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Trends in Disability-Free Life Expectancy Among Chinese Older Adults

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Objectives: This study evaluates trends in disability-free life expectancy (DFLE) of Chinese adults aged 60 and older. **Methods:** Based on two national disability surveys in 1987 and 2006 as well as mortality data from World Population Prospects, the Sullivan method was used to calculate DFLE. **Results:** DFLE increased from 13.0 to 13.9 years at age 60 and from 1.2 to 1.5 years at age 90 in1987 and 2006, respectively. The proportion of DFLE increased after age 75. The proportion of DLE, with severe disability decreased while that of least disability increased. Onset of disability was delayed from 0.3 years to 4.7 years across disability types. **Conclusions:** Trends in DFLE by age and severity of disability as well as the delayed onset of disability provide evidence for the compression of morbidity among the oldest old in China. But a similar trend was not found among the young-old.

Keywords: *disability-free life expectancy; older adults; Chinese*

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Evidence continues to mount that current life expectancy has increased with the steady decline in mortality in both developed and developing countries (Cai & Lubitz, 2007; Crimmins & Saito, 2001; Jitapunkul, Kunanusont, Phoolcharoen, Suriyawongpaisal, & Ebrahim, 2003; Zeng, Gu, & Land, 2004). As individuals live longer, quality of life becomes a central issue for both them and society as a whole. Are people living healthier in their longer lives, or are they spending an increasing portion of their older years with sensory, physical, and mental disabilities? The answer to this question will have a profound impact on medical systems, retirement systems, and, in particular, the demand for long-term care. Indeed, increased life expectancy is almost always accompanied by a debate about quality of life and whether the years gained will be spent in good or poor health.

The concept of healthy life expectancy was first proposed by Sanders in 1964. It is a population-level health indicator derived from estimates of mortality and disability and addresses the question of whether observed increases in life expectancy are accompanied by decreases in morbidity (Robine & Ritchie, 1991). Measuring healthy life expectancy means bringing together both quantitative (that is mortality) and qualitative (for example, disability) data on peoples' lives to estimate the average time that an individual will live in varying heath states (Lièvre, Alley, & Crimmins, 2008). A report of the U.S. Department of Health Education and Welfare first defined *disability-free life expectancy* (DFLE) as the state of being "free of bed-disability and institutionalization." This report showed that DFLE increased slightly from 1958 to 1966, whereas life expectancy had remained stagnant (Sullivan, 1971). More researches from around the world, including the United States (Richard, Rogers, Rogers, & Belanger, 1992; Hayward, Crimmins, & Saito, 1998; Crimmins & Saito, 2001), the United Kingdom (Bajekal, 2005; Breakwell & Bajekal, 2006), France (Cambois, Robine, & Hayward, 2001), Canada (Belanger, Martel, Berthelot, & Wilkins, 2002), and Denmark (Bronnum-Hansen, Davidsen, & Kjoller, 2003), have since emerged (Robine, 1989; Robine, Brouard, & Colvez, 1987; Robine, Mathers, & Bucquet, 1993; Robine & Ritchie, 1991). Scenarios of the compression (Fries, 1980, 1983, 1989, 2002; Fries, Green, & Levine, 1989) and expansion (Gruenberg, 1977, 2005) of morbidity, as well as the intermediate one-dynamic equilibrium (Manton, 1982), have been proposed. Although the most commonly used form of health expectancy is DFLE (Lièvre et al., 2008), health expectancy can refer to life-years free of any form of general or specific morbidity and its consequences, for example, independent life expectancy and dementia-free life expectancy (Bone, Bebbington & Nicolaas, 1998). Active life

