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This study examined the transitions of disability over 5 years among older adults and the influences of health behaviors on these transitions. Data was obtained from the community cohort of the National Long-Term Care Survey in 1994 (n = 5,089) and their follow-up data in 1999. Generalized logit regressions revealed that obesity increased the risk of disability. Light drinking decreased the risk of disability. Among disabled individuals, the risk of status decline was higher for those underweight or physically inactive, and those taking vitamin and/or mineral supplements regularly or working on a hobby were less likely to further decline in the disability statuses. In an older population, having more contacts with friends, having regular social activities, and having a body mass index ≥ 25 were beneficial to survival. These findings indicate that older adults may have greater personal control over their lives based on their choices about lifestyles and social connections.

Keywords: *aging; physical disability; activities of daily living; healthy behaviors; longitudinal studies*

Physical disability is defined as difficulty or dependence in self-care tasks (Activities of Daily Living, ADL) (Fried et al. 2004). The performance of ADLs reflects the individual's ability to live independently. Therefore, it is an important problem among older adults living in the community (Manton 1988; Gill, Hardy, and Williams 2002). Our previous

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analysis revealed that among older adults aged 65+ with a certain degree of functional limitation, at least 39% had developed severe disability over a 15-year time period (Wu et al. 2007). A common perception about the long-term disabled elderly is that they are not likely to improve or regain independent functioning. Recent evidence demonstrates that disability for many older people is a highly dynamic process that is reversible and often recurrent, particularly for those who are physically frail (Boaz 1994; Gill et al. 2002; Gill and Kurland 2003; Hardy and Gill 2004; Hardy et al. 2005; Manton 1988). Disability transition can occur in either direction, decline or improvement, for all age groups (Lagergren 1994).

Although chronic diseases have been identified as the main cause of functional decline and death, many studies now suggest that chronic diseases might not be a necessary consequence of aging (Fried and Guralnik 1997). As the eradication of diseases could be viewed as the elimination or reduction of forces external to individuals and their lifestyle choices, individual choices about behavior and lifestyle may play a very important role in longevity and physical function in old age. Recently, there has been a controversy regarding the degree to which healthy lifestyles can increase longevity and postpone functional decline (Hubert et al. 2002). Some studies have examined the relationship between disability and specific types of lifestyle behaviors. Findings from these studies have demonstrated the benefits of physical activity and the negative consequences of sedentary behaviors for maintaining ADL ability (Elia 2001; Haight et al. 2005; Hardy and Gill 2005). Some reports indicated that moderate alcohol use was associated with better ADL outcome (LaCroix et al. 1993; Wang et al. 2002). The potential harm of body weight in old age has recently received considerable attention. Consistent findings show that obesity leads to the onset of disability (Fried and Guralnik 1997; Ferraro et al. 2002; Jenkins 2004; Wu et al. 2007) and being underweight is a strong predictor of mortality (Seidell and Visscher 2000; Taylor and Østbye 2001). However, controversy exists about the relationship between obesity and mortality among older people (Rossner 2005). There are some studies suggesting that obesity increases the risk of mortality (Østbye and Taylor 2005), has no effect on mortality (Darmadi-Blackberry et al. 2004; Reynolds, Saito, and Crimmins 2005), and decreases the risk of mortality (Inelmen et al. 2003; Rossner 2001; Taylor and Østbye 2001). In addition, although social networks and social activities have been found to be strongly related to survival and health status among the elderly, information about its effect on disability outcomes remains unclear and further analysis is needed for a better understanding (Mendes de Leon et al. 1999). A recent study conducted by Hubert and

colleagues (2002) assessed the relationship between morbidity and a lifestyle score created by adding the number of three unhealthy factors (smoking, physical inactivity, and underweight/overweight). This analysis method aimed to assess the combined impact of the three unhealthy factors on morbidity. The results indicate that any two or more of these unhealthy behaviors existing simultaneously led to an accelerated decline on the level of morbidity. To our knowledge, few analyses have been conducted to examine a variety of disability transition outcomes in a broader set of explanatory variables related to health behaviors. In this study we attempted to fill this gap in the literature by analyzing data from the National Long Term Care Survey (NLTCS) (Clark 1998).

The objectives of this study were to examine the variation of changes in functional status over 5 years, including onset, recovery, improvement, and decline of disability, and death. In addition, we examined the independent effect of each behavioral explanatory variable on the changes of functional status. Verbrugge and Jette (1994) proposed a conceptual model of the disablement process based on qualitative research. This model hypothesized that diseases and chronic conditions are the main causes of disability via specific impairments and functional limitations. In addition to the main disablement pathway, risk factors such as sociodemographic, lifestyle, psychological, and social factors can also regulate the disability progression. According to this theory and the previous research findings (as surveyed above), we hypothesized that after controlling for the effects of demographics and the burden of comorbidity, some behavioral factors such as physical activity, smoking, drinking, body mass index, vitamin intake, hobbies, social contacts, and social participations will have independent contributions to the transitions of physical disability over 5 years.

