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RESEARCH ARTICLE

Explaining Disability Trends in the U.S. Elderly and Near-Elderly Population

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Objective. To examine disability trends among U.S. near-elderly and elderly persons and explain observed trends.

Data Source. 1996–2010 waves of the Health and Retirement Study.

Study Design. We first examined trends in Activities of Daily Living and Instrumental Activities of Daily Living limitations, and large muscle, mobility, gross motor, and fine motor indexes. Then we used decomposition analysis to estimate contributions of changes in sociodemographic composition, self-reported chronic disease prevalence and health behaviors, and changes in disabling effects of these factors to disability changes between 1996 and 2010.

Principal Findings. Disability generally increased or was unchanged. Increased trends were more apparent for near-elderly than elderly persons. Sociodemographic shifts tended to reduce disability, but their favorable effects were largely offset by increased self-reported chronic disease prevalence. Changes in smoking and heavy drinking prevalence had relatively minor effects on disability trends. Increased obesity rates generated sizable effects on lower-body functioning changes. Disabling effects of self-reported chronic diseases often declined, and educational attainment became a stronger influence in preventing disability.

Conclusions. Such unfavorable trends as increased chronic disease prevalence and higher obesity rates offset or outweighed the favorable effects with the result that disability remained unchanged or increased.

Key Words. Disability, near-elderly, elderly, obesity, mobility

Longevity has increased in the United States, but trends in population health, including rates of disability, are less clear. Previous studies based on data immediately before and for the early years of the 21st century generally have reported declining disability trends among the elderly population (Cutler 2001; Manton, Gu, and Lamb 2006). However, more recent studies have shown either an increasing or no disability trend among the elderly (Seeman et al. 2010; Crimmins and Beltrán-Sánchez 2011; Freedman et al. 2013). Evidence on disability trends for near-elderly persons is comparatively sparse with mixed results (Martin, Schoeni, and Andreski 2010; King et al. 2013; Martin and Schoeni 2013), possibly due to different disability measures or time periods used.

Whether disability rates are declining is important for several reasons. First, such trends affect future expenditures on personal health care services. Second, trends in disability affect future demand for long-term care services in terms of both facilities and personnel. Third, disability is closely linked to quality of life, particularly of the elderly, the group in which disability is most prevalent.

To the extent that disability rates have changed, it is important to know why these changes have occurred. Improved socioeconomic status (SES) composition of the population, including increased educational attainment and higher real household income (McLaughlin et al. 2010; Reynolds and Crimmins 2010) may have lowered disability rates. More highly educated persons may be more efficient in illness management (Grossman 1972) and have less exposure to job-related health risks (Cutler 2001).

Several factors, however, are known to increase disability. First, although there is some evidence that disability rates conditional on having a chronic disease have declined (Cutler 2005; Cutler, Landrum, and Stewart 2009b), having chronic diseases remains an important predictor of disability. Nearly one-quarter of persons with chronic diseases have at least one activity of daily living (ADL) limitation (Anderson et al. 2004). Second, obesity increases the probability of being disabled, both directly, for example, through strain on lower extremities, and indirectly through its effects on increased prevalence of chronic diseases (Alley and Chang 2007; Al Snih et al. 2010), such as diabetes mellitus. Another study reported that prevalence of severe obesity (body mass index [BMI] ≥35) increased six percentage points during 1985–2000 among persons aged 50–69 years (Sturm, Ringel, and Andreyeva 2004). If the observed upward trend of obesity rates were to continue (as it has), disability prevalence measured as having any ADL limitation would increase by one more percent annually compared with no obesity increase. Third, heavy drinking and smoking are leading risk factors for heart disease, respiratory disease, and stroke (Sundell et al. 2008; Roerecke and Rehm 2010; Shah and Cole 2010), and

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all are important precursors for disability. Their declining prevalence may have lowered disability rates (Garrett et al. 2011; Jemal et al. 2011; Daw, Nowotny, and Boardman 2013).