expectancy, or the length of time an individual can expect to live without chronic disability, has also received increasing attention from researchers (Crimmins, Hayward, & Saito, 1994, 1996; Reynolds, Saito, & Crimmins, 2005). Most analyses divide life into two states—active or inactive—based on a person's ability to perform personal care functions or activities of daily living (ADLs) and instrumental ADLs (IADLs) in such studies. Based on not only personal care activities but a much wider range of functions, others defined functioning into four exclusive states as no functioning problems, some functional problems, unable to provide independent living, and unable to provide personal care (Crimmins et al., 1994). Another research defined *inactive population* as two parts: those institutionalized for physical or mental health problems and those living in the community with an activity-limiting disability (Crimmins, Saito, & Ingegneri, 1997). The differences between active life expectancy, DFLE, and healthy life expectancy are not always clear, as many studies do not distinguish between these concepts (Crimmins & Saito, 2001; Crimmins et al., 1997). The main reason for this is confusion surrounding the definitions and usage of terms such as *disability*, *handicap*, and *functional limitation* (Verbrugge & Jette, 1994). In addition, age at onset of morbidity or disability is an important measure of health. Most studies have concluded that healthy/active life expectancy changes depending on the time period studied (Crimmins & Saito, 2001; Crimmins et al., 1997). For example, different studies have shown different trends in active life expectancy in the United States. The increase in life expectancy seen in the 1970s was concentrated in disabled years and reflected an expansion of morbidity (Cai & Lubitz, 2007; Crimmins & Saito, 2001; Crimmins et al., 1997), 1980s changes supported the theory of dynamic equilibrium (Cai & Lubitz, 2007; Crimmins & Saito, 2001; Crimmins et al., 1997), and trends in 1992-2003 were in line with both the compression of morbidity and dynamic equilibrium (Cai & Lubitz, 2007).

However, few studies have examined healthy or active life expectancy in China (Grab, Dowd, & Michel, 1991; Jiang, 1994; Qiao, 1999; Saito, Qiao, & Jitapunkul, 2003; Tang, Xiang, Zimmer, Fang, & Kaneda, 2005; Wang, 1993). The earliest research dates from the 1990s. Wang (1993) began researching healthy life expectancy using data from 1987 National Sample Survey of the Handicapped and 1992 China Old Age Supporting System Survey. She found that although women had a longer life expectancy than men, they spent a relatively larger proportion of their remaining lives disabled (Wang, 1993). The same conclusion can be seen in Grab et al.'s (1991) research. Qiao (1999), Jiang (1994), Gu, Zeng, and Liu (2001), and Tang

and 1.12 per thousand in the disabled population in 1987 and 2006, respectively. The accuracy of the data was greater than 95% for both surveys. The

et al. (2005) also studied healthy life expectancy among Chinese elders, but there were limitations. For example, some studies used province-level surveys (Tang et al., 2005) or data that were more than 20 years old (Wang, 1993). The Chinese Longitudinal Healthy Longevity Survey, one of the few longitudinal surveys, focused only on the oldest old and did not contain detailed data on the degree of disability (Zeng et al., 2004). Moreover, most of these studies defined *disability* as limitations in ADLs or IADLs, which is self-reported disability. Although self-reported measures of function are commonly used by researchers to assess an individual's level of independence in basic self-care skills, studies have also indicated that the self-report measures may not always agree with performance-based measures (Sherman & Reuben, 1998) and are more prone to measurement error than clinical assessments (Mutchler, 2007).

This article is the first to compare DFLE between 1987 and 2006 in China. It used the most up to date, detailed, and nationally representative database in China. Disability was diagnosed by clinicians and not self-reported, which is the most remarkable feature in our study. Because the widening sex differential in life expectancy has been a central feature in mortality trends (Kevin, 2000), we examined sex differences in DFLE to determine if this was the case for China and to elucidate differences in health status between men and women. The results of this detailed analysis of disability severity are important for policy and program-planning purposes (Mayhew, 2001). In addition, age at onset of disability was studied, which can reveal change in health status (Fries, 1980).

Method

Morbidity Data

The prevalence data used to calculate DFLE came from cross-sectional waves of the China National Sample Survey on Handicap/Disability conducted in 1987 and 2006. These surveys, the only two nationwide studies of disability in China since the 1980s, have provided researchers with valuable information on disability. Using stratified, multiphase, and cluster probability sampling designs, which covered all provinces, autonomous regions, and municipalities in China, both of the surveys are organized by Chinese government. Results of a postsurvey quality check showed omission rates of 1.06 and 1.31 per thousand in the resident population and 1.16 and 1.12 per thousand in the disabled population in 1987 and 2006, respectively. The accuracy of the data was greater than 95% for both surveys. The

taken to a clinician for further screening. Using professional tools to check

samples were nationally representative, and the data were reliable (Leading Group of China National Sample Survey on Disability & National Bureau of Statistics of the People's Republic of China, 1987; Leading Group of the Second China National Sample Survey on Disability & National Bureau of Statistics of the People's Republic of China, 2006).

