Trends in Selected Health Dimensions among the U.S. Elderly, 1982-1999

Peiyun She*†

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Abstract

This paper estimates and analyzes levels and trends in selected health dimensions (i.e., chronic conditions, sensory limitations, functional limitations, ADL disability, and IADL disability) among the US non-institutionalized elderly, using detailed data from the National Long Term Care Surveys (NLTCS) for 1982 to 1999. This paper also compares trends using measures that include the use of assistive devices versus measures that do not. The generalized estimating equation (GEE) approach is then adopted to examine whether there are significant time trends in various measures after controlling for sociodemographic characteristics, and whether there are differences in the probability of having various limitations among the sociodemographic groups. The results show evidence of improved health and declined disability. Moreover, whether to include the use of assistive devices in the definition greatly affects the levels and trends of selected sensory limitations and ADLs. The effectiveness of assistive devices in reducing disability is suggested. Significant differences have also been found for most sociodemographic groups for various measures.

As a result of population aging, there have been growing numbers and proportions of elderly people in the United States. The situation will be more acute when the Baby Boomers begin to reach old age in 2011. Since disability tends to increase with age in cross-sectional studies, the sustained increase of life expectancy has raised a concern about whether Americans are enjoying longer, healthier lives, or whether an increasing fraction of the life course is now spent in states of mild or severe disability. The concern is further strengthened by the economic strains of health expenditures on the disabled elderly, besides the impacts of disability on the afflicted ones, families, and caregivers. Much research has been conducted to address this concern, by examining

*Department of Demography, University of California, Berkeley, 2232 Piedmont Avenue, Berkeley, CA 94720; email: peiyun@demog.berkeley.edu

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either the trends in the prevalence of disability over time, or the trends in disability-free life expectancy relative to the trend in total life expectancy[1]. However, different studies vary greatly in terms of the specific measures used, largely depending on the availability of the information from the data set in use.

The terminology of disability was confusing and inconsistent before Nagi differentiated among a number of "closely related and often overlapping but analytically separable" phenomena surrounding disability (Nagi 1965). Nagi's model (Nagi 1965; Nagi 1991) clarifies terms and concepts of disability. According to his model, active pathology is interruption or interference with normal processes and efforts of the organisms to regain normal state; impairments are anatomical, physical, or mental abnormalities or losses in one physical system, such as a missing limb or brain damage; functional limitations refer to performance at the level of the whole organism, such as reaching or walking; disability refers to limitations in performance of social roles and tasks in the context of the socio-cultural and physical environment. Further, built on Nagi's framework, the disablement process was developed by the Institute of Medicine (Pope and Tarlov 1991) and Verbrugge and Jette (1994). The model describes how chronic and acute conditions affect functioning in specific body systems, generic physical and mental actions, and activities of daily life, and how the personal and environmental factors speed or slow the disablement process (Verbrugge and Jette 1994). One of the contributions of this model is that it elaborates the role of assistive technology, among other things, in the disablement process, as disability is deemed as the gap between personal capabilities and environmental demands. In addition, WHO's new classification, the International Classification of Functioning, Disability and Health (ICF) (WHO 2001) defines disability as a consequence of efforts to interact and participate within a variety of environments, which also recognizes the role of assistive technology in defining disability. Accordingly, disability could be differentiated into an individual's abilities regardless of situational requirements and those abilities as they are bolstered or diminished by a person's social and physical environment, that is, whether or not with personal or equipment assistance[2](Verbrugge and Jette 1994).

Based on these frameworks, considerable research has been conducted on disability trends among the US elderly[3]. Most often, functional limitations are measured by difficulty with specific body functions as proposed by Nagi (1976); and disability is measured by difficulty with activities of daily living (ADL) (Katz et al. 1963) and instrumental activities of daily living (IADL) (Lawton and Brody 1969). The results based on different surveys (covering roughly the 1980s and the 1990s periods) are mixed. The prevalence of overall disability (defined as having any ADL or IADL disability) has been shown to have declined by studies based on the National

[1]The latter is also referred to as the debate of compression versus expansion of morbidity/disability.

[2]Verbrugge and Jette (1994) coined them as intrinsic versus actual disability.

[3]For a comprehensive review and summary, please refer to Freedman et al. (2002).

Long Term Care Survey (NLTCS), the National Health Interview Survey (NHIS), and the Medicare Current Beneficiary Survey (MCBS). Moreover, studies based on the NLTCS, the NHIS, the MCBS, and the Supplements on Aging (SOA) to the NHIS showed declines in IADL disability. However, for overall ADL disability, conflicting evidence is offered: The NLTCS showed declines; the SOA showed increases; and the NHIS showed no changes. With respect to overall functional limitations, the SOA and the Survey of Income and Program Participation (SIPP) both showed declines while the MCBS showed increases. Studies on specific sensory limitations also provide mixed results: The SIPP showed declines in vision limitation; and the SOA showed no changes in vision or hearing limitations. The inconsistency amongst survey results has been due to both differences in survey design and differences in what has been actually measured in the surveys. The former refers to the sample design, the mode of interview, and the frequency and timing of interviews, etc. The latter differs in the specific measures used, question wordings, and the definitions of the measures, for example, intrinsic disfunction versus actual disfunction. Information based on one single sets of surveys would probably eliminate the above-mentioned inconsistency. Fortunately, the NLTCS provides detailed information on all the domains of the disablement process. However, previous studies based on the NLTCS have mainly focused on just the categories of any IADL and/or ADL disability (Manton et al. 1997; Manton and Gu 2001). Disability is an important dimension of health but clarification of trends in the other health dimensions, such as chronic conditions and functioning, are also important for understanding overall trends in health. Hence, it is both an opportunity and a need to provide further evidence concerning trends in the health dimensions based on the NLTCS.

Moreover, the NLTCS also offers the opportunity to compare trends using different constructions of disability measures – that is, measures that include the use of assistive devices versus measures that do not. Hence, one could differentiate between functional ability improvement measures that result from the use of aids, and those that result from true improvements in underlying health. In addition, in recognition that there have been compositional changes in the elderly population, and that few studies have focused on trends in disparities for major demographic and socioeconomic groups, this paper also aims to address the following questions: Are the disability trends confounded by changes in sociodemographic compositions of the elderly? And are all socioeconomic and demographic groups benefiting equally in the prevalence of disability and functioning?

1 Data and Methods

The National Long Term Care Surveys (NLTCS)[4], considered as "one of the best designed surveys for analyzing national disability trends" by Freedman et al. (2002), is

[4]More information about the NLTCS is available at http://www.cds.duke.edu.

used in this study. The NLTCS consists of a series of nationally representative surveys of Medicare beneficiaries aged 65 or over, with a particular emphasis on the elderly who are functionally impaired. Administered by the U.S. Bureau of the Census, the NLTCS began in 1982, and follow-up surveys were conducted in 1984, 1989, 1994 and 1999. The survey was designed to facilitate both longitudinal analysis, by re-surveying many of the same individuals in subsequent waves, and cross-sectional analysis at the time of each wave, by adding a sample of individuals who became 65 years of age since the previous survey. In addition, the institutionalized elderly were interviewed from 1984 on. However, the institutional survey does not have all the detailed measures as in the community survey. As a result, most of the measures examined are just for the non-institutionalized elderly, except for ADL disability, which is available for both institutionalized and non-institutionalized elderly. Question wordings are consistent across waves for identifying chronic conditions, sensory limitations, functional limitations, and disability. Detailed information on these health dimensions is listed in Table 1.

Chronic conditions. Questions were asked about whether the elderly person had any of 15 selected medical conditions at the time of the interview, and whether the elderly person had had any of 12 selected conditions in the last 12 months. In addition, information on Alzheimer's disease, mental retardation, and senility was collected through proxy respondents (except that information on Alzheimer's disease was not collected in 1982 or 1984).

Sensory limitations. Information on three sensory functions is available from all waves of the surveys. The question regarding vision sought to determine if the elderly person could see well enough to read ordinary newsprint, with or without glasses or contact lenses. Questions about speaking and hearing were asked only in those cases when the surveys were conducted through proxy respondents. The proxy was asked whether the elderly person's speech is understandable to most people, and whether he/she usually hears and understands what is being said to him/her without difficulty.