Method

Data Source

The NLTCS was conducted by the Duke University Center for Demographic Studies and sponsored by the National Institute of Aging. The NLTCS studied people in the United States aged 65 and older with a particular emphasis on the aged who were functionally impaired, including community and institutional residents. The sample was randomly drawn from Medicare beneficiary enrollment files. An initial screening interview was used to identify functional status of the participants, and to determine

who would receive a subsequent detailed community or institutional interview. The NLTCS was conducted in 1982, 1984, 1989, 1994, 1999, and 2004. This study used the 1994 community sample and the follow-up data in 1999. The survey of 1994 was chosen because it oversampled nondisabled people and the oldest old (aged 95+). This method of sampling increased the variance in disability outcome, which can increase precision of data analysis and enhance the representativeness of the sample. The 2004 wave data had not been released at the time this analysis was completed, and hence it was not used in the analysis. A total of 5089 older adults had received the community detailed interviews in 1994. The 3,067 participants having detailed follow-up information in 1999 were used for this study, including the 284 deaths identified by the 1999 screening.

The Outcome Variable

Physical disability was assessed by the ADL scale, which contains six activity items, including eating, dressing, bathing, toileting, mobility around the home, and transferring in and/or out of bed. The respondents were asked whether they were able to perform each of the six items without assistance from another individual for at least three months. The ADL disability score ranged from 0 to 6, with a higher score indicating an accumulation of disabilities. We tracked the disability scores of the sample at the two time points. In this community cohort, 320 became institutionalized during the 5-year period, and so they received institutionalized follow-up interviews in 1999. The ADL scale was included in both community and institutional surveys with consistent wording of questions in both surveys and across waves.

Based on ADL disability scores measured at the two time points, the sample was categorized into six groups: “Maintain” were those without an ADL limitation in the five years; “Onset” were those with 0 score of disability initially and follow-up scores > 0 (this could include new onset and recurrence of disability); “Same-status” were those with the same disability score over time; “Declined,” “Improved,” and “Recovered” were those with disability scores that increased, decreased, and returned to 0, respectively. Those who had died had no follow-up data and so they were grouped separately as “Death.”

Explanatory Variables

Body Mass Index. Self-reported weight and height were used to calculate Body Mass Index (BMI)—weight (kilograms) divided by the square of

height (meters). According to the Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults (Flegal et al. 1998), BMI values were categorized into four levels: less than 18.5 (underweight), 18.5 – 24.9 (normal weight), 25 – 29.9 (overweight), and 30 or higher (obese).

Lifestyle habits. Respondents were asked how many days per week they drank alcoholic beverages (such as beer, wines, or liquor) and then how many drinks they consumed on days when they drank. In addition, respondents reported whether they smoked at the time of the interview, and if yes, how many cigarettes they smoked per day. We adopted the criteria that had been used in other studies for categorizing alcohol consumption and smoking status (Taylor and Østbye 2001; Ferraro et al. 2002). The subjects were classified into "Heavy drinker" (daily, or 3-6 times/week with more than 5 drinks each time), "Light drinker" (1-2 times/week, or 3-6 times/week with less than 5 drinks each time), and "Nondrinker." Current smokers were classified into "Heavy smoker" (1 or more pack/day), and "Light smoker" (less than 1 pack/day). Physical activity was assessed by a comparison question, "Would you say that you are physically more active, less active, or about the same as other persons your age?" The measures for hobby and for consumption of vitamin and/or mineral supplements were dichotomized. The respondents reported whether they were working on a hobby (such as painting, sewing, arts, and craft), and whether they were taking vitamin and/or mineral supplements at least once a week.

Social connection. The level of social connection was evaluated by social contacts and social activities, using four dichotomous variables: frequent contact with friends, frequent contact with relatives, regular participation in social activities, and regular participation in senior activities. These four variables were coded as 1 = "yes" and 0 = "no." They were created by summarizing the responses to the following questions.

The respondents were asked "Did you talk with friends including neighbors during the past month?" (yes/no) and "Did you talk with relatives including children during the past month?"(yes/no). Those who answered "yes" to each question reported in what way the contact had occurred (by phone and/or by visit) and how often. "Frequent contact" was defined as calling and visiting at least three times last month.

The respondents were asked, "Did you go to a meeting of a civic, religious, professional, recreational club, or a religious service during the prior month?"(yes/no). Those who answered "yes" were classified as "regularly

participate in social activities." Those who answered "yes" to the question "Do you regularly go to a senior center and/or an adult center?" were classified as "regularly participate in senior activities."