The 1987 survey is based on the International Classification of Impairment, Disability and Handicap (World Health Organization, 1980), and the 2006 survey is according to the International Classification of Functioning, Disability and Health (ICF; World Health Organization, 2001) in the design. ICF is an important international taxonomy for classifying and measuring function, disability, and health with standardized concepts and terminology (Stucki, 2007; Wade & Halligan, 2003). It is based on positive descriptions of human functioning as opposed to solely negative consequences of disease (Jette, Tao, & Haley, 2007). ICF offers a biopsychosocial perspective on disability and enables the assessment of bodily functions and structures, activity, participation, and environmental factors. Received favorably by health care professionals, disability rights organizations, and proponents of the social model of disability, ICF provides a multidimensional framework for the description of disability (Ibragimova, Lillvist, Pless, & Granlund, 2007). Although it has been called "handicap" in 1987 and "disability" in 2006, it is the same terminology "*canji*" in Chinese. From the questionnaire and measurement, we can tell both of them measure the abnormity of body function and structure, which is "impairment" essentially. In this sense, we know it is comparable between the two surveys in impairment level. Most of the procedures of the two surveys as well as items about disability are similar for the correspondence, although more items are added in 2006 survey, and detailed analysis as well as interpretation should be careful (see details in Table 1).

In line with China's current disability standards, this study defined a disabled person as someone suffering from one or more abnormalities in anatomical structure or the loss of a certain organ or function (either psychological or physiological), who has lost (totally or in part) the ability to perform an activity in the normal way. Both surveys considered visual, hearing and speech, physical, intellectual, and mental disabilities. In our research, people who had one or more of the above disabilities will be regarded as the disabled. During data collection, interviewers screened the survey respondents using a special questionnaire that checked visual, hearing, speech, physical, intellectual and mental functioning. People scoring positive for potential problems were suspected of being disabled and were taken to a clinician for further screening. Using professional tools to check

	status, nationality, and employment)	status, nationality, and employment)	

Table 1
Comparison of Two National Sample Surveys on Handicap/Disability in China, 1987 and 2006

	1987	2006	Comparability
Reference time	0:00, April 1	0:00, April 1	Yes
Organizer	Leading group of China national sample survey on disability and its office	Leading group of the second China national sample survey on disability and its office	Yes
Coordinator	Ministry of Civil Affairs, National Bureau of Statistics of China, Ministry of Health, Ministry of Finance, Association of Blind and Deaf People, and other related governmental agencies of China	Ministry of Civil Affairs, National Bureau of Statistics of China, Ministry of Health, Ministry of finance, et al., China Disabled Person's Federation (CDPF),[a] and other related governmental agencies of China	Yes
Sample design	Stratified, multiphase, and cluster probability	Stratified, multiphase, and cluster probability	Yes
Sample size	1,579,314(1.5‰)[b-1]	2,526,145 (1.9%)[b-2]	Yes
Coverage[c]	29 provinces 424 cities/counties 3,169 community	31 provinces 734 cities/counties 5,964 community	Yes
Training	Uniform training by the organizer	Uniform training by the organizer	Yes
Interviewers	Trained staff whose work are for the civil affairs as well as for disabled person, students, and others	Trained staff whose work are for the disabled people from different levels, college students, and others	Yes
Questionnaires	Household questionnaire: 1. Address, household size, demographic information of the respondents (age, sex, education, marital status, nationality, and employment)	Household questionnaire: 1. Address, household size, demographic information of the respondents (age, sex, education, marital status, nationality, and employment)	Yes

(continued)

detailed standards of different disability type in the diagnosis, and we can provide them if you are especially interested in any type. One needs to be cautious in interpretation.

Table 1 (continued)

	1987	2006	Comparability
	2. Hukou	2. Hukou: more information on migration	Yes
		Household information (household income, assets, house type, size, and others)	No
	Disabled person questionnaire:	Disabled person questionnaire:	Yes
	1. Total disability (disabled or not)	1. Total disability (disabled or not)	
	2. Disability details (type, severity, age of onset)	2. Disability details (type, severity, age of onset)	Depended on[d]
	Type: six categories (vision, hearing and speech, physical, intellectual, mental, and multiple)	Type: seven categories (vision, hearing, speech, physical, intellectual, mental, and multiple)	
	3. Cause, activity, and demand	3. Cause, activity, and demand	Depended[e]
		Insurance	No
Screening questions	Do you have any problem of eye/ear/speech/physical activity/intellectual/mental?	Do you have problem of eye/ear/speech/physical activity/intellectual/mental?	Yes
Medical examination	Medical specialist clinician	Medical specialist clinician	Yes

a. After the 1987 survey, the Chinese government found it is pressing to establish an organization to safeguard the rights of persons with disabilities, improve their conditions, and exploit the potentials of disabled persons. In 1988, China Disabled Persons' Federation (abbreviated as CDPF) was established.