Although some studies have investigated explanations of disability trends (Freedman and Martin 1998; Freedman et al. 2007; Schoeni, Freedman, and Martin 2008), only a few have gauged the relative importance of the examined factors in explaining disability trends (Freedman et al. 2007; Schoeni, Freedman, and Martin 2008). Without a rigorous evalution of the relative importance of underlying causal factors, it is difficult to formulate a comprehensive strategy to promote population health. Also, few earlier studies (e.g., Cutler, Landrum, and Stewart 2009b) have quantified the importance of intertemporal changes in disabling effects of factors contributing to disability trends, for example, trends in disabling effects of chronic diseases, smoking and heavy drinking, or in improvements in functioning associated with higher educational attainment.

This study investigated changes in disability prevalence in the United States among persons aged 53–88 years during 1996–2010. We used decomposition analysis to estimate contributions of changes in population sociodemographic composition, chronic diseases, and health behaviors, and trends in their disabling effects during the same period to disability trends. While most studies have focused on ADL and instrumental activities of daily living (IADL) limitations (Freedman et al. 2007; Aranovich et al. 2009; Seeman et al. 2010), we used four additional measures of disability. The four measures are among the precursors of ADL and IADL limitations. There are notable differences in trends using alternative measures.

Data

Data for this study came from 1996 to 2010 waves of the health and retirement study (HRS). We treated the HRS data as a time series of cross-sections. The HRS is a biannually conducted, nationally representative longitudinal survey of persons aged 50+ years and their spouses or partners who could be of any age. The HRS has administered a consistent set of disability measures across waves. It provides six disability indexes derived from specific sets of tasks, enabling us to attain an overview of how each dimension of physical functions has changed over time. The HRS covers the baby-boom generation (persons born 1946–1964), allowing us to examine disability trends in a population group soon to dominate the U.S. elderly population.

Disability Measures

We used the following six primary functional limitation indices from RAND HRS data: number of ADL, IADL, mobility, large muscle, gross motor, and fine motor limitations. The RAND HRS data first derive a variable that indicates whether the respondent has difficulty in performing a task (1 = difficulty, 0 = no difficulty), then generate all the six indices by the sum of number of difficulties that a person has in completing a particular set of tasks. Each set of tasks represents one dimension of functioning. The tasks included in the ADL limitations measure are bathing, dressing, eating, getting in or out of bed, and walking across the room. The other indexes include the tasks of IADL limitations—using a phone, handling money, preparing meals, shopping and taking medication; mobility index—walking one block, walking several blocks, walking across the room, climbing one flight of stairs and climbing several flights of stairs; large muscle index—sitting for 2 hours, stooping, kneeling or couching, getting up from a chair, and pushing or pulling large objects; fine motor index—picking up a dime, eating, and dressing; and gross motor index---walking one block, walking across the room, climbing one flight of stairs, and bathing.

Analysis

We divided our study sample into six age groups: 53–58; 59–64; 65–70; 71–76; 77–82; and 83–88, that is, two groups of near-elderly, and four groups of elderly persons. This grouping allowed for separate analysis of the near-elderly, persons aged 53–64, and elderly persons, those aged 65+.

We first examined whether there were statistically significant changes in the study's disability measures and in the explanatory variables, including sociodemographic characteristics, self-reported chronic diseases, and health behaviors among HRS participants between 1996 and 2010. Then we used decomposition analysis to estimate the relative importance of sources of the differences in disability indexes between 1996 and 2010: (1) the roles of trends in the sample population's sociodemographic characteristics, chronic diseases, and health behaviors (compositional effect) and (2) trends in the above factors' disabling effects (structural effect).

$$\begin{aligned} Y_i^{2010} = {} & \beta_{0,2010} + \beta_1 X_{i,2010} + \beta_2 \text{Diseases}_{i,2010} \\ & + \beta_3 \text{HealthBehaviors}_{i,2010} + \varepsilon_{i,2010} \end{aligned} \tag{1a}$$

$$Y_i^{1996} = \beta_{0,1996} + \beta_1 X_{i,1996} + \beta_2 \text{Diseases}_{i,1996} + \beta_3 \text{HealthBehaviors}_{i,1996} + \varepsilon_{i,1996} \tag{1b}$$