Control Variables

Demographics included race, living location, marital status, and income. The three-level race variable (White, Black, others) was selected for this study. Black and other races were combined into one category in the analyses because there were only 57 participants (1.7%) in other races. Living location was dichotomized into larger city (medium and/or large cities, suburbs of large cities) and other (rural, farms, small cities, towns). Marital status was classified into three levels: married, ever married (widowed, divorced, separated), and never married. Household income was classified into four levels: less than $8000, $8000 – 14,999, $15,000 – 24,999, and $25,000 or more. Of the 3,067 participants, 391 (12%) answered "do not know/refuse" to the income question or did not answer the income question at either assessment time. We adopted the method of managing missing data as described in other studies (Mendes de Leon et al. 1999), these data were coded "missing" separately so that the 391 participants would be retained in the multivariate analysis and results could be adjusted for the potential effect of missing income.

Functional limitation was defined as having difficulty in carrying out each of the following seven basic bodily functions: climbing, lifting and carrying, bending, reaching, and grasping. *IADL* (*Instrumental Activities of Daily Living*) *limitation* was defined as having difficulty in the following tasks essential to household management: light housework, laundry, meal preparation, grocery shopping, getting around outside, walking to distant places outside, money management, and using the telephone (Fried et al. 2004). Functional limitations and IADL limitations have been shown to have a direct link to the onset of disability among ADL independent older adults (Verbrugge and Jette 1994).

Comorbidity was defined as multiple medical conditions existing simultaneously. The presence of comorbid conditions is a main cause of disability in old age (Verbrugge and Jette 1994). In this study, nine chronic conditions commonly related to physical disability were selected: rheumatoid arthritis, diabetes, cancer, heart attack or other heart problems, hypertension or high blood pressure, stroke, asthma, paralysis, broken hip and/or bone. The respondents were asked whether they had any of these conditions

at the time of the interview. Missing numbers of the 9 conditions ranged from 4 (missing diabetes, 0.07%) to 20 (missing broken hip/bone, 0.06%). A missing response to a chronic condition was coded as not having that condition. The score of comorbidity was the total number of chronic conditions between 1994 and 1999.

Analysis

All analyses were performed using SAS version 9.1.2 (SAS Institute 2004). First, we examined descriptive information for the overall sample, such as the frequency distribution of baseline ADL scores, disability transition patterns, sample characteristics, and baseline assessments for the study variables. Second, descriptive data for the five disability transition subgroups were examined. Proportional differences across groups were determined by the Chi-square test. Differences in comorbidity mean scores across groups were tested using one-way analysis of variance (ANOVA). Subsequently, we conducted three logit-regression models to analyze the independent effect of each variable on disability transitions and mortality.

Model 1 used data from all participants without an ADL limitation at baseline. The dependent variable was dichotomous (Onset, Maintain). This analysis estimated the odds ratios of disability "Onset" versus "Maintain" ADL ability for each independent variable. A binary variable (coded as 1 = having functional limitation or/and an IADL limitation, 0 = otherwise) was entered in this model to control for baseline functional status.

Model 2 used data from all participants who were disabled at baseline. The dependent variable was a 3-level nominal variable (Declined, Improved, and Same-status). The "Recovered" group was collapsed into the "Improved" group. We conducted a generalized logit regression model to fit the data, using "Same-status" as the reference level. Baseline ADL scores were included as a control variable because the initial degree of disability could affect its transition status. This analysis derived regression coefficients representing the linear effects of the independent variables on the log odds. Based on these results, we obtained two sets of odds ratios: one for "Declined" versus "Same-status," and another for "Improved" versus "Same-status."

Model 3 used data from the whole sample. The dependent variable was dichotomous (Dead, Alive). This analysis estimated the odds ratios of "Death" versus five-year survival. Baseline disability scores were included to assess the effect of disability on survival.

Table 1
The Distribution of Baseline Disability Scores ($N = 3,067$)

	n	%
No ADL limitation	766	25.0
No ADL limitation (but having functional limitation or/and IADL)	1,155	38.0
1 ADL limitation	409	13.3
2 ADL limitations	251	8.2
3 ADL limitations	194	6.3
4 ADL limitations	116	3.8
5 ADL limitations	97	3.2
6 ADL limitations	79	2.6

Note: ADL = activities of daily living. ADL limitations (6 items)—eating, dressing, bathing, toileting, mobility around the home, and transferring in and/or out of bed. Functional limitations (7 items)—climbing one flight of stairs, lifting a 10-pound package, bending, reaching above head, combing and/or brushing hair, washing hair, using fingers to grasp and handle small objects. Instrumental ADL limitations (8 items)—light housework, laundry, meal preparation, grocery shopping, getting around outside, walking to distance places outside, money management, and using telephone.