b-1, b-2. These show the proportion of sample to the whole population, which are representative to the whole nation in corresponding year.

c. Because there are some administrative changes of provinces based on the geographic range of China, the total number of provinces in China mainland varied from 29 to 31. So both of the surveys covered the whole country.

d. Most disability types, such as vision/physical, are comparable, whereas others can be comparable after some calculation; for example, hearing and speech is one category in 1987, but it is two individual categories in 2006. Hence, one needs to be cautious in interpreting when to compare hearing and speech disability and multiple disabilities after recalculation. Dementia is included in intellectual disability, but it belongs to mental disability in 2006. There are many detailed standards of different disability type in the diagnosis, and we can provide them if you are especially interested in any type. One needs to be cautious in interpretation.

e. There are more items and some different categories in 2006 than in 1987.

sex and disability severity level. The Sullivan method uses the prevalence

body function and structure, activity, and participation, trained physicians gave the final diagnosis and assessment of disability. The respondents received examinations from multiple physicians and techniques. So diagnoses of disability were performance based and hence more accurate than the self-reported measures used in other studies.

Another indicator used in our research is age at onset of disability. Based on the question "When did you know you had a disability?" we define age at onset as year of knowledge of disability minus year of birth.

This article focuses on the older adult (age 60 and older) subsamples from both surveys. A total of 30,703 persons were classified as disabled from the subsample of 140,042 older adults in 1987, and 85,260 were classified as disabled from the subsample of 354,859 older adults in 2006. For each survey, the proportion of older adults to the entire survey population was representative of their proportion in the national population.

Mortality Data

Data on the number of deaths by age and sex for 1987 and 2006 were obtained from the World Population Prospects (2004 revision) Population Database of the United Nations Population Division (United Nations Population Division, 2006). It has detailed life table information from 1950 to 2050 for whole age groups each five years by country, and the 2004 version contains the most recent data. We selected central total life expectancy (e_x) from the database. To ensure the data quality and for the comparison of different countries, the preparation of the official population estimates and projections of the United Nations involved two distinct processes: (a) the incorporation of all new and relevant information regarding the past demographic dynamics of the population of each country or area of the world and (b) the formulation of detailed assumptions about the future paths of fertility, mortality, and international migration. Estimation of life expectancy is based on published life tables for the periods 1982-1990, 1990-2000, and 1999-2000. These life tables were calculated from the 1982, 1990, and 2000 census counts and the 1973-1975 Cancer Epidemiology Survey (United Nations Population Division, 2006).

Sullivan Method

DFLE is the average number of years spent free of disability by a person of a particular age. We calculated DFLE using the Sullivan method for each sex and disability severity level. The Sullivan method uses the prevalence

at Age X increased for every age group, from 17.5 years to 19.0 years at age 60 and from 3.6 years to 3.7 years at age 90. As expected, $DFLE_x$ also

of disability in each age group to divide the number of person-years into years with and without disability (Sullivan, 1971). The required data can be obtained through cross-sectional disability survey and period life table. It has been used extensively to estimate DFLE (Bronnum-Hansen et al., 2003; Gispert, Puig, Puigdefabregas, Tresserras, & Busquets, 2003; Gispert, Ruiz-Ramos, Bares, Viciana, & Clot-Razquin, 2007; Gutierrez-Fisac, Gispert, & Sola, 2000; Minicuci & Noale, 2005; Nusselder et al., 2005; Valkonen, Sihvonen, & Lahelma, 1997) in various populations. The Sullivan method remains the most widely used method by far, for it uses more readily available data and simple assumption than multistate life table method (Imai, 2007).