Equation (1a) shows the relationship between disability measures and the explanatory variables in 2010 ($\hat{Y}^{2010}$). Equation (1b) is the counterpart for 1996. The subscript *i* is for individual *i*. The vector *X* represents sociodemographic variables, including age, gender, race, ethnicity, marital status, and educational attainment measured in years of schooling completed, and household income. The second set of explanatory variables, diseases, consists of binary variables for ever having been told by a physician that the person had hypertension; diabetes mellitus; cancer; chronic lung problems; heart problems; psychiatric problems; stroke; and arthritis or rheumatism. Covariates for HealthBehaviors include self-reports of whether the person is obese (BMI >30), heavy drinking (>two drinks daily), current smoker, and former smoker.

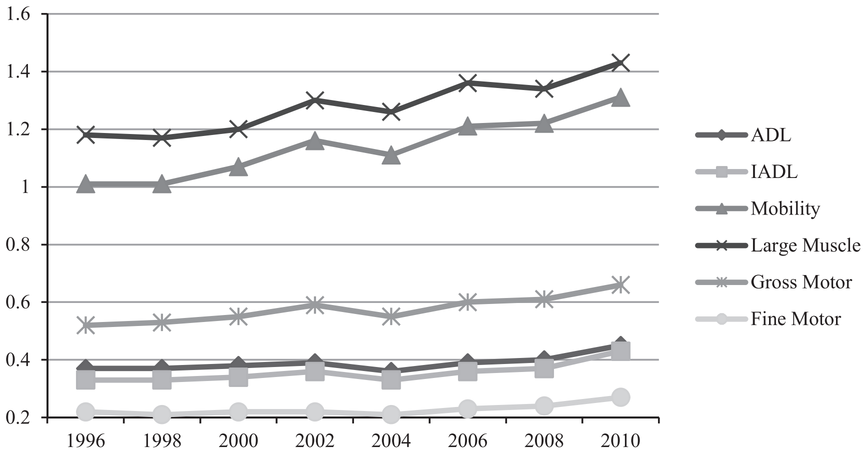
Taking the difference between equations (1a) and (1b) yields equation (2)[1]:

$$Y_i^{2010} - Y_i^{1996} = \underbrace{(\hat{\beta}_{0,2010} - \hat{\beta}_{0,1996}) + \sum_{k=1}^{K} \bar{X}_{k,2010}(\hat{\beta}_{k,2010} - \hat{\beta}_{k,1996})}_{\hat{\Delta}_s^u(\text{structural effect})} + \underbrace{\sum_{k=1}^{K} (\bar{X}_{k,2010} - \bar{X}_{k,1996})\hat{\beta}_{k,1996}}_{\hat{\Delta}_X^u(\text{compositional effect})} \tag{2}$$

The first term on the right of equation (2) is for the change in the intercepts for 2010 and 1996, which are temporal changes not associated with the examined explanatory variable. The second term, the summation over explanatory variables 1 to *K*, represents the sum of the products of the values of the *K* explanatory variables for *X* in 2010 and the corresponding changes in parameter estimates between follow-up (2010) and baseline periods (1996). The sum of the products represents the total change less the intercepts due to changes in effects of each explanatory variable on being disabled, assuming the structure of the follow-up period, 2010. The third term is the sum of products of changes in levels of explanatory variables and the effects of these variables on disability that prevailed in the baseline period. We conducted the decomposition analysis using Stata 11's Blinder-Oaxaca twofold decomposition for linear regression models (Jann 2008).

Decomposition analysis has been widely applied to study labor market outcomes, such as sources of differences in wages between men and women, categorized as differences in wage determinants such as work experience and

Figure 1: Disability Trends



differences in effects of various determinants of wages, which if unfavorable to a particular group, for example, women, has been interpreted as wage discrimination against that group (Blinder 1973; Oaxaca 1973; Fortin, Lemieux, and Firpo 2011). This type of analysis has also been used to identify components of differences between two rates (Kitagawa 1955), and more recently extended to partition intertemporal changes in disability (Freedman and Martin 1999; Freedman et al. 2007).