Functional limitations. The surveys asked respondents how difficult it is for them to carry out a variety of functions. Simply put, the seven functional limitations include basic body functions such as climbing, lifting and carrying, bending, reaching, and grasping. The questions asked the elderly to rate their levels of difficulty as "not difficult", "somewhat difficult", "very difficult", or "cannot perform the function at all". In this analysis, the categories of "somewhat difficult", "very difficult", and "cannot do it at all" are combined into one single category as "having some difficulty".

Disability. The NLTCS asks questions in greater detail than any other U.S. surveys on disability measures. Eight IADLs and six ADLs were assessed in detail. A person was chronically disabled on an ADL or IADL if the person could not perform (or was expected not to be able to perform) the activity without help for more than 90 days because of disability or health problems (including old age). Although the institutional surveys included the same ADLs, none of the IADLs questions were

Table 1: Measures on chronic conditions, functional limitations, and disability for the US non-institutionalized elderly, 1982-1999

Category	Detailed information
Medical conditions (at the time of the interview)	Arthritis, paralysis, other permanent numbness or stiffness, multiple sclerosis, cerebral palsy, epilepsy, Parkinson's disease, glaucoma, diabetes, cancer, frequent constipation, frequent trouble sleeping, frequent severe headaches, obesity or overweight, and arteriosclerosis or hardening of the arteries
Medical conditions (in the last 12 months)	A heart attack, any other heart problem, hypertension, a stroke, circulation trouble in arms or legs, pneumonia, bronchitis, flu, emphysema, asthma, a broken hip, and other broken bones
Mental conditions	Mental retardation, senility, and Alzheimer's disease
Sensory limitations	Vision, hearing, speaking
Functional limitations	Climbing one flight of stairs, Bending to put on his/her socks or stockings, Lifting a 10-pound package like a bag of groceries and holding it for a few minutes, Reaching above his/her head, Combing or brushing his/her hair, Washing his/her hair, Using his/her fingers to grasp and handle small objects
IADLs	Doing light housework, doing laundry, meal preparation, grocery shopping, getting around outside, getting to places outside of walking distance, money management, and using the telephone
ADLs	Eating, getting in and out of bed, getting around inside, dressing, bathing, and getting to the bathroom or using the toilet

Table 2: Assistive technology used by the US non-institutionalized elderly, 1982-1999

Category	Detailed information
Vision	Glasses or contact lenses
Hearing	Hearing aid
Speaking	Artificial larynx (voice box)
Eating	Special dishes/utensils
Dressing	Special clothing
Transferring	Railing, walker, cane, crutches, and bed lift
Inside mobility	Wheelchair, railing, walker, cane, crutches, brace, chairlift etc.
Bathing	Shower seat, walker, cane, hand-held shower, grab bars, etc.
Toileting	Raised toilet, walker, can, portable toilet, bedpan, etc.
Outside mobility	Wheelchair, walker, cane, crutch, brace, handrail, etc.
Phoning	Special telephone

asked.

In addition to these questions on various health dimensions, information is also available about the use of assistive technology for specific limitation or disability, as shown in Table 2. Starting from 1984, information was gathered on the use of assistive devices such as glasses, hearing aid, or voice box for sensory limitations. Detailed information on assistive devices used to accommodate ADL disability and selected IADL disability is also available for all waves. This information is taken into account when estimating contrasting measures for a single health dimension. For example, for vision limitation, difficulty in seeing with or without glasses or contact lenses, and difficulty in seeing without the devices are estimated. Hearing and speaking limitations are estimated in two ways: in one way, the self-respondents are assumed not to have any difficulty since they could participate in the surveys themselves; in the other way, if hearing aid or voice box were used, the elderly persons are considered to have the specific sensory limitation. For all the ADLs and one IADL (i.e., outside mobility), two definitions of disability are used here: one is the inability to perform the activity without personal help and/or assistive device; the other is the inability to perform the activity without personal help, in other words, if the elderly person used assistive devices alone to accommodate the disability, he/she is considered not to be disabled in that specific activity.

In this paper, I will first examine levels and trends in the prevalence of various measures of the selected health dimensions described above. All the estimates are weighted to represent the non-institutionalized elderly population, the institutionalized population, or the total elderly population, whatever appropriate. Missing cases are relatively small for the considered measures, and are omitted from the prevalence calculations for both numerator and denominator. Regression models will then be constructed to examine whether there are significant time trends in various measures after controlling for sociodemographic characteristics, and whether there are differ-

Table 3: List of independent variables (with reference categories in brackets)

Variables	Categories
Wave	1982, 1984, 1989, 1994, [1999]
Age	[65-69], 70-74, 75-79, 80-84, 85-89, 90+
Sex	[Male], Female
Race	White, [Non-white (i.e., black or other races)]
Marital status	Married, [Non-married (i.e., never married, divorced, or widowed)]
Educational level	0-8, 9-11, 12, [13+] years of schooling

ences in the probability of having various limitations among the sociodemographic groups.

A standard logistic regression model could have been used if the observations were thought to be independent, for example, if from a single cross-sectional study. However, since the NLTCS involves interviewing the same person more than once, this assumption of independence is obviously violated. To account for the dependency of subjects over time, I adopted the generalized estimating equation (GEE) approach, which was originally proposed by Liang and Zeger in 1986 (Liang and Zeger 1986; Diggle et al. 1994). Simply put, the GEE method accounts for the structure of the covariances of the correlated measures through its specification in the estimating process. The method is robust in the sense that it provides consistent estimates of the coefficients and their variances even if the correlation matrix is incorrectly specified. An exchangeable correlation structure, also know as compound symmetry, is used in estimating the models. Compound symmetry makes constant the correlations between any two measurements within a subject. Theoretically, each subject could have one covariance matrix, but the GENMOD procedure in SAS (version 8.1), which is used to carry out all the GEE estimations, only allows users to specify the same form of covariance matrix for all subjects.

The models take the form:

$$\boldsymbol{logit}[\boldsymbol{P}(\boldsymbol{Y_{ij}} = \boldsymbol{1}|\boldsymbol{X_{ij}} = \boldsymbol{x_{ij}}] = \boldsymbol{log}(\tfrac{\boldsymbol{P(Y_{ij}=1|X_{ij}=x_{ij})}}{\boldsymbol{P(Y_{ij}=0|X_{ij}=x_{ij})}}) = \boldsymbol{\beta_0} + \boldsymbol{\beta_1 x_{ij}}$$

Where $\boldsymbol{Y_{ij}}$ denotes the binary response for various disability measures, with 1 as having the disability and 0 otherwise, from subject $\boldsymbol{i}$ at time $\boldsymbol{j}$, for $\boldsymbol{i} = \boldsymbol{1, \cdots, n}$ and $\boldsymbol{j} = \boldsymbol{1, \cdots, 5}$; $\boldsymbol{x_{ij}} = \boldsymbol{(x_{ij1}, \cdots, x_{ijp})'}$ denote a $\boldsymbol{p \times 1}$ vector of explanatory variables associated with $\boldsymbol{y_{ij}}$; $\boldsymbol{corr(Y_{ij}, Y_{ij'}) = \rho}$, assuming exchangeable correlation structure. The six covariates are survey wave, age, sex, race, marital status, and educational levels, as shown in Table 3. Among them, survey wave, age, and educational levels are categorical variables, and are entered the regression models as sets of dummies, while sex, race, and marital status are considered as dummy variables. For each model, the odds ratios and the corresponding significance levels are presented.

2 Results

2.1 Descriptive analyses

2.1.1 Chronic conditions and comorbidity

Table 4 displays the estimates of prevalence for each chronic condition. The conditions are listed according to a decreasing order based on the 1999 estimates. A general observation is that there have been decreases between 1982 and 1999 in the reported prevalence of most diseases among the elderly population. For easy interpretation, these diseases and conditions could be divided into four broad categories according to the magnitude of their prevalence[5].