Results

Disability Profiles of the Sample

Table 1 presents the frequency distribution of baseline disability scores. Of the 3,067 participants in the analytic sample, 1,921 (63%) had no ADL limitation initially. Among these ADL independent older adults, 1,155 had at least one functional limitation and/or IADL limitation.

Disability mean scores at the two time points for each subgroup are shown in Table 2. During the five-year period, 284 (9.6%) died, 1,128 (36.6%) remained ADL independent (“Maintain”), and 668 (21.7%) developed one or more ADL limitations (“Onset”). The sample initially contained 1,146 (37.4%) disabled (with at least one ADL limitation). Five years later, 187 remained with the same number of limitations (“Same-status”), 527 increased the number of limitations (“Declined”), 135 decreased the number of limitations (“Improved”), and 138 regained ADL independence (“Recovered”).

Sample Characteristics and Health Behaviors Assessments

Table 3 and Table 4 present the descriptive information about the sample and the study variables. Overall, the age of the sample ranged from 65 to 102 years (mean age = 76.5 years). Women accounted for 68% of the

Table 2
The Distribution of Disability Transition (N = 3,067)

			ADL Mean Score	
	n	%	1994	1999
Maintain ADL ability	1,128	36.6	0.00	0.00
Onset/recurrent	668	21.7	0.00	2.93
Declined	527	17.1	2.09	4.46
Same-status	187	6.1	2.85	2.85
Improved	135	4.4	4.19	2.51
Recovered	138	4.5	1.85	0.00
Death	284	9.6	1.63	—

Note: ADL = activities of daily living.

sample. The majority was White (89%), nonsmokers (90%), and nondrinkers (78%). Nearly half had household incomes below $15,000 (44%), were married (48%), were living in large cities (40%), and were taking vitamin or mineral supplements regularly (48%). About one-third were of normal weight (39%), were physically active (36%), and were working on a hobby (30%). About two-thirds had frequent contacts with friends (62%) and with relatives (67%). More than half reported regular participation in social activities (58%) but only 11% went to a senior center or an adult center regularly. The proxy response rate was 13%. The variables with little variance, such as Medicare coverage (97%) and cognitive impairment (0.8%) were excluded from this analysis.

Descriptive data for the subgroups are also presented in Table 3 and Table 4. There were significant group differences in disability transition regarding age, gender, income, marital status, BMI, alcohol consumption, physical activity, working on a hobby, social activity, comorbidity, and contact with friends. Group differences can be identified by comparing the subgroup rates to the sample rate in a row. For example, women accounted for 82.2% in the "Declined" group, which was significantly higher than the sample average rate (68%). Likewise, the "Maintain" group had significantly more "younger" 65 to 74 years of age (51.7% vs. 35.4%), and more physically active older adults (50.3 % vs. 37.8%). The "Same-status" group had the highest rate of individuals physically inactive (50.3% vs. 26.8%).

Predictors of Disability Onset

As shown in Table 5, five predictors emerged: functional/IADL limitations (odds ratio (OR) = 1.13; confidence intervals (CI) = 1.05-1.21), older

Table 3
Overall Sample Characteristics and Comparisons Across the Five Subgroups of Disability Transition – (*n*) %

	Overall		Maintain	Onset	Same-Status	Improved	Declined	
	(3,067)	%	(1,128)	(668)	(187)	(273)	(527)	*p*
Age								<.0001
65 - 74	(1,081)	35.4	51.7	24.4	28.3	37.9	22.9	
75 - 84	(1,597)	52.2	45.3	61.8	56.2	55.2	52.4	
85 - 94	(337)	11.0	2.8	12.7	13.9	5.9	21.5	
95 - 102	(45)	1.5	0.2	1.1	1.6	1.1	3.2	
Gender								<.0001
Female	(2,086)	68.0	58.5	70.8	73.8	72.2	82.2	
Male	(981)	32.0	41.5	29.2	26.2	27.8	17.8	
Race								0.1000
White	(2,742)	89.4	90.6	91.0	89.3	87.2	87.3	
Black or others	(325)	10.6	9.4	9.0	10.7	12.8	12.7	
Income								<.0001
$8,000 or less	(494)	16.1	10.4	17.3	20.3	18.7	22.0	
$8,000-$14,999	(846)	27.6	24.8	29.5	34.8	30.4	27.9	
$15,000-$24,999	(629)	20.5	23.4	20.7	17.7	21.3	18.4	
$25,000 or more	(707)	23.0	31.4	21.0	17.7	19.1	15.8	
Missing	(391)	12.8	9.7	11.5	9.6	10.6	15.9	
Living location								0.2600
Medium or large city	(1,214)	40.0	41.5	36.1	39.5	38.6	40.5	
Country, farm, small city, town	(1,827)	60.1	58.6	63.9	60.5	61.4	59.5	
Marital status								<.0001
Married	(1,445)	47.8	60.0	43.8	41.9	47.6	32.1	
Widowed, divorced, separated	(1,487)	49.2	37.5	52.1	55.9	50.2	64.2	
Never married	(93)	3.1	2.5	4.1	2.2	2.2	3.7	
Number of medical conditions in 5 years - (N) Mean	(2,783)	2.3	1.9	2.5	2.6	2.8	2.7	<.0001