Results

Increase in Prevalence of Disability

The total prevalence of disability increased from 21.8% in 1987 to 24.0% in 2006. In the young old (ages 60 to 74), the prevalence of disability increased from 12.1%, 17.6%, and 25.8% for ages 60 to 64, 65 to 69, and 70 to 74, respectively, in 1987 to 12.4%, 18.0%, and 26.4% in 2006. However, among the oldest old (age 75 and older), the prevalence decreased from 37.5%, 49.3%, and 58.8% for ages 75 to 79, 80 to 84, and 85 and older, respectively, in 1987 to 36.3%, 46.7%, and 55.9%. Nonetheless, the prevalence of disability increased with age at both survey times.

Trends in Life Expectancy and DFLE by Age

For most age groups, life expectancy increased between 1987 and 2006, while the prevalence of disability also increased. Therefore, it was crucial to determine what was happening with DFLE. Were the Chinese living longer but in a state of disability?

Table 2 shows life expectancy at Age X (e_x) and DFLE at Age X ($DFLE_x$) for persons ages 60 and older based on data from the 1987 and 2006 surveys. The sample size is quite large, and the confidence interval is so small. So we only listed the standard error of $DFLE_x$. The 1987 results were very close to those of Grab et al. (1991). The proportion of $DFLE_x$ on e_x was 67.8% for women age 65 and 54.0% for those age 75 in Grab's study. The corresponding values in our study were 67.9% and 53.3%. Life expectancy at Age X increased for every age group, from 17.5 years to 19.0 years at age 60 and from 3.6 years to 3.7 years at age 90. As expected, $DFLE_x$ also

is given as a proportion of the total life expectancy in the upper panel, and it is given as a proportion of the total DLE in the lower panel. Results show

increased for every age group, from 13.0 years to 13.9 years at age 60 and from 1.2 years to 1.5 years at age 90. The older one was, the less increase he or she experienced in $DFLE_x$.

The proportion of $DFLE_x$ decreased from 74.1% to 73.1% at age 60 and increased from 54.2% to 55.2% at age 75. The change increased as age increased: It was 1.0% at age 75, increased to 2.5% at age 85, and reached 3.7% at age 90. The proportion of $DFLE_x$ on e_x decreased with increased age. In short, both absolute years of $DFLE_x$ and the proportion of $DFLE_x$ on e_x showed significant differences by age.

Sex Differences in DFLE

Both men and women enjoyed increased DFLE between 1987 and 2006. $DFLE_x$ increased from 12.6 to 12.9 years for men at age 60 and from 13.3 to 14.9 years for women this same age (Table 2). Although women had a greater total life expectancy at every age, they also had a greater life expectancy with a disability (disabled life expectancy, or DLE). As a result, the share of e_x that was disability free was smaller for women than men: 75.1% and 74.3% for men at age 60 in 1987 and 2006, respectively, and 73.2% and 72.1% for women. Regardless of sex, the proportion of $DFLE_x$ on life expectancy decreased for people at age 70 and before but increased at age 75 and after between 1987 and 2006. Differences between men and women were constant at 2%.

DFLE by Disability Severity

Disability severity was classified into four categories—mild, moderate, severe, and very severe—which reflected different function level. People with mild disability means that people can finish the specific task with a little difficulty or they can live by themselves, whereas people with very severe disability means they cannot finish normal task or they can't live by themselves at all. To be easily interpreted, we calculated average DLE by disability severity.

In general, the length of DLE_x varied from 0.3 years to 2 years according to disability severity. Years of DLE_x with mild, moderate, severe, and very severe disability was 0.9, 0.7, 1.6, and 2.0 years at age 60 in 2006, respectively, and 0.8, 0.9, 1.1, and 1.7 years in 1987. Compared with 1987, length of DLE_x with very severe disability and severe disability decreased by almost 0.3 years in every age group in 2006. In Table 3, DLE_x by severity is given as a proportion of the total life expectancy in the upper panel, and it is given as a proportion of the total DLE in the lower panel. Results show

Table 2
Life Expectancy at Age X (e_x) and Disability-Free Life Expectancy at Age X ($DFLE_x$) by Age and Gender, China 1987 and 2006