One potential limitation of applying decomposition analysis in this study is focusing on two single waves, 1996 and 2010. The estimated disability trends may be sensitive to the choice of the specific waves. However, the pattern of estimates of mean disability measures for each wave, 1996–2010, indicates that the choice of 1996 and 2010 is representative of disability trends over 1996–2010 (Figure 1).

Results

Overall, disability tended to increase or remain the same between 1996 and 2010 (Table 1), except for the number of ADL limitations among persons aged 83–88 years for whom the mean number of limitations declined from 1.00 in 1996 to 0.87 in 2010. Increased disability trends were more frequent among the near-elderly than the elderly population. The younger near-elderly group, ages 53–58 years, experienced statistically significant increases on four

Table 1: Disability Changes by Age Group

Age Group	*53–58*		*59–64*		*65–70*		*71–76*		*77–82*		*83–88*	
Year	*1996*	*2010*	*1996*	*2010*	*1996*	*2010*	*1996*	*2010*	*1996*	*2010*	*1996*	*2010*
ADL	0.19	0.23	0.23	0.29***	0.25	0.28	0.38	0.38	0.56	0.57	1	0.87**
IADL	0.15	0.18**	0.17	0.24***	0.23	0.22	0.32	0.32	0.55	0.55	1.06	1.01
Mobility	0.74	0.82**	0.82	0.99***	0.88	1.12***	1.08	1.3***	1.36	1.58***	1.87	2.02**
Large muscle	1.02	1.13***	1.11	1.29***	1.12	1.35***	1.23	1.45***	1.35	1.62***	1.63	1.76***
Gross motor	0.3	0.36***	0.35	0.45***	0.39	0.48***	0.54	0.59*	0.78	0.81	1.3	1.22
Fine motor	0.13	0.14	0.15	0.18***	0.17	0.18	0.24	0.25	0.32	0.35	0.49	0.48
Observations	4,087	1,611	4,511	2,715	1,698	2,915	2,821	3,345	2,111	2,258	1,256	1,393

Notes. *, **, *** respectively means difference between two examined waves significant at 10%, 5%, 1% level; disability is measured by counts of limitation.

measures, IADL limitations, and mobility, large muscle, and gross motor function indexes. The 59–64 age group experienced statistically significant increases in disability on all measures. By contrast, there were statistically significant increases in disability rates on only three measures among persons aged 71–76, and on two measures in the 77–82 and 83–88 age groups. There were statistically significant increases in the mobility and large muscle indexes in all age groups.

Substantial changes in demographic mix occurred in our analysis sample between 1996 and 2010 (Table 2). Most notably, mean educational attainment increased from 1 to 2 years. The sample proportions of Hispanic persons increased, especially for near-elderly persons. Proportions of currently married individuals increased among older individuals but decreased markedly among the near elderly. Real household income increased for the 59–64, 71–76, and 77–82 age groups. The prevalence of several self-reported chronic diseases increased, most notably diabetes mellitus, hypertension, cancer, psychiatric diseases, and arthritis, particularly arthritis in the older age groups. In the health behavior category, rates of smoking decreased while obesity increased substantially. There were no changes in prevalence of heavy drinking apart from the 83–88 age group for whom there was an increase from 0.02 in 1996 to 0.04 in 2010 in the proportion of heavy drinkers.

The decomposition analysis was based on predicted differences in numbers of limitations in different disability measures over a 14-year period, 1996–2010. Predicted differences tended to match actual differences (Table 3). The largest difference between predicted and actual differences was for the large muscle index among persons aged 53–58 (0.038). Negative predicted differences, that is, lower disability in 2010 than 1996, only occurred in the elderly age groups.

Changes in sociodemographic composition tended to lower disability. For example, sociodemographic shifts accounted for a 0.064 decline in the number of ADL limitations among persons aged 83–88, which was as around half of the predicted change between 1996 and 2010 in ADL limitations (−0.114). Overall, changes in sociodemographic mix had large impacts on disability changes in the older age groups, while relatively minor impacts on disability among the near-elderly persons, except for the large muscle index.

The rise in self-reported chronic disease prevalence during 1996–2010 consistently increased disability. The adverse effects of growth in chronic disease prevalence most often exceeded the favorable impacts of changed sociodemographic mix on disability.