Except for diabetes, the seven most prevalent conditions all show obvious declines in prevalence over the survey period. Arthritis is the condition that has the highest prevalence for all waves, and it is also the one declining the most rapidly. The prevalence of arthritis has declined from 69% in 1982 to about 50% in 1999. Given that arthritis is the most or one of the most important disabling diseases, this has important implications for future functioning and disability. Hypertension, which is both a disease itself and a risk factor for other diseases, has also declined in prevalence gradually from 45% in 1982 to 39% in 1999. In addition, obesity or overweight, frequent trouble sleeping, circulation trouble in arms or legs, and heart problems other than heart attack all depict a decreasing trend. On the other hand, the prevalence of diabetes has increased from 11% in 1982 to 14% in 1999. Diabetes is a very costly disease, and can induce complications. The increase in diabetes prevalence may have big impact on health care expenditures.

In the category with second-highest level of prevalence, frequent constipation, numbness or stiffness other than arthritis, and arteriosclerosis also show a decreasing trend in prevalence. The prevalence for the other two conditions in this category, flu and bronchitis, increased from 1982 to 1989, and then decreased from 1989 to 1999; nevertheless, the proportions in 1982 are smaller than in 1999. The category of less prevalence displays a mixed picture, with the prevalence for glaucoma, cancer, and stroke increasing moderately, for emphysema, frequent severe headaches, and heart attack decreasing, and for asthma, pneumonia, and other broken bones increasing first and then decreasing. The fourth category contains those diseases and conditions with the smallest prevalence. Among them, the prevalence for Parkinson's disease, Alzheimer's disease, a broken hip, and multiple sclerosis has increased, while it has declined for the others. Nonetheless, the magnitude is small for any of these conditions.

In addition, the mean number of diseases and conditions has declined over time, as seen in Table 5 – When all 30 conditions are considered, the mean number has declined from over 4 in 1982 to near 3 in 1999. The declining trend is also supported

[5]The cutoff points are chosen arbitrarily.

Table 4: Estimated prevalence (per 100) of chronic conditions for the US non-institutionalized elderly aged 65 and over, 1982-1999

Conditions	1982	1984	1989	1994	1999
Rheumatism or arthritis	69.14	67.38	62.47	55.98	49.92
Hypertension	45.11	42.75	40.61	39.38	39.19
Obesity or overweight	30.13	27.74	25.41	22.49	17.99
Frequent trouble sleeping	36.07	34.68	28.41	23.68	17.97
Circulation trouble in arms/legs	40.79	37.50	32.01	22.29	17.38
Diabetes	11.22	12.10	14.00	13.81	14.09
Other heart problem	19.96	24.06	23.02	19.27	13.74
Frequent constipation	26.96	23.71	17.85	12.85	9.14
Other numbness/stiffness	18.84	15.50	14.66	12.04	8.69
Flu	16.42	17.03	19.00	10.87	8.68
Bronchitis	9.94	11.70	12.28	11.32	7.96
Arteriosclerosis	20.37	18.83	14.99	10.63	7.60
Glaucoma	5.87	5.75	6.62	7.06	6.57
Cancer	5.80	5.69	5.02	5.88	5.99
Asthma	6.87	7.10	6.52	5.23	5.58
Emphysema	8.41	9.02	6.04	5.97	5.08
Frequent severe headaches	14.37	14.25	12.43	7.50	4.38
Stroke	3.16	2.18	2.32	3.71	3.81
Pneumonia	2.81	2.87	5.00	3.96	3.05
Heart attack	3.64	3.84	2.89	2.10	2.93
Other broken bones	3.86	3.56	5.17	4.58	2.84
Paralysis	2.97	2.87	3.26	2.20	1.65
Parkinson's disease	0.77	1.49	1.25	1.11	1.32
Senility	2.62	2.20	1.71	1.51	1.21
Alzheimer's disease	NA	NA	0.56	0.78	0.91
A broken hip	0.49	0.56	0.83	0.95	0.82
Multiple sclerosis	0.11	0.46	0.23	0.13	0.27
Epilepsy	0.95	0.44	0.94	0.26	0.24
Mental retardation	0.75	0.52	0.18	0.28	0.14
Cerebral palsy	0.10	0.21	0.05	0.06	0.08

Table 5: Mean number of chronic conditions for the US non-institutionalized elderly aged 65 and over, 1982-1999

Number of conditions	1982	1984	1989	1994	1999
Among 30 conditions	4.08	3.95	3.64	3.06	2.55
Among 6 conditions	1.85	1.82	1.73	1.59	1.42

Table 6: Estimated prevalence (per 100) of comorbidity for the US non-institutionalized elderly aged 65 and over, 1982-1999

Category	1982	1984	1989	1994	1999
no conditions	4.59	6.08	7.98	12.91	19.33
1 condition	9.48	9.86	14.95	16.73	19.85
2 or more conditions	85.93	84.07	77.07	70.36	60.82

when just the six common conditions are considered, where it has declined from 1.85 to 1.42. The six conditions chosen are those well-known and considered to affect functioning and disability to a large extent, which include arthritis, hypertension, obesity, diabetes, cancer, and cardiovascular disease[6]. Furthermore, although the majority of the elderly (ranging from about 60% to about 86%) have more than one condition (i.e., experience comorbidity), the proportions with comorbidity have declined, and the proportions with no condition or just one condition have increased over the survey period, as shown in Table 6. The magnitude of change is large, for example, there have been an absolute increase of about 15 percentage points in having no condition, and an absolute increase of 10 percentage points in having just one condition over the period from 1982 to 1999.

2.1.2 Functional limitations

This section presents the results for sensory and other functional limitations, as illustrated in Table 7 and Table 8, respectively. When actual limitations are considered, the proportions with vision impairment have declined gradually over the survey period, from about 11% in 1982 to about 9% in 1999. The prevalence for hearing and speaking impairment is relatively small. Only about one percent of the elderly population has speaking limitation. However, a general trend of decreasing prevalence is also shown, although with some fluctuations – the prevalence with hearing problem has declined from about 4% to 1.6%, while it has declined from 1.14% to 0.83% for speaking impairment. On the other hand, the use of assistive devices to accommodate these limitations has changed over the survey period, as shown in Table 7. The proportions using glasses or contact lenses have declined over time, but remain very large – about 90% of the elderly used glasses or contact lenses. For hearing aid, the prevalence increased from about 9% in 1984 to about 11% in 1999. The proportions using artificial larynx are extremely small all the time, nonetheless, these figures show an upward trend. The prevalence of sensory limitations is then estimated taking into account the use of assistive devices, that is, treating the use of devices as a sign of limitation. For example, if the elderly person reports no difficulty in vision while at the same time reporting wearing glasses or contact lenses, the person is reclassified as limited in vision. Similar adjustments are made for hearing and speaking limitations.

[6]In this analysis, cardiovascular disease includes heart attack, stroke, and other heart problems.

Table 7: Estimated prevalence (per 100) of sensory limitations and related AT use for the US non-institutionalized elderly aged 65 and over, 1982-1999

	1982	1984	1989	1994	1999
Prevalence:					
Vision	11.36	11.02	10.74	10.13	8.95
Hearing	3.83	4.26	3.72	3.01	1.65
Speaking	1.14	1.01	1.47	1.02	0.83
Prevalence:					
Glasses/contact lenses	NA	93.60	90.10	92.28	89.40
Hearing aid	NA	8.82	10.11	11.15	10.86
Artificial larynx (voice box)	NA	0.03	0.08	0.16	0.20
Prevalence (adjusted):					
Vision	NA	95.76	92.54	94.54	92.19
Hearing	NA	12.04	13.22	13.25	11.95
Speaking	NA	1.02	1.55	1.18	1.03

After such adjustments, the proportions of sensory limitations increase dramatically for vision, increase substantially for hearing, and increase slightly for speaking. However, the trends have become less visible and less smooth. Given that wearing glasses or contact lenses is common and does not impose much inconvenience in daily life, the adjustment for vision might not tell much. On the contrary, the use of hearing aid and the use of artificial larynx do suggest the severity of the impairment, and might be well taken into account. The results suggest that hearing aid and voice box are effective and important in accommodating hearing or speaking limitations.