	1987				2006				Proportion Change
Age	e_x	$DFLE_x$	Standard Error of $DFLE_x$	Proportion (%) ($DFLE_x/e_x$)	e_x	$DFLE_x$	Standard Error of $DFLE_x$	Proportion (%) ($DFLE_x/e_x$)	(2006 to 1987)
60	17.5	13.0	.02	74.1	19.0	13.9	.01	73.1	−0.9
65	14.2	9.7	.02	68.8	15.2	10.4	.01	68.1	−0.7
70	11.2	7.0	.02	62.1	11.9	7.4	.01	62.0	−0.1
75	8.7	4.7	.03	54.2	9.1	5.0	.02	55.2	1.0
80	6.6	3.1	.03	46.5	6.8	3.3	.02	48.3	1.7
85	4.9	2.0	.05	40.3	5.1	2.2	.02	42.8	2.5
90	3.6	1.2	.07	35.0	3.7	1.5	.03	38.7	3.7
Male									
60	16.8	12.6	.03	75.1	17.3	12.9	.02	74.3	−0.8
65	13.6	9.5	.03	70.1	13.8	9.6	.02	69.5	−0.6
70	10.8	6.8	.03	63.6	10.7	6.8	.02	63.4	−0.2
75	8.4	4.7	.03	55.7	8.1	4.6	.02	56.6	0.9
80	6.4	3.1	.04	47.6	6.0	3.0	.02	49.9	2.3
85	4.8	1.9	.08	39.9	4.4	2.0	.03	44.9	5.0
90	3.5	1.2	.12	34.3	3.2	1.2	.05	38.5	4.2
Female									
60	18.2	13.3	.01	73.2	20.7	14.9	.02	72.1	−1.1
65	14.7	10.0	.03	67.9	16.7	11.2	.02	67.1	−0.7
70	11.6	7.1	.03	61.2	13.1	8.0	.02	61.0	−0.2
75	8.9	4.7	.04	53.3	10.0	5.4	.02	54.3	0.9
80	6.7	3.1	.04	45.7	7.5	3.5	.02	47.3	1.6
85	4.9	2.0	.06	40.4	5.5	2.3	.03	41.9	1.6
90	3.6	1.3	.08	37.6	4.0	1.5	.04	38.5	0.9

ancy (Crimmins, Saito, & Hayward, 1993; Rogers, 1990). Mathers and

that the proportion of DLE_x with very severe and severe disability decreased, whereas that of moderate and mild disability increased (Table 3). For example, the proportion of DLE_x with very severe disability decreased from 5.8% to 5.5% at age 65 and from 13.2% to 12.0% at age 80. The proportion of DLE_x with moderate disability increased from 7.6% to 10.1% at age 65 and from 12.2% to 18.0% at age 80. From the lower panel, we can find young old people take more of their lives of DLE_x with mild disability (30% to 40%), whereas oldest old people take more of their lives of DLE_x with severe and very severe disability (more than 30%) in both surveys.

Age at Onset of Disability

The age at onset of disabilities was older in 2006 than 1987, which is to say the onset of disability was compressed toward the end of life. For example, the age of physical disability was almost 5 years later in 2006, and intellectual disability was near 4 years later (Table 4).[1]

Discussion

Disability among aging individuals has become an extremely important public health concern and is arguably the largest health problem in both developed and developing countries (Mayhew, 2001). We found that although the total prevalence of disability increased with age between 1987 and 2006, prevalence levels increased among the young old and decreased among the oldest old. Similar trend have been reported in Hong Kong from 1996 to 2004 (Chou & Leung, 2008) and Taiwan from 1993 to 1999 (Zimmer, Martin, & Chang, 2002). However, both of the morbidity data used here are cross-sectional, which means only prevalence of disability is available, but not the incidence of disability. We know the proportion of older persons disabled in a population at any given time is determined by past rates of incidence of disability, past rates of recovery in functioning, and the history of death rates of the disabled and nondisabled persons in the population (Chou & Leung, 2008). This study only examines the change from 1987 to 2006 in the prevalence of disability in Chinese older persons, but the rates affecting this prevalence must be investigated in future studies with longitudinal data sets. Hence, caution must be taken in interpreting the trend in disability. At the same time, many studies have discussed the merits of the incidence and prevalence methods of estimating health life expectancy (Crimmins, Saito, & Hayward, 1993; Rogers, 1990). Mathers and

Table 3
Proportion of Disability Life Expectancy by Severity at Age X (DLE_x) on Total Life Expectancy at Age X (e_x) and Total Disability Life Expectancy at Age X (DLE_x) by Age, China 1987 and 2006