Note: Proportional differences across transition groups were determined by Chi-square two-tailed test. Mean score differences across transition groups were determined by one-way ANOVA, two tailed test.

Table 4
Assessments of Health-Related Behaviors and Comparisons Across the Five Subgroups of Disability Transition – (*n*) %

	Overall		Maintain	Onset	Same-Status	Improved	Declined	
	(3,067)	%	(1,128)	(668)	(187)	(273)	(527)	*p*
Body Mass Index (kg/m)								<.0001
< 18.5 (underweight)	(112)	3.7	2.2	3.4	1.1	3.3	5.9	
18.5-24.5 (normal weight)	(1,193)	38.9	39.4	39.2	36.9	32.6	35.3	
25-29.9 (overweight)	(1,153)	37.6	43.7	36.2	35.3	34.4	33.4	
≥ 30 (obese)	(608)	19.8	14.6	21.1	26.7	29.7	25.4	
Alcohol consumption								<.0001
Heavy drinker	(212)	6.9	10.4	6.4	5.9	4.0	4.0	
Light drinker	(479)	15.6	22.8	11.8	11.2	14.3	9.9	
Nondrinker	(2,376)	77.5	66.8	81.7	82.9	81.7	86.3	
Smoking status								0.2000
Heavy smoker	(63)	2.1	2.0	2.4	1.6	1.5	2.1	
Light smoker	(221)	8.1	9.7	7.0	4.8	8.4	6.3	
Not smoking	(2,757)	89.9	88.4	90.6	93.6	90.1	91.7	
Physical active								<.0001
Less than others	(822)	26.8	10.2	19.5	50.3	48.4	46.1	
Same as others	(1,155)	37.7	39.5	41.3	32.6	33.3	33.8	
More than others	(1,090)	35.5	50.3	39.2	17.1	18.3	20.1	
Working on a hobby	(911)	29.7	36.5	30.4	28.9	27.5	20.7	<.0001
Taking vitamin at least once a week	(1,480)	48.3	49.8	46.9	52.9	48.4	44.4	0.1700
Frequent contact with friends	(1,892)	61.7	67.1	64.1	58.8	62.6	56.0	0.0003
Frequent contact with relatives	(2,045)	66.7	70.1	66.5	62.6	65.9	65.5	0.1200
Regular participation in social activities	(1,764)	57.5	66.1	63.3	47.6	49.8	48.6	<.0001
Regular participation in senior activities	(325)	10.6	11.1	9.4	10.7	9.5	12.1	0.5800

Note: Proportional differences across disability transition groups were determined by Chi-square two-tailed test.

age (OR = 1.15; CI = 1.12-1.17), comorbidity (OR = 1.42; CI = 1.29-1.56), obesity (OR = 1.57; CI = 1.13-2.18), and physical inactivity (OR = 1.51; CI = 1.06-2.15). Light drinkers had a lower risk of disability than nondrinkers (OR = 0.63; CI = 0.46-0.88).

Predictors of Decline and Improvement in Disability Status

Also shown in Table 5, among the disabled individuals, age (OR = 1.06; CI = 1.02-1.09), being underweight (OR = 3.8; CI = 1.25-11.52), and being physically less active (OR = 1.38; CI = 1.04-1.83) led to the development of more ADL limitations. The following disabled older adults had a lower risk of status decline than their counterparts: men (OR = 0.77; CI = 0.6-0.98), those taking vitamin and/or mineral supplements regularly (OR = 0.81; CI = 0.67-0.97), and those working on a hobby (OR = 0.74; CI = 0.6-0.92). This analysis was adjusted for the significant effect of baseline disability score—that is, the disabled who had more ADL limitations was less likely to further increase limitations (OR = 0.61; CI = 0.53-0.7) due to the ceiling effect of the score. Instead, they were more likely to reduce limitations (OR = 1.14; CI = 1-1.31).

No variable investigated in this study was found to have significant effect on the improvement of disability status except age. The odds of recovery and improvement were lower for older disabled individuals (OR = 0.96; CI = 0.93-0.99).