It varies much across functions for the proportions of the elderly having some difficulty, as shown in Table 8. The functions are listed in the table from the highest to the lowest prevalence in having difficulty. The most challenging activity for the elderly is to climb one flight of stairs. Lifting a 10-lb package and bending to put on socks are the next challenging activities for the elderly. On the other hand, the least demanding activities are to comb or wash one's hair. The general pattern is that the proportions with no difficulty have increased over time, while the proportions with various levels of difficulty have declined. For example, more than one half of the elderly have some levels of difficulty in climbing one flight of stairs, but it has improved greatly over time in this function – the proportions having difficulty have declined from about 51% to less than 37%. Similar declining patterns with various magnitudes could be found for many other activities, and most of them have declined substantially.

Table 8: Estimated prevalence (per 100) of having some difficulty in functional limitations for the US non-institutionalized elderly aged 65 and over, 1982-1999

Functional limitations	1982	1984	1989	1994	1999
Climb stairs	51.38	57.45	50.11	41.76	36.66
Lift packages	36.68	38.30	30.25	26.01	22.11
Bend to put on socks	31.65	30.47	26.63	23.47	18.61
Reach over head	23.07	21.84	19.76	16.03	11.66
Grasp small objects	20.64	18.67	17.45	13.32	12.39
Wash one's hair	14.95	17.27	14.83	11.54	9.49
Comb one's hair	11.31	10.71	8.76	7.58	7.05

2.1.3 ADLs and IADLs

As illustrated in Table 9, more than 80% of the non-institutionalized elderly could perform ADLs and IADLs independently. The proportions increased from 1984 to 1994, while decreased from 1994 to 1999. The overall trend shows a moderate decrease (from about 18% to about 17%) in the proportions of the elderly disabled in ADLs or IADLs. Specifically, the proportions of the elderly disabled in just IADLs or at least one IADL have declined, while for ADLs the proportions have increased slightly. In more details, there were no big changes in the prevalence for one or two ADLs, an increasing, though small, trend for three or four ADLs, and a decreasing trend for five to six ADLs. For IADLs, except for the category of having just one IADL problem, the prevalence of having two to eight IADLs has declined over the survey period. In addition, Table 10 detailed the prevalence for each ADL and IADL over time. Among the ADLs, the order from the highest to the lowest prevalence (from about 10% to about 2%) is bathing, inside mobility, transferring to and from bed, toileting, dressing, and eating. The order by prevalence for the IADLs (from about 13% to about 3%) is: getting around outside, going to places outside of walking distance, shopping, doing laundry, cooking, doing light housework, managing money, and making phone calls. All the IADLs, except for getting around outside, made some improvements over time, with difficulties in doing laundry and shopping declining the most. As for ADLs, it shows a mixed picture. Three ADLs (i.e., eating, dressing, and getting around inside) showed moderate decreases in prevalence over the survey period, while the other three (i.e., transferring to and from bed, toileting, and bathing) showed increases in prevalence.

At the same time, the proportions of the elderly using assistive devices to accommodate disability have changed over time, as shown in Table 11. For most activities, there have been increasing time trends in AT usage. The most rapid increase is found for bathing – from about 46% in 1982 to about 80% in 1999. Device usage for toileting and transferring has also increased rapidly. On the other hand, the proportions using devices for inside or outside mobility have been high, although no large increases have been shown over time. In contrast, the use of AT for eating and dressing remained

Table 9: Estimated prevalence (per 100) of disability groups for the US non-institutionalized elderly aged 65 and over, 1982-1999

Category	1982	1984	1989	1994	1999
ADL and IADL:					
No ADLs or IADLs	81.92	81.49	82.83	84.13	82.84
ADLs or IADLs	18.08	18.51	17.17	15.87	17.16
IADLs only	4.77	5.40	3.86	3.50	3.23
ADL:					
At least one ADL	13.31	13.10	13.31	12.37	13.93
1 ADL	4.17	4.25	3.94	3.66	4.15
2 ADLs	2.59	2.57	2.77	2.43	2.87
3 ADLs	1.69	1.90	2.04	2.05	2.16
4 ADLs	1.27	1.12	1.66	1.30	1.62
5 ADLs	1.46	1.33	1.55	1.35	1.16
6 ADLs	2.13	1.93	1.36	1.59	1.96
IADL:					
At least one IADL	17.33	17.64	16.12	14.73	15.50
1 IADL	3.16	4.02	3.97	3.78	5.14
2 IADLs	2.76	2.78	2.32	2.30	2.39
3 IADLs	2.76	2.63	2.51	2.08	2.01
4 IADLs	2.09	2.21	1.92	1.67	1.13
5 IADLs	1.51	1.63	1.26	1.29	0.93
6 IADLs	1.86	1.65	1.55	1.44	1.36
7 IADLs	1.60	1.26	1.31	1.01	1.16
8 IADLs	1.58	1.46	1.27	1.15	1.37

Table 10: Estimated prevalence (per 100) of specific IADLs and ADLs for the US non-institutionalized elderly aged 65 and over, 1982-1999

Activity	1982	1984	1989	1994	1999
Eating	2.73	2.40	2.20	2.10	2.49
Dressing	5.30	4.68	4.57	4.06	4.28
Toileting	5.60	5.47	5.52	5.84	6.60
Getting in/out of bed	6.58	6.17	6.34	5.78	7.28
Getting around inside	9.36	8.98	9.38	8.78	9.22
Bathing	10.04	10.09	10.11	9.59	10.60
Making phone calls	3.91	3.47	3.05	2.38	2.35
Managing money	5.57	5.41	4.96	4.49	4.21
Light housework	5.36	4.99	4.58	4.38	4.52
Preparing one's meals	6.54	5.98	5.45	5.11	4.72
Doing laundry	9.14	8.39	7.49	6.48	5.77
Grocery shopping	12.28	11.60	10.40	8.98	7.89
Going places outside of walking distance	12.14	12.19	10.07	9.33	9.50
Getting around outside	12.97	12.87	12.76	11.58	13.42

low with moderate increases over time. As discussed earlier, if AT alone resolves the specific disability for the elderly person, he/she could be alternatively defined as non-disabled in that activity. As shown in Table 12, the corresponding estimated prevalence is smaller, as compared to the results in Table 10. More importantly, all the activities in Table 12 display some degree of improvement. This indicates that AT to some degree resolves the elderly person's inability in performing certain daily activities. The differences in the prevalence of eating and dressing between the two are small, while there are large disparities for toileting, bathing, and three mobility-related activities (i.e., transferring, inside, and outside mobility). The results suggest the efficiency of AT in elevating the disability in mobility-related activities. For example, the unadjusted prevalence of disability in inside mobility was more than 9% for 1999, while the adjusted one was not yet 3%. In addition, AT also played a significant role in reducing disability in bathing and toileting.

Compared to the community-dwelling elderly, prevalence rates were much higher for the institutionalized elderly (see Table 14), as expected. The dominant majority of the institutionalized elderly (from 90% to 97%) had at least one ADL disability. The proportion increased rapidly from 1984 to 1989, but have not changed afterwards in a decade. Specifically, most institutionalized elderly (about 90%) needed help in bathing, and more than 80% needed help in inside mobility. The lowest prevalence in disability was for eating, but still about 45% of the elderly needed help on that. Almost all ADLs showed increasing time trends in prevalence: the trends have increased moderately for eating and bathing, while more rapidly for the other four activities.