	1987					2006					Change (2006 to 1987)				
Age	Very Severe	Severe	Moderate	Mild	Total	Very Severe	Severe	Moderate	Mild	Total	Very Severe	Severe	Moderate	Mild	Age
60	4.6	5.3	6.4	9.5	25.8	4.6	3.5	8.3	10.5	26.9	−0.1	−1.8	1.9	1	60
65	5.8	6.5	7.6	11.0	31.0	5.5	4.2	10.1	12.1	31.9	−0.3	−2.3	2.4	1	65
70	7.4	8.3	9.2	12.7	37.6	6.9	5.1	12.4	13.5	37.9	−0.5	−3.2	3.1	0.9	70
75	9.9	10.6	10.9	14.2	45.6	9	6.3	15.2	14.3	44.8	−0.8	−4.2	4.3	0.1	75
80	13.2	13.2	12.2	14.7	53.4	12	8	18	13.8	51.8	−1.2	−5.3	5.8	−1	80
85	16.6	15.8	13.2	13.8	59.4	15.9	9.8	19.6	11.8	57.1	−0.6	−6	6.4	−2	85
90	19.5	18.2	13.8	12.8	64.3	21.3	11.6	19.6	9	61.5	−1.2	−6.6	5.9	−3.9	90
Age	Very Severe	Severe	Moderate	Mild	Total	Very Severe	Severe	Moderate	Mild	Total	Very Severe	Severe	Moderate	Mild	Age
60	18.0	20.4	24.7	36.9	100.0	17.1	13.0	30.9	39.0	100.0	−0.9	−7.4	6.2	2.2	60
65	18.6	21.1	24.6	35.7	100.0	17.2	13.2	31.7	37.9	100.0	−1.4	−7.9	7.1	2.3	65
70	19.7	22.1	24.6	33.6	100.0	18.2	13.5	32.7	35.6	100.0	−1.5	−8.6	8.1	2.0	70
75	21.7	23.2	24.0	31.2	100.0	20.1	14.1	33.9	31.9	100.0	−1.6	−9.2	10.0	0.8	75
80	24.8	24.8	22.8	27.6	100.0	23.2	15.4	34.7	26.6	100.0	−1.6	−9.4	11.9	−0.9	80
85	27.9	26.6	22.3	23.2	100.0	27.8	17.2	34.3	20.7	100.0	−0.1	−9.5	12.1	−2.5	85
90	30.3	28.3	21.4	20.0	100.0	34.6	18.9	31.9	14.6	100.0	4.3	−9.4	10.5	−5.3	90

Table 4
Average Age at Onset of Disability Among the Older Adults by Type, China 1987 and 2006

Type of Disability	1987	2006	Change (2006 to 1987)
Visual	63.6	63.9	0.3
Hearing and speech	61.6	64.5	2.9
Physical	52.8	57.5	4.7
Intellectual	42.0	45.7	3.7
Mental	45.7	47.8	2.0

Robine (1993) have shown that prevalence and incidence methods of computing active life expectancy result in very similar conclusions, except under unusual circumstance of very rapid change. After that, Crimmins et al. (Crimmins & Saito, 2001; Crimmins et al., 1997) used a prevalence-based method to evaluate the trend of DFLE in the United States from 1970 to 1990. Without unusual rapid change in China during this period, we believe the prevalence-based DFLE can show the trend of health in Chinese older adults.

DFLE is a more comprehensive indicator of health than life expectancy because it introduces the concept of quality of life. This article provides evidence that life expectancy increased in China between 1987 and 2006 for older adults and that these increases were concentrated in years spent without disability. Based on mortality data from several China census and reasonable assumption, the trend of life expectancy is reliable. The health status of older adults as a whole improved, but significant age differences still existed. Less change in DFLE was seen among the young old than the oldest old in the two decades studied.

Our results mirror the trend in the United States between 1980 and 1990, during which most of the increase in life expectancy was in disability-free years (Crimmins et al., 1997). Because there are many differences in data between the United States and China, we cannot compare the trend in detail. For example, first, the definitions and measures of disability were different: The United States studied ADL and IADL limitations, which are measures of self-reported disability, whereas the Chinese surveys used professional clinicians to measure performance-based disability. Second, the time period studied was longer in China than in the United States; perhaps the Chinese experienced decreases during the first several years and increases later on, just as DFLE in the United States decreased in the 1970s

increases later on, just as DFLE in the United States decreased in the 1970s

cause great long-term care needs in the near future. Study on consistent and further trends of disability among old adults in China is necessary.

and increased in the 1980s (Crimmins & Saito, 2001). Future international study should consider this issue to collect more comparable data, especially performance-based measures.