Predictors of Mortality

Again as presented in Table 5, the predictors of mortality included age (OR = 1.07; CI = 1.05-1.1) and being male (OR = 1.88; CI = 1.36-2.62). Three health-related behaviors were found to have independent contributions to a five-year survival: BMI ≥ 25 (OR = 0.66; CI = 0.49-0.9 for overweight and/or normal; OR = 0.53; CI = 0.35-0.81 for obesity and/or normal), frequent contacts with friends (OR = 0.74; CI = 0.55-0.98), and engaging in social activities regularly (OR = 0.65; CI = 0.48-0.87). Among the 284 deaths, 164 (58%) were disabled at baseline. This analysis indicated that ADL disability did not have a fatal effect over five years (OR = 1.07; CI = 0.98-1.17), but the effect of comorbidity on dying was significant (OR = 1.14; CI = 1.02-1.28).

Table 5
Odds Ratios and 95% Confidence Intervals from the Three Multivariate Logit Regression Models

	Model 1		Model 2				Model 3	
	Onset		Declined		Improved		Dead	
Baseline disability status[a]	1.13	(1.05 – 1.21)***	0.61	(0.53 – 0.70)****	1.14	(1.00 – 1.31)	1.07	(0.98 – 1.17)
Age	1.15	(1.12 – 1.17)****	1.06	(1.02 – 1.09)***	0.96	(0.93 – 0.99)*	1.07	(1.05 – 1.10)****
Male[b]	0.74	(0.57 – 0.97)	0.77	(0.60 – 0.98)*	0.95	(0.74 – 1.23)	1.88	(1.36 – 2.62)***
White[b]	1.34	(0.90 – 2.01)	0.92	(0.69 – 1.24)	0.98	(0.71 – 1.34)	1.04	(0.68 – 1.58)
Living in medium or large city[2]	0.88	(0.70 – 1.12)	1.05	(0.87 – 1.26)	0.96	(0.78 – 1.17)	1.24	(0.95 – 1.63)
Marital status (never married)	1.00		1.00		1.00		1.00	
Married	0.70	(0.36 – 1.37)	0.91	(0.58 – 1.44)	1.11	(0.67 – 1.84)	0.83	(0.38 – 1.81)
Separated or divorced	0.82	(0.42 – 1.59)	0.98	(0.63 – 1.52)	0.92	(0.57 – 1.51)	0.85	(0.39 – 1.81)
Income (≥ $25,000)	1.00		1.00		1.00		1.00	
$8,000 or less	1.12	(0.74 – 1.69)	0.83	(0.56 – 1.23)	0.96	(0.62 – 1.48)	1.20	(0.74 – 1.95)
$8,000–$14,999	1.09	(0.79 – 1.51)	0.65	(0.47 – 0.88)**	0.88	(0.63 – 1.22)	1.07	(0.71 – 1.63)
$15,000–$24,999	1.13	(0.82 – 1.57)	0.98	(0.67 – 1.44)	1.11	(0.74 – 1.67)	0.86	(0.54 – 1.38)*
Number of medical conditions	1.42	(1.29 – 1.56)****	1.15	(1.00 – 1.33)*	1.06	(0.91 – 1.23)	1.14	(1.02 – 1.28)*
BMI (18.5 – 24.9 kg/m)	1.00		1.00		1.00		1.00	
< 18.5	0.94	(0.47 – 1.89)	3.80	(1.25 – 11.52)*	2.49	(0.77 – 8.07)	1.48	(0.85 – 2.59)**
25 – 29.9	0.93	(0.72 – 1.20)	0.68	(0.43 – 1.07)	0.73	(0.45 – 1.19)	0.66	(0.49 – 0.90)*
≥ 30	1.57	(1.13 – 2.18)**	0.62	(0.39 – 1.00)	0.79	(0.48 – 1.31)	0.53	(0.35 – 0.81)**
Alcohol consumption (nondrinker)	1.00		1.00		1.00		1.00	
Heavy drinker	0.92	(0.60 – 1.41)	0.77	(0.44 – 1.36)	0.66	(0.35 – 1.24)	0.45	(0.22 – 0.93)
Light drinker	0.63	(0.46 – 0.88)*	1.08	(0.68 – 1.72)	1.37	(0.84 – 2.23)	0.87	(0.57 – 1.32)

(continued)

Table 5 (continued)