Furthermore, the prevalence of disability in ADLs is estimated for the total US

Table 11: Estimated proportions of AT usage for ADLs for the US non-institutionalized elderly aged 65 and over, 1982-1999

(I)ADLs	1982	1984	1989	1994	1999
Inside mobility	80.62	81.74	83.88	87.43	86.99
Toileting	62.81	67.55	76.36	84.36	81.45
Transferring	66.81	71.08	76.67	79.42	81.37
Bathing	46.37	51.52	62.28	68.28	80.47
Outside mobility	68.23	69.82	72.05	73.80	69.00
Eating	10.47	7.27	12.40	12.11	11.82
Dressing	9.13	7.31	8.96	11.45	10.15

Table 12: Estimated prevalence (per 100) of adjusted disability in specific ADLs for the US non-institutionalized elderly aged 65 and over, 1982-1999

Activity	1982	1984	1989	1994	1999
Eating	2.60	2.32	2.07	1.95	2.37
Toileting	3.27	2.87	2.65	2.47	2.85
Getting around inside	3.49	3.15	3.23	2.73	2.96
Getting in/out of bed	3.69	3.18	3.07	2.76	2.95
Dressing	5.03	4.53	4.37	3.79	4.04
Bathing	7.10	6.64	6.13	5.63	5.16
Getting around outside	7.50	7.15	6.96	4.97	5.79

Table 13: Estimated prevalence (per 100) of disability for the US institutional elderly aged 65 and over, 1984-1999

Status	1984	1989	1994	1999
At least one ADL	91.62	97.09	96.71	97.03
No ADL	8.38	2.91	3.29	2.97
Eating	43.29	45.03	44.40	45.45
Dressing	72.34	77.34	78.94	82.26
Toileting	61.34	64.60	74.87	76.60
Transferring to and from bed	76.20	77.94	78.99	85.04
Inside mobility	80.51	81.81	83.20	86.40
Bathing	93.42	95.56	94.44	94.29

Table 14: Estimated prevalence (per 100) of disability for the US elderly aged 65 and over, 1984-1999

Category	1984	1989	1994	1999
Eating	4.54	4.54	4.26	4.26
Dressing	8.22	8.54	7.89	7.49
Toileting	8.39	8.74	9.37	9.49
Getting in/out of bed	9.82	10.25	9.52	10.48
Getting around inside	12.70	13.34	12.58	12.40
Bathing	14.43	14.77	13.93	14.05
No ADLs or IADLs	77.01	78.31	79.83	79.43
IADL only	5.57	3.81	3.49	3.22
1-2 ADLs	7.34	7.18	6.41	7.01
3-4 ADLs	3.95	4.59	4.07	4.50
5-6 ADLs	6.13	6.12	6.20	5.84

elderly population, that is, the combined institutionalized and non-institutionalized elderly, from 1984 to 1999. The results are shown in Table 14. Compared to the figures in Table 9 and Table 10, similar patterns are found for the combined population, although they differ in magnitude. For example, the estimated proportions non-disabled in 1984 have changed from about 81% for the non-institutionalized elderly to about 77% for the combined population, and from about 83% to about 79% in 1999. In addition, the prevalence for each ADL has increased compared to that shown in Table 10. For the combined population, the general trend is that the proportions non-disabled have increased over time (from 77% to more than 79%), the proportions having just IADLs have declined, and the proportions disabled in ADLs displayed a mixed picture. The prevalence over time for 1-2 and 5-6 ADLs has declined, while it has increased for 3-4 ADLs. For specific activities, the patterns are as follows: The prevalence for eating and dressing has declined slightly; for transferring to and from bed and toileting, it has increased; and for getting around inside and bathing, it has fluctuated to slightly lower levels.

2.2 GEE analyses

2.2.1 Chronic conditions and comorbidity

This section presents results from the GEE models for selected conditions and comorbidity. The selected conditions include arthritis (one of the non-lethal conditions), cardiovascular disease (one of the lethal conditions), diabetes (one of the most costly conditions), hypertension (an important risk factor and chronic condition). The analysis of comorbidity is constrained to the elderly having at least one condition, and it contrasts having just one condition versus having more than one condition (i.e., comorbidity). The results are presented in Table 15.

Table 15: Odds ratio estimates from the GEE models for selected chronic conditions for the US non-institutionalized elderly aged 65 and over, 1982-1999

Predictors	Arthritis	Cardiovascular	Diabetes	Hypertension	Comorbidity
Wave					
1982	**1.4967*****	**1.2928*****	**0.6146*****	0.9785	**1.8455*****
1984	**1.4200*****	**1.2776*****	**0.6383*****	**0.8844****	**1.6915*****
1989	**1.3111*****	**1.2870*****	**0.8326*****	**0.8570*****	**1.4179*****
1994	**1.1209*****	**1.1386*****	**0.9894*****	**0.8812*****	**1.2247*****
1999	-	-	-	-	-
Age					
65-69	-	-	-	-	-
70-74	**1.0942***	**1.1159****	0.9894	1.0048	0.8896
75-79	**1.1654*****	**1.1933*****	**0.8948***	**0.8958****	0.9488
80-84	**1.1302****	**1.2848*****	**0.7731*****	**0.7966*****	**0.8360****
85-89	1.0367	**1.3143*****	**0.6172*****	**0.6629*****	**0.7986****
90+	0.8935	**1.2507*****	**0.4077*****	**0.5180*****	**0.7127*****
Sex					
Male	-	-	-	-	-
Female	**1.8916*****	0.9973	1.0869	**1.6934*****	**1.1940*****
Race					
White	**0.8506****	1.0911	**0.6784*****	**0.5733*****	0.8956
Others	-	-	-	-	-
Marital status					
Married	1.0030	0.9734	1.0117	1.0405	0.9825
Others	-	-	-	-	-
Education					
0-8 years	**1.6113*****	**1.2343*****	**1.7723*****	**1.2814*****	**1.4652*****
9-11 years	**1.5358*****	**1.1849*****	**1.8632*****	**1.3467*****	**1.5206*****
12 years	**1.1305****	1.0658	**1.2839*****	1.0494	1.1073
13+ years	-	-	-	-	-

Note: Significance levels: $***$ **.001**, $**$ **.01**, $*$ **.05**

After controlling for sociodemographic characteristics, significant decreasing time trends have been found for arthritis, cardiovascular disease, and comorbidity, while significant increasing time trends for diabetes and hypertension. Among those showing improvements over time, the magnitude of declines was the biggest for comorbidity – the odds of having comorbidity in 1982 were about 1.8 times higher than the odds in 1999, and the odds were about 1.7, 1.4, and 1.2 times higher for 1984, 1989, and 1994, respectively, in comparison with 1999. The odds of having either arthritis or cardiovascular disease have also declined over time, with arthritis declining more than cardiovascular disease. On the other hand, a significant increasing time trend was shown for diabetes – the odds for having diabetes in 1982 were about 61% as high as the level of 1999, and the percentages have increased to about 64% in 1984, about 83% in 1989, and about 99% in 1994. As for hypertension, there was no significant difference in the odds between 1982 and 1999, and the odds in 1984, 1989, and 1994 were about 12% less than the odds in 1999. In other words, the odds of having hypertension have declined from 1982 to 1984, remained at about the same levels until 1994, and increased from 1994 to 1999. These results agree with the descriptive analyses discussed earlier, except for hypertension, for which a decreasing time trend was found.

With respect to the sociodemographic characteristics, age effects are found to vary among the models. The odds of having cardiovascular disease have increased with age, although the rate of increase slowed down for ages above 90. For arthritis, the odds have increased with age for the young elderly, and there was no significant difference between the oldest old (i.e., ages above 85) and ages 65-69. On the other hand, the odds of having diabetes or hypertension were found to have declined gradually with age after age 75. For comorbidity, the odds have declined with age after age 80, while there have been no significant differences between ages 70-79 and ages 65-69. As for other factors, the odds were higher for women than for men in having arthritis, hypertension, or comorbidity, while there was no significant gender difference in the odds of having cardiovascular disease or diabetes. Whites were less likely than non-Whites to have arthritis, diabetes, or hypertension, while for cardiovascular disease or comorbidity, no significant differences were found between Whites and non-Whites. Marital status was not found to be significant for any of these four conditions or comorbidity. On the other hand, educational attainment was shown to have a negative effect on the probability of having any of the selected conditions or comorbidity. That is, the more education (i.e., at least high school graduate) a person has, the less likely it is that he or she will have any of the selected conditions or comorbidity.