Sex differences exist between men and women in China with regard to DFLE. Men had higher proportions of DFLE than women at both survey times, although the absolute number of years of life expectancy was higher among women. This is consistent with findings from other countries (Belanger et al., 2002; Crimmins & Saito, 2001; Gispert et al., 2007). In addition, we found that the differences between men and women were constant during the period studied, a finding that, to date, has not been reported in other studies on China.

Proportion of DLE_s with very severe and severe disability decreased, whereas that of moderate and mild disability increased in every age group. Combined with the fact that the age at onset of disability was delayed over the time period studied, our study strongly supports the theory of compression of morbidity (Fries, 1980), especially among the oldest old.

The primary reasons for the increase in DFLE are the corresponding increase in life expectancy, changes in prevalence of disability, and revisions of standards of disability. Improved treatment and diagnosis have led to an increased life expectancy and delay in the progression of disease to disability. There are significant age differences in the health status of older adults in our study. For the young old (60 to 74), who were born in the 1930s and 1940s, when China was in war and had poor economic status, they experienced substantially hard and difficult living in early life. Many studies support the idea that one's general health status as a child and specific health events or problems later in life are related to health in old age (Crimmins, 2005). Our study may support this and indicate that intervention of bad early life events, especially those that are congenital (e.g., birth defects), would help prevent disabilities in older adults. For the oldest old people in our study, the result of mortality selection may be contribute to the fact that the Chinese oldest old tend to be more robust with respect to various genetic and nongenetic characteristics (Zeng et al., 2004) and thus the percentage of long-term severe morbidity does not increase substantially at extremely advanced ages. From above analysis, we can conclude that a different cohort may experience different stages of epidemiology transition. Future work on period and cohort factors that explain trends of health is very important (Crimmins, 2004). An implication of this study is, with the survival of the young old cohort, the increasing disability would cause great long-term care needs in the near future. Study on consistent and further trends of disability among old adults in China is necessary.

this field. Fortunately, China Disabled Person's Federation has conducted the follow-up survey, which is the second China national sample survey on

Limitations

There are several limitations to this study. First, the surveys included only community-dwelling elders and excluded those living in institutions. Estimates of prevalence of disability would have been higher had the highly disabled elders living in institutions been included, even though these persons accounted for only 0.7% of the total older adult population in 2005 (National Bureau of Statistics, People's Republic of China, 2006). However, the percentage is far lower than the United States. The institutionalized population age 50 and older is 2.4% in 2000 (U.S. Census Bureau, 2000); hence, institutionalization will have a larger impact on DFLE in the United States. A study from the United States has explored this effect (Crimmins et al., 1997). Second, education plays an important role in the prevalence of disability (Chou & Leung, 2008; Gispert et al., 2003; Pascual & Cantarero, 2007) as well as health expectancy (Lièvre et al., 2008). Future studies should strive to obtain detailed information about mortality based on educational background to calculate DFLE by education. Finally, there is no uniform definition or standards for measurement of disability worldwide, so it is hard to make comparisons between countries. Different methods of measuring disability may account for some of the discrepancies in findings between countries. Future work should focus on developing improved methodologies that will enable the capture of more uniform data that can be compared across borders.

Conclusion

This article provides the first estimates on trends of DFLE between 1987 and 2006 in China. Based on the two nationally representative and performance-based measures of disability data set in China, the health status of older adults as a whole improved, which reflected from the increase of DFLE as well as its proportion to life expectancy; the age at onset of disability was delayed; and the proportion of DLE_s with severe disability decreased, especially in the oldest old. Our study strongly supports the theory of compression of morbidity in China now. Chinese older adults live longer and the increases in life expectancy were concentrated in years spent without disability. Further research on detailed types as well as causes of DFLE would be meaningful, although caution must be taken in interpreting the results. Powerful methodology and comparable data are still needed in this field. Fortunately, China Disabled Person's Federation has conducted the follow-up survey, which is the second China national sample survey on

disability annually. We are looking forward to developing more valuable research based on those data.

Note

1. Because there is a bit of difference between the category of the two surveys, we calculate the hearing, speech, and both hearing and speech in 2006 together to compare with the same category in 1987. Meanwhile, dementia was taken out from intellectual disability to mental disability in 1987 to compare the corresponding two categories with 2006.

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