	Model 1		Model 2				Model 3	
	Onset		Declined		Improved		Dead	
Smoking status (not smoking)	1.00		1.00		1.00		1.00	
Heavy smoker	2.04	(0.98 – 4.26)	1.27	(0.48 – 3.37)	0.76	(0.26 – 2.22)	1.31	(0.56 – 3.08)
Light smoker	1.04	(0.67 – 1.59)	1.16	(0.55 – 2.46)	1.63	(0.74 – 3.58)	1.46	(0.91 – 2.34)
Physical active (same as others)	1.00		1.00		1.00		1.00	
Less than others	1.51	(1.06 – 2.15)**	1.38	(1.04 – 1.83)*	0.75	(0.55 – 1.01)	1.46	(1.05 – 2.05)**
More than others	0.79	(0.61 – 1.02)**	0.73	(0.52 – 1.02)	1.25	(0.86 – 1.81)	0.79	(0.56 – 1.12)*
Taking vitamin at least once a week[b]	1.01	(0.80 – 1.27)	0.81	(0.67 – 0.97)*	0.89	(0.73 – 1.09)	1.30	(0.99 – 1.70)
Working on a hobby[b]	0.86	(0.67 – 1.10)	0.74	(0.60 – 0.92)**	0.96	(0.76 – 1.20)	0.89	(0.64 – 1.23)
Frequent contact with friends[b]	0.98	(0.76 – 1.26)	0.90	(0.73 – 1.10)	1.05	(0.84 – 1.31)	0.74	(0.55 – 0.98)*
Frequent contact with relatives[b]	0.89	(0.69 – 1.14)	1.03	(0.85 – 1.25)	1.08	(0.88 – 1.33)	0.97	(0.73 – 1.29)
Regular participation in social activities[b]	1.13	(0.88 – 1.46)	1.03	(0.85 – 1.26)	1.02	(0.83 – 1.26)	0.65	(0.48 – 0.87)**
Regular participation in senior activities[b]	0.73	(0.50 – 1.07)	1.09	(0.81 – 1.48)	0.98	(0.70 – 1.37)	1.05	(0.66 – 1.67)
Proxy respondent[b]	0.69	(0.46 – 1.02)	0.98	(0.76 – 1.27)	1.13	(0.85 – 1.49)	0.88	(0.62 – 1.26)

a. Baseline disability status variable: Model 1 used baseline functional limitation/instrumental activities of daily living (IADL) score (0 or 1); Model 2 used baseline ADL score (ranged 1- 6); Model 2 used baseline ADL score (ranged 0 – 6).

b. The reference levels of the binary variables were not listed.

*$p < .05$. **$p < .01$. ***$p < .001$. ****$p < .0001$. Chi-square p-values indicating the significance of the correlations with disability transitions. Onset vs. Maintain; Declined vs. Same Status; Improved vs. Same Status; Dead vs. Alive

Discussion

The analysis of the NLTCS data demonstrated that change in disability status over five years has a considerable range of outcomes, including onset, recovery, improvement, and decline of disability status and death. We examined the independent influences of the health-related variables on these outcomes. Major findings were summarized in three areas.

Lifestyle habits. The important role of physical activity in the transitions of disability and mortality found in this study is consistent with other studies showing that physical activity is beneficial in maintaining physical function and sedentary behavior is strongly associated with the onset of disability (Elia 2001; Haight et al. 2005). Our result also indicated that physical inactivity led to the development of more ADL limitations among the disabled elders. Regarding alcohol consumption, our findings support the result from earlier studies (LaCroix et al. 1993; Wang et al. 2002) showing that light drinkers were more likely to maintain their ADL abilities than nondrinkers. Smoking had no independent influence on transition of ADL disability or mortality over five years. An earlier study showed that a combination of smoking, drinking, and physical inactivity had a significant impact on disability levels over 12 years (Hubert et al. 2002).

As vitamins and minerals are essential to normal metabolism and other bodily functions, many older adults take vitamin or mineral supplements. About half of our sample reported regular consumption. However, little is known about what level of consumption will have an influence on the transition of disability. We examined the effect of this variable as a health behavior variable (not from a clinical point of view), by comparing those who took supplements with those who did not. Its effect among older disabled adults seems particularly important. Regular intake of vitamin and/or mineral supplements and working on a hobby appeared to have an effect on preventing further decline in disability levels but was not strong enough to reverse the disability process and did not impact survival.