2.2.2 Sensory limitations

The results from the GEE models for the probability of having functional limitations (including sensory limitations) are shown in Table 16 to Table 18.

Based on the models, all three sensory functions have been shown to display some

Table 16: Odds ratio estimates from the GEE models for sensory limitations for the US non-institutionalized elderly aged 65 and over, 1982-1999

Predictors	Vision	Hearing	Speaking	Hearing (adjusted)
Wave				
1982	**1.4488*****	**2.0493*****	**1.2890***	NA
1984	**1.4222*****	**1.9842*****	**1.3258****	1.0145
1989	**1.3746*****	**1.7650*****	**1.5376*****	**1.1724****
1994	**1.1463*****	**1.7074*****	1.0855	**1.1616****
1999	-	-	-	-
Age				
65-69	-	-	-	-
70-74	**1.3206*****	**1.3203****	1.1586	**1.3659*****
75-79	**1.6549*****	**1.8615*****	1.1925	**1.9462*****
80-84	**2.2237*****	**2.9600*****	**1.3737****	**2.9758*****
85-89	**3.1588*****	**4.9469*****	**2.2029*****	**4.8629*****
90+	**4.5300*****	**9.3325*****	**2.3533*****	**8.4729*****
Sex				
Male	-	-	-	-
Female	0.9964	**0.5135*****	**0.6231*****	**0.5038*****
Race				
White	**0.7755*****	1.1297	**0.7519****	**1.6782*****
Others	-	-	-	-
Marital status				
Married	**0.9225***	1.0315	**1.1930***	1.0644
Others	-	-	-	-
Education				
0-8 years	**1.7825*****	**2.2397*****	**1.6013*****	**1.2104****
9-11 years	**1.3351*****	**1.5103*****	1.1412	1.1459
12 years	1.0456	**1.3632*****	**1.3030***	0.9601
13+ years	-	-	-	-

Note: Significance levels: $***$ **.001**, $**$ **.01**, $*$ **.05**

improvements over the survey period. Significant decreasing time trends were found for the odds in having any limitations, with the magnitude of declines being larger for hearing limitation. For speaking limitation, the time trend was not as strong or smooth as for vision or hearing impairment. The odds of having speaking problem have increased from 1982 to 1989, and declined afterwards to a lower level than in 1982. In addition, the risks of deterioration in sensory functioning have increased rapidly with age, especially for hearing. For example, the odds of hearing limitation were about 9 times higher for ages 90 and over than for ages 65-69. On the other hand, only ages 85 and above were found to be significantly more likely to have speaking problem than ages 65-69. The odds were much lower (about 40-50%) for females than for males to have hearing or speaking limitations, while no significant difference was found for vision limitation. Whites were less likely than non-whites to have vision or speaking limitations, while race is insignificant in accounting for differences in hearing limitation. The effects of marital status were mixed: as compared to the non-married, the married had lower odds in having vision limitation, higher odds in having speaking limitation, and no significant difference in having hearing limitation. With respect to educational attainment, the effect was stronger for hearing than for vision or speaking – The odds of having hearing limitation were more than two times higher for the elderly with less than eight years' education than with more than 13 years' education. As for vision limitation, having a high school education has significantly reduced the odds, while no significant difference was found between the high school graduates and the college attendees. On the other hand, the elderly with less than 8 years or 12 years of education, while not those with 9-11 years of education, have experienced significantly more speaking limitation than those with 13 or more years of education.

As the use of hearing aid has been found from previous descriptive analysis to have some impact on the trends in hearing limitation, the model for the probability of having difficulty in hearing with or without hearing aid is also estimated, as shown in the last column of Table 16. When hearing aids are considered, there was a significant decreasing trend from 1989 to 1999, though the declines were much smaller – which implies that the use of hearing aid was effective in eliminating hearing limitation for some elderly persons. Similar to the unadjusted version, hearing limitation has increased dramatically with age – the odds were a bit larger in younger ages and a bit smaller in older ages. In agreement with the unadjusted model, women were less likely to have hearing limitation. As for racial factor, no significant difference was found for the unadjusted version, however, the adjusted model shows that whites were more likely than non-whites to have hearing problem or using hearing aid. This would imply that whites had more access to hearing aid or were more willing to use hearing aids to accommodate their hearing problem, and that such accommodations were effective. Same as before, marital status was not found to be a significant factor. As for educational attainment, the effects were smaller for the adjusted model, and only the elderly with less than 8 years of schooling have higher odds than those with

13 years or more.

Table 17 and Table 18 present the results from the GEE models for the seven functional limitations. As shown, the results are similar across functions in levels of significance, though different in the magnitude of effects. For brevity, I will describe them in general instead of one by one.

Significant decreasing time trends have been shown for all the seven functional limitations. The odds have declined more rapidly for lifting a 10-pound package, climbing a flight of stairs, washing one's hair, and reaching over one's head, with the odds being more than two times higher in 1982 than in 1999. For some functions (climbing a flight of stairs, lifting a 10-lb package, and washing one's hair), the odds have increased with age after age 75; while for some other functions (reaching to put on socks, use fingers to grasp and handle small objects, and combing one's hair), it was not until age 80 did age start to take effect, and the odds have increased thereafter. In addition, the age effect for bending to put on socks was mixed: Compared to ages 65-69, the odds for ages above 90 were 1.60 times higher, while the odds for ages 75-79 were 10% lower. On the other hand, women were more likely than men to have difficulty with all these functions. Gender differences were much bigger for lifting a 10-pound package and washing one's hair, due to gender differences in muscle strength for the former and expected gender difference in the complexity of the task for the latter. Without exception, whites were found to be less likely than non-whites to have any of these functional limitations. The effects of marital status were not as clear: compared to the non-married, the odds for the married were lower for climbing stairs and lifting packages; the odds were higher for combing one's hair; and no significant differences were found for the other functions. The effects of educational attainment were highly significant and were in the expected direction – The more years of education a person has, the smaller risk it is that he or she would have the difficulty in any of these functions.

2.2.3 ADLs and IADLs

The results from the GEE analyses for ADLs disability and IADLs disability are shown in a series of tables: Table 19 for the six ADLs; Table 20 for the selected ADLs, with adjustment to AT use; and Table 21 and Table 22 for the eight IADLs.

As shown in Table 19, after sociodemographic characteristics are controlled, there were significant decreasing time trends for disability in dressing, inside mobility, and bathing, though the trends leveled off from 1994 to 1999. On the other hand, there were no significant trend for disability in toileting, and mixed trends for disability in eating or transferring. For eating, the odds have declined from 1982 to 1994, and increased from 1994 to 1999; while for transferring, no significant differences were found in the odds between 1982-1989 and 1999, though the odds in 1994 were about 23% lower than in 1999. Age effects were significant for all the ADLs disability. For inside mobility or bathing, the odds of disability have increased gradually and

Table 17: Odds ratio estimates from the GEE models for functional limitations for the US non-institutionalized elderly aged 65 and over, 1982-1999

Predictors	Climbing stairs	Lifting packages	Bending
Wave			
1982	**2.4909*** **	**2.6378*** **	**1.9029*** **
1984	**2.2118*** **	**2.2665*** **	**1.6397*** **
1989	**1.8273*** **	**1.9863*** **	**1.6807*** **
1994	**1.1662*** **	**1.2049*** **	**1.2169*** **
1999	-	-	-
Age			
65-69	-	-	-
70-74	1.0668	1.0183	0.9481
75-79	**1.1711*** **	**1.1935*** **	**0.9074** **
80-84	**1.4576*** **	**1.5055*** **	1.0022
85-89	**1.9032*** **	**2.1043*** **	1.0421
90+	**3.2502*** **	**3.7092*** **	**1.6144*** **
Sex			
Male	-	-	-
Female	**1.5518*** **	**2.3268*** **	**1.1194*** **
Race			
White	**0.8549** **	**0.7140*** **	**0.8902** **
Others	-	-	-
Marital status			
Married	**0.8747*** **	**0.9038** **	0.9926
Others	-	-	-
Education			
0-8 years	**1.9587*** **	**1.7921*** **	**1.5137*** **
9-11 years	**1.7887*** **	**1.5037*** **	**1.3276*** **
12 years	**1.2784*** **	**1.2626*** **	**1.1028***
13+ years	-	-	-

Note: Significance levels: $***$ **.001**, $**$ **.01**, $*$ **.05**

Table 18: Odds ratio estimates from the GEE models for functional limitations for the US non-institutionalized elderly aged 65 and over, 1982-1999 (cont.)

