2006).

On the whole, our findings provided support for the expansion of morbidity hypothesis. Thus, the longer lives as indicated by increases in life expectancy in Singapore cannot be directly equated with healthier lives. The results herein
are similar to a study conducted in Sweden from 1992 to 2002 where the prevalence of mobility limitations among adults aged 77 and older has increased (Parker, Ahacic, & Thorslund, 2005). Crimmins, Saito, and Ingegneri (1989, 1997) found that using various definitions of disability, there was an expansion of morbidity in the United States from 1970 to 1980, but in the subsequent decade from 1980 to 1990, there was evidence of morbidity compression. In Asian countries such as Japan and Indonesia, it was found that disability related to ADLs had expanded over time from 1992 to 1998 and 1993 to 1997, respectively (Hidajat, Hayward, & Saito, 2007; Saito, 2001), although a recent study in China reported a compression of disability life years from 1987 to 2006 (Liu, Chen, Song, Chi, & Zheng, 2009). Comparisons of these studies with the current study must be made with caution because of differences in health measures used as well as differences in time periods and contexts.

Changes in mobility prevalence rates and mobile life expectancy over time can also be explained by a number of other additional factors, apart from actual pathological health changes. Exogenous factors that change over time such as the higher educational attainment of more recent cohorts, increased awareness and knowledge of health problems, access to health care services, new or changes to health policies, and introduction of assistive devices can all serve to change respondents’ reporting of their health status, and hence prevalence rates, over time. In our current study for instance, the overall proportion of respondents who reported requiring walking aids such as quad sticks and walking frames had more than doubled over time, from 2.3% in 1995 to 5.2% in 2005. This increase in prevalence could be a reflection of either actual mobility deterioration or a better availability, knowledge and use of such assistive devices over time, or both (Zimmer & Chappell, 1994). The recent cohorts of older Singaporeans are also better educated than earlier cohorts, which could have influenced their awareness level and propensity to report on health issues. Over the 10-year period, improved standards of living in Singapore may also have raised expectations and demands on one’s own health as well as health care services, both of which could have contributed to changes in prevalence rates. Therefore, any interpretation of or conclusion on changes in mobility prevalence over time should not be made superficially without due consideration given to these other possible explanations. Further studies on the effect of period changes on changes in mobility functions over time are needed.

Changes to the survey design, data collection, and response rates could also affect prevalence rates and changes over time. In our study, the survey design and data collection method for the two surveys remained unchanged. The slightly better response rate in 2005 (64%, compared to 60% in 1995) could
indicate better fieldwork and might have resulted in more older adults with poor health being interviewed, contributing to the higher prevalence rates in 2005. The nonrespondents could also be in poorer health than the respondents, and prevalence rates could have been underestimated. We, however, do not have information on the health status of the nonrespondents to ascertain this. In this study, the nonresponses were treated as random.

Our study is limited in a few areas. As there are no publicly available data on the institutionalized population in Singapore by age and gender, we could not include and take into account this segment of the population in our computations. However, based on selected data from the Census of Population 2000, we can deduce that only a very small proportion of the population over the age of 65 reside in institutions (see Note 2). What are the implications of excluding the institutionalized population in our study? If we take on the assumption that older Singaporeans with mobility limitations are more likely to be residing in institutions such as homes for the elderly or assisted living homes, then it is likely that we could have overestimated life expectancy without mobility limitations and underestimated life expectancy with mobility limitations. Nevertheless, since the proportion of older adults residing in institutions is relatively small, such errors in estimations should be marginal.

This study has used only a single indicator of health, that is, mobility status. While mobility is very important and is key to independent living, we acknowledge that by itself, it is not a comprehensive measure of health status. As various other studies have shown, using different health dimensions produced varying estimates and evidence for the expansion or compression of morbidity hypotheses (Crimmins, 1996). In addition, a compression of morbidity using one particular dimension of health such as disability does not necessarily indicate better overall health over time as there could be worsening of health in other health dimensions such as diseases and medical conditions (Parker & Thorslund, 2007). Thus, computations using a range of health dimensions would provide a more complete picture of a nation’s health. Nonetheless, because of limited health-related data that are comparable between the 1995 and 2005 NSSC, we could only use a single measure of mobility status. For future studies, a range of health dimensions should be used to provide a more comprehensive picture of the health status of older Singaporeans and their expected average life time in different health states.

The Sullivan method used in this study has a limitation. By employing age-specific mobility prevalence rates, a stock measure, instead of incidence rates to obtain the number of person-years lived in a mobility state at a particular age, a bias could have been introduced to the mobile life expectancy estimates since the prevalence rates are partially dependent on past mobility...
conditions and probabilities of becoming functionally limited or recovery from limitations (Mathers, 1991). To resolve this bias, longitudinal data should be used to obtain the transition rates between mobility states and a multistate life table method used to compute the mobile life expectancy estimates (Rogers, Rogers, & Belanger, 1990). However, because such data are not available, the Sullivan method which uses more readily available data from cross-sectional surveys was used instead. Simulation models conducted have shown that the Sullivan and multistate life table methods generally produce similar results provided that transition rates are smooth and regular over time and there are no sudden changes (Mathers, 1991; Robine & Mathers, 1993).

In conclusion, the evidence for increases in mobility limitations and longer life expectancy with mobility limitations as found in this study have important policy implications. In a highly urban setting such as Singapore, there could be a need to further develop disability-friendly infrastructures. This would enable older adults to move around with fewer difficulties, remain mobile and continue to live in the community, and maintain a high quality of life.

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Declaration of Conflicting Interests

The authors had no conflicts of interest with respect to their authorship or the publication of this article.

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Notes

1. We were unable to analyze by ethnicity because neither published material nor the data needed to compute ethnicity-specific life tables were available.
2. Data from Census of Population 2000 Report Statistical Release 1: Demographic Characteristics showed that 4.5% of the resident population aged 65 and above reported “others” for living arrangements, apart from other categories: living with spouse, living with children only, living alone, and living with other elderly...
persons only. Thus, up to 4.5%, possibly less, could be residing in institutions. Hermalin (2002, p. 146) reported that 1.5% of the elderly in Singapore live in institutions.

3. It is very likely that proxies were not used in the 1995 survey as there was no indication in the questionnaire; proxy variables were also not in the data set. In addition, the official report by MCYS (1996) made no mention of proxy interviews.

References