BMI. Although currently there is controversy about body weight in old age, most studies, including the current findings, consistently show that BMI ≥ 30 in old age causes disability. The study by Ferraro et al. (2002) also identified that those who are underweight manifest a higher risk of disability in most instances, but our findings show that the impact of being underweight on ADL ability was significant only in the population of disabled older adults. The difference in the results may be related to the measurement of

disability outcome. We used the six-item ADL scale to measure disability while Ferraro et al. examined the upper-body disability (nine items) and lower-body disability (10 items) separately. Recently, debate persists about the relationship between obesity in old age and mortality. Our findings reveal a short-term positive effect of being overweight among elders, indicating that BMI ≥ 25 was associated with a five-year survival. When we repeated the analysis with and without controlling for comorbidities, the results were consistently significant in the same direction. These results partially support a recent study showing that being overweight (BMI = 25 – 29.9) is associated with survival but obesity (BMI ≥ 30) increases risk of mortality in old age (Thorpe and Ferraro 2004). One explanation for the discrepancy may be the diversity of samples and years of follow-up. Thorpe and Ferraro's results were from a 20-year study in a younger sample with a wider age range (25-70 years of age). The current study is a five-year follow-up of older adults aged 65 to 106 years. Our findings indicate that a higher BMI in old age is beneficial to survival, which has also been observed by other researchers (Inelmen et al. 2003; Rossner 2001; Taylor and Østbye 2001). Overweight and obese older adults may live longer but a higher proportion of them may be in a disabled state in their remaining years. It seems that among older adults, being slightly heavier than the recommended weight but not to the degree of being at risk for ADL limitations may be beneficial. It has been suggested that the ideal body weight for older adults may actually be higher than those for younger adults (Kennedy, Chokkalingham, and Srinivasan 2004). These findings support the suggestion for reconsidering the BMI categories for the older population (Thorpe and Ferraro 2004).

Social connection. Since the seminal work by Berkman and Syme (1979) on the impact of social networks on longevity, many researchers have explored the idea that social relationships are good for health. However, information about its effect on the transition of ADL disability is limited (Mendes de Leon, Glass, and Berkman 2003). Current analysis from the NLTCS data did not reveal a significant link between the social connection variables and any type of disability transition over five years. Two studies conducted by Mendes de Leon et al. (1999, 2003) examined the effects of social networks (contact with children, relatives, friends, a confidant) and social activities on the onset and recovery of disability. Their results indicated that social activities and contact with friends and relatives (other than children) reduced the risk of disability onset and also increased the chance of recovery. Because the NLTCS data combined the assessments

for contact with relatives and with children, the results from the two data sets are not comparable.

Social activities of older adults are expected to decrease due to age and health problems. After removing the variances due to age and comorbidities, the positive effect of social connections on survival was still significant although not all types of social connections were equally beneficial. Participation in social activities such as professional meetings and church activities had significant contributions to longevity but going to senior or adult centers did not have the same effect. Frequent contact with friends and neighbors were more important than with relatives and children. Other studies also found that relationships with friends, other than with children, were strongly associated with survival among older adults. In the article titled "Why do friendships matter for survival?" Mendes de Leon (2005) has tried to explain this phenomenon. He indicated that relations with friends are discretionary ties whereas relations with children are less discretionary ties, and that discretionary ties provide a greater survival benefit than those less discretionary. Discretionary ties mark a person's ability to develop and maintain the sort of connections with others that form the basis of social capital. These connections can promote self-efficacy and positive emotion and enhance social supports in late life. These factors have been shown to contribute to longevity (Vaillant and Mukamal 2001).

This study has some limitations. First, self-reported height and weight were used to calculate BMI. Some researchers have found that obese individuals and older adults tend to underestimate their weights (Rowland 1990; Stevens et al. 1990), which might lead to a bias in classification (some overweight individuals might actually be obese). If this tendency did occur in the NLTCS data, then our findings of higher disability risk and lower mortality risk among people with BMI ≥ 30 would likely be among people with higher BMIs. Second, the rate of proxy respondents in our analytic sample was 13%. Although proxies tend to overestimate functional deficits, the use of proxies for ADL assessment has been shown to be reliable (Hardy et al. 2005; Neumann, Araki, and Gutterman 2000). In addition, we have included the proxy index in the three regression models to control for its potential effect, and the results demonstrated no significant difference between proxies and self-reports on disability transition and mortality. Third, as some studies assessed long-term disability outcome with follow-up about every 10 years (Ferraro et al. 2002), this analysis used two-wave data to assess a 5-year change of disability status. One study with monthly assessment for ADL status has reported that the recovery rate among newly disabled older adults was high and the recovery was short

lasting (Hardy and Gill 2004). Therefore, it is possible that the "Maintain" ADL independent group had included some people who became newly disabled and then recovered in the five-year time period, and so this group may be better named as "Maintain/Recovery." The membership of individuals in other groups (Onset/Recurrent, Declined, Improved, and Death) would not be affected by the frequency of assessment.

In summary, the important roles of health behaviors on functional change and mortality resulting from this analysis indicate that older adults may have greater personal control over their lives based on their choices about lifestyle and social connections. Findings add evidence to the cumulative body of knowledge on disability and longevity. Such knowledge can help in predicting disability transitions and developing lifestyle interventions for a healthy life in old age.

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