Predictors	Reaching	Grasping	Washing hair	Combing hair
Wave				
1982	**2.0862*** **	**1.4557*** **	**2.1586*** **	**1.7170*** **
1984	**1.6954*** **	**1.3499*** **	**1.8618*** **	**1.4941*** **
1989	**1.6963*** **	**1.3757*** **	**1.8713*** **	**1.4690*** **
1994	**1.2941*** **	1.058	**1.2748*** **	**1.1033***
1999	-	-	-	-
Age				
65-69	-	-	-	-
70-74	1.0426	1.0354	1.0743	1.0237
75-79	1.0292	1.0492	**1.2222*** **	1.0447
80-84	**1.0907***	**1.1324****	**1.6168*** **	**1.2467*** **
85-89	**1.2501*** **	**1.2589*** **	**2.1076*** **	**1.4407*** **
90+	**1.6250*** **	**1.5874*** **	**3.7000*** **	**2.1152*** **
Sex				
Male	-	-	-	-
Female	**1.5029*** **	**1.2223*** **	**2.1322*** **	**1.8895*** **
Race				
White	**0.8294*** **	**0.8398*** **	**0.7100*** **	**0.6309*** **
Others	-	-	-	-
Marital status				
Married	1.0014	1.0490	1.0429	**1.1070****
Others	-	-	-	-
Education				
0-8 years	**1.6822*** **	**1.4745*** **	**1.4843*** **	**1.6599*** **
9-11 years	**1.5580*** **	**1.4094*** **	**1.3689*** **	**1.4172*** **
12 years	**1.1256****	**1.1443****	**1.1570****	**1.1480****
13+ years	-	-	-	-

Note: Significance levels: $***$ **.001**, $**$ **.01**, $*$ **.05**

smoothly with age until ages above 90, when the odds increased dramatically. The odds of having disability in transferring or toileting have increased with age after age 75, and for disability in eating or dressing, the odds have increased significant with age after age 80. For bathing or toileting, the odds of disability were higher for women than for men, while no significant gender differences were found for the other four ADLs. Whites were shown to have lower disability risks than non-whites in all the ADLs except for bathing. For four activities (i.e., eating, dressing, transferring, and toileting), the odds in disability for the married were higher than for the non-married; the direction reversed for toileting; and no significant difference was found for bathing. The elderly with less than 8 years of schooling had significantly higher odds than those with more years of education in having any of the ADLs disability except for toileting.

The results in Table 19 do not show significant time trends for transferring or toileting. Given that AT plays an important role in resolving disability, and that earlier descriptive analyses have shown large increases over time in the use of assistive device for transferring, toileting, and bathing, it is interesting to examine whether there were significant decreasing time trends for these activities after taking into account the use of assistive devices, that is, when disability is considered as the inability to carry out the activity with or without assistive devices. The results based on the corresponding GEE models are presented in Table 20. As shown, significant decreasing time trends have been found for disability in transferring or toileting, although the trends leveled off from 1994 to 1999. In addition, for bathing disability, the magnitude of declines over time was larger compared to the results in Table 19. As for other factors, the effects of race, marital status, and educational attainment have become larger, and gender effect has become significant (with females having higher odds than males), for disability in transferring. With respect to disability in toileting, the effects of race and marital status have become larger, educational attainment has become significant, while gender has become insignificant. Finally, the effects of race, marital status, and educational attainment have become highly significant in explaining disability in bathing. In general, differences in AT usage have strengthened the differences in the actual disability for these selected ADLs.

As compared to the results for ADLs disability, the GEE regression models for IADLs disability have displayed more homogeneous patterns, as shown in Table 21 and Table 22. The risks of being disabled in any of these IADLs are shown to have declined over the survey period. It has declined more rapidly for shopping, doing laundry, and going places outside of walking distance, while for doing housework and making phone calls, the trends leveled off in the recent two waves. One exception is disability in outside mobility, for which the odds in 1994 were significantly higher than in 1999. For all these activities, the odds of disability have increased rapidly with age. – For some activities (i.e., cooking, shopping, doing housework, and making phone calls), the risks have increased from age 75 on. Females are generally found to have lower odds than males in having the IADLs disability, except for three activities (i.e.,

Table 19: Odds ratio estimates from the GEE models for ADLs for the US non-institutionalized elderly aged 65 and over, 1982-1999

Predictors	Eating	Dressing	Transferring	Inside mobility	Bathing	Toileting
Wave						
1982	**1.2593*****	**1.4621*****	1.0343	**1.2971*****	**1.2681*****	0.9731
1984	**1.1580***	**1.3067*****	0.9815	**1.2023*****	**1.2479*****	0.9786
1989	1.1030	**1.3113*****	1.0264	**1.3105*****	**1.2392*****	0.9811
1994	**0.8673***	1.0041	**0.7767*****	1.0212	0.9372	0.9259
1999	-	-	-	-	-	-
Age						
65-69	-	-	-	-	-	-
70-74	0.9679	0.9487	0.9614	**1.1238****	**1.1348*****	1.0846
75-79	1.0930	1.0877	**1.0951***	**1.2932*****	**1.3644*****	**1.2860*****
80-84	**1.5906*****	**1.4398*****	**1.4748*****	**1.8749*****	**1.9630*****	**1.7093*****
85-89	**2.0196*****	**1.8788*****	**1.9382*****	**2.7661*****	**2.6712*****	**1.3856*****
90+	**4.0201*****	**3.4474*****	**3.5104*****	**5.4593*****	**4.5009*****	**3.7577*****
Sex						
Male	-	-	-	-	-	-
Female	0.9307	0.9896	1.0318	1.0151	**1.2796*****	**1.3477*****
Race						
White	**0.7705*****	**0.7245*****	**0.7587*****	**0.7743*****	1.0448	**0.8915***
Others	-	-	-	-	-	-
Marital status						
Married	**1.4057*****	**1.5646*****	**1.0942****	**0.9039****	1.0017	**1.1039****
Others	-	-	-	-	-	-
Education						
0-8 years	**1.3195*****	**1.2480*****	**1.2890*****	**1.1936*****	**1.1009***	1.0553
9-11 years	1.1318	1.1038	**1.1654****	**1.1917*****	1.0533	1.0466
12 years	1.1243	1.0673	1.0857	1.0666	1.0246	0.9556
13+ years	-	-	-	-	-	-

Note: Significance levels: $***$ **.001**, $**$ **.01**, $*$ **.05**

Table 20: Odds ratio estimates from the GEE models for selected ADLs (adjusted for AT use) for the US non-institutionalized elderly aged 65 and over, 1982-1999

Predictors	Transferring	Toileting	Bathing
Wave			
1982	**1.5036*** **	**1.3933*** **	**1.7238*** **
1984	**1.3095*** **	**1.2102** **	**1.6076*** **
1989	**1.3017*** **	**1.1324** *	**1.4555*** **
1994	0.9922	0.9336	**1.1686*** **
1999	-	-	-
Age			
65-69	-	-	-
70-74	0.9194	1.0033	1.0751
75-79	1.0235	**1.1384** *	**1.2396*** **
80-84	**1.3305*** **	**1.5311*** **	**1.7905*** **
85-89	**1.6898*** **	**1.9890*** **	**2.4866*** **
90+	**3.0921*** **	**3.5338*** **	**4.9108*** **
Sex			
Male	-	-	-
Female	**1.1642** **	0.9859	**1.1346*** **
Race			
White	**0.7366*** **	**0.6843*** **	**0.8233*** **
Others	-	-	-
Marital status			
Married	**1.6599*** **	**1.4665*** **	**1.2688*** **
Others	-	-	-
Education			
0-8 years	**1.3379*** **	**1.4069*** **	**1.5049*** **
9-11 years	**1.1474** **	**1.1721** *	**1.1589** *
12 years	**1.1442*** **	1.1000	**1.1815** **
13+ years	-	-	-

Note: Significance levels: *** * * .001**, **** .01**, *** .05**

Table 21: Odds ratio estimates from the GEE models for IADLs for the US non-institutionalized elderly aged 65 and over, 1982-1999

Predictors	Cooking	Shopping	Laundry	Housework
Wave				
1982	**1.7321*** **	**3.0198*** **	**2.3055*** **	**1.4489*** **
1984	**1.5979*** **	**2.4229*** **	**1.9535*** **	**1.3781*** **
1989	**1.4967*** **	**2.0518*** **	**1.7527*** **	**1.3421*** **
1994	**1.1627*** **	**1.3548*** **	**1.2417*** **	1.0709
1999	-	-	-	-
Age				
65-69	-	-	-	-
70-74	1.0798	1.0786	**1.0887***	1.0545
75-79	**1.3711*** **	**1.4381*** **	**1.3104*** **	**1.3247*** **
80-84	**2.0653*** **	**2.1499*** **	**1.9478*** **	**1.7818*** **
85-89	**3.1189*** **	**3.6518*** **	**2.9193*** **	**2.6065*** **
90+	**6.6194*** **	**7.4934*** **	**6.1292*** **	**5.2959*** **
Sex				
Male	-	-	-	-
Female	**0.7441*** **	**1.3408*** **	**0.7833*** **	**0.6766*** **
Race				
White	**0.6581*** **	**0.7670*** **	**0.6905*** **	**0.6780*** **
Others	-	-	-	-
Marital status				
Married	**1.2352*** **	0.9548	0.9874	**1.2417*** **
Others	-	-	-	-
Education				
0-8 years	**1.4321*** **	**1.7037*** **	**1.6008*** **	**1.4060*** **
9-11 years	**1.1854****	**1.4030*** **	**1.2738*** **	**1.2475*** **
12 years	**1.1857****	**1.2710*** **	**1.2655*** **	**1.2439*** **
13+ years	-	-	-	-

Note: Significance levels: $***$ **.001**, $**$ **.01**, $*$ **.05**

Table 22: Odds ratio estimates from the GEE models for IADLs for the US non-institutionalized elderly aged 65 and over, 1982-1999 (cont.)

Predictors	Outside mobility	Traveling	Managing money	Phoning
Wave				
1982	**1.5123*****	**2.3214*****	**1.5989*****	**1.8677*****
1984	**1.3376*****	**2.0827*****	**1.5548*****	**1.6611*****
1989	**1.3495*****	**1.4816*****	**1.4282*****	**1.5384*****
1994	**0.9064****	**1.0969***	**1.1737*****	1.0900
1999	-	-	-	-
Age				
65-69	-	-	-	-
70-74	**1.1745*****	**1.1646*****	**1.1125***	1.1278
75-79	**1.4978*****	**1.5882*****	**1.5852*****	**1.5360*****
80-84	**2.3094*****	**2.4405*****	**2.3916*****	**2.3917*****
85-89	**3.8724*****	**3.8705*****	**3.5814*****	**3.6011*****
90+	**8.3545*****	**7.0557*****	**7.0782*****	**7.2773*****
Sex				
Male	-	-	-	-
Female	**1.2222*****	**1.8783*****	**0.8920****	**0.6096*****
Race				
White	**0.7687*****	**0.7753*****	**0.7261*****	**0.6305*****
Others	-	-	-	-
Marital status				
Married	**0.7956*****	0.9814	1.0555	**1.2605*****
Others	-	-	-	-
Education				
0-8 years	**1.1502****	**1.8482*****	**1.7435*****	**2.1353*****
9-11 years	**1.1879*****	**1.5212*****	**1.2417*****	**1.3014*****
12 years	1.0667	**1.2846*****	**1.1662****	**1.2860****
13+ years	-	-	-	-

Note: Significance levels: $\mathbf{***}$ **.001**, $\mathbf{**}$ **.01**, $\mathbf{*}$ **.05**

shopping, outside mobility, and going places outside of walking distance). Without exception, the odds for whites were significantly lower than for non-whites in any of these IADls. The results are mixed for marital status. For cooking, doing housework, and making phone calls, the odds for the married were higher than for the non-married, while for outside mobility, it is the opposite that was true. For the rest of the IADLs (i.e., shopping, doing laundry, managing money, and going places outside of walking distance), no significant differences were found between the married and the non-married. Educational attainment is highly significant for all these activities. In general, the risks in having the disability have declined with the increase in years of schooling. For most activities, significant differences were found for each category in comparison to the reference category, that is, 13 or more years of education. For outside mobility only, there was no significant difference between the elderly with 12 years' schooling and those with 13 years or more.

3 Discussion

Based on the analyses of various measures of selected health dimensions from the NLTCS, we found evidence of improved health and declined disability for the US non-institutionalized elderly from 1982 to 1999. Without exception, the prevalence of any of the seven functional limitations, or any of the eight IADLs has declined significantly, whether or not taking into account changes in sociodemographic compositions. Declines have also been shown for the prevalence of some of the chronic conditions and comorbidity, while the prevalence of diabetes has increased over time. The prevalence of sensory limitations or ADLs disability was reduced when residual limitations or disability after the use of assistive devices were considered. And more importantly, declining time trends were found for these adjusted measures, suggesting the significant role of assistive devices in reducing disability and promoting independence. In general, the underlying health of the non-institutionalized elderly may have improved, supported by the declining prevalence of most diseases and all functional limitations. In addition, light disability (i.e., IADL disability) has declined over time as well. Furthermore, the most severe type of disability (i.e., ADLs disability) may have moved toward less severe disability, as assistive devices alone (i.e., without personal assistance) tends to be more efficient in resolving less severe disability.

The results are mixed for different measures concerning disparities among different socioeconomic and demographic groups. Roughly put, the elderly who are older, non-whites, or with lower levels of educations tended to have a higher probability of having various limitations or disability. Except for selected diseases (i.e., diabetes and hypertension) and comorbidity, the probability of having limitations or disability has increased with age, although some increased gradually with age, while some increased with age only until older ages. Except for hearing limitation, whites always showed advantage over other races in various domains of health. In addition, it is always true that higher levels of education is associated with better health and functioning. On

the other hand, the effects of sex or marital status are less in agreement. Females are found to have lower risks of having sensory limitations and some IADLs, while higher risks of having selected diseases, all the functional limitations, and some of the ADLs and IADLs. Regarding marital status, differences in having selected diseases, hearing limitation, some functional limitations, or disability in some IADLs were not significant between the married and the non-married, and the effects were inconsistent for the measures showing significant differences. Unfortunately, since the regression models have chosen to constraint the patterns for different groups to be the same in all periods, this analysis is unable to identify widening or narrowing disparities over time among the groups.

As suggested by the GEE analyses, differences in AT usage have strengthened the disparities among sociodemographic groups in the actual disability of selected activities. It is hence of interest to examine disparities of AT usage among these groups directly. In addition, although AT has been found to play a role in reducing disability, the significance of AT in preventing further disability, and in keeping the elderly from institutionalization is scarcely examined, which also calls for further examination.

In addition, the results show that the US institutionalized elderly have become more disabled over the period from 1984 to 1999, and that disability trends for the combined institutionalized and non-institutionalized elderly, and the non-institutionalized elderly alone, have been similar, although obviously levels of the former have been bigger than the latter. However, as the estimates are influenced at the first place by the assumption of the size of the institutionalized population over time, this should be taken with caution.

For all the discussed measures for selected health dimensions, only prevalence, but not incidence rates, was considered. Prevalence is an indicator of the stock of health, and it is important in providing information for community health services. However, prevalence is not a measure of risk, and to explore the relationship between exposure and the risk of disability, incidence rates must be used. Although the NLTCS, given its longitudinal design, theoretically should have offered the opportunity for estimating incidence rates, however, it is not yet possible to do that in practice until appropriate weights are made available for all waves.

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