Table 2: Descriptive Statistics by Age Group

Age Group	*53–58*		*59–64*		*65–70*		*71–76*		*77–82*		*83–88*	
Year	*1996*	*2010*	*1996*	*2010*	*1996*	*2010*	*1996*	*2010*	*1996*	*2010*	*1996*	*2010*
Demographic characteristics												
Age (years)	55.91	56.45***	61.44	61.40	66.94	67.85***	73.73	73.38***	79.29	79.23	85.08	85.26***
Female	0.57	0.62***	0.54	0.59***	0.45	0.59***	0.57	0.56	0.61	0.57***	0.65	0.59***
Black	0.16	0.15	0.17	0.15	0.12	0.15***	0.13	0.16***	0.13	0.13	0.14	0.09***
Hispanic	0.10	0.14***	0.08	0.12***	0.08	0.09*	0.06	0.09***	0.06	0.08***	0.05	0.06
Education (years)	12.32	13.18***	11.99	13.17***	11.76	12.72***	11.35	12.27***	10.82	12.20***	10.27	12.01***
Married	0.75	0.68***	0.72	0.66***	0.87	0.65***	0.62	0.60*	0.47	0.54***	0.36	0.43***
Income†	90.04	85.84	72.73	81.96***	63.41	66.26	46.65	54.34***	37.29	45.10***	33.50	36.03
Chronic diseases												
Hypertension	0.42	0.45**	0.47	0.56***	0.51	0.65***	0.53	0.69***	0.54	0.71***	0.56	0.72***
Diabetes	0.11	0.17***	0.15	0.23***	0.17	0.26***	0.17	0.28***	0.15	0.26***	0.12	0.23***
Cancer	0.06	0.08***	0.08	0.11***	0.10	0.16***	0.14	0.19***	0.17	0.24***	0.16	0.25***
Lung disease	0.08	0.09	0.10	0.09*	0.11	0.12	0.12	0.13**	0.11	0.14**	0.12	0.12
Heart disease	0.14	0.14	0.18	0.18	0.24	0.25	0.31	0.31	0.35	0.36	0.40	0.44*
Stroke	0.03	0.03	0.04	0.05***	0.06	0.07	0.08	0.09	0.11	0.11	0.14	0.15
Psychiatric disease	0.15	0.22***	0.14	0.24***	0.12	0.20***	0.14	0.16***	0.13	0.16***	0.14	0.15
Arthritis	0.45	0.44	0.55	0.56	0.54	0.66***	0.53	0.71***	0.55	0.73***	0.60	0.72***
Health behaviors												
Obese	0.26	0.38***	0.24	0.38***	0.20	0.36***	0.16	0.31***	0.13	0.25***	0.09	0.15***
Heavy drinker	0.06	0.07	0.06	0.06	0.07	0.06	0.06	0.06	0.04	0.04	0.02	0.04*
Former smoker	0.62	0.53***	0.63	0.56***	0.64	0.60***	0.59	0.60	0.52	0.56**	0.46	0.52***
Current smoker	0.25	0.20***	0.20	0.17***	0.16	0.14**	0.11	0.10*	0.08	0.06***	0.04	0.03*
Observations	4,087	1,611	4,511	2,715	1,698	2,915	2,821	3,345	2,111	2,258	1,256	1,393

†Household income (unit: 1,000 dollars).

Notes. *, **, *** respectively, means difference between two examined waves significant at 10%, 5%, 1% level.

Table 3: Decomposition Analysis Results

	53–58	59–64	65–70	71–76	77–82	83–88	53–58	59–64	65–70	71–76	77–82	83–88
			ADL limitations						**IADL limitations**			
1. Predicted (2010)	0.229	0.281	0.268	0.367	0.521	0.844	0.179	0.228	0.211	0.307	0.507	0.986
2. Predicted (1996)	0.181	0.223	0.242	0.343	0.541	0.959	0.135	0.151	0.229	0.284	0.531	1.005
3. Difference (2010-1996)	0.048	0.057	0.026	0.023	−0.020	−0.114	0.045	0.077	−0.017	0.022	−0.024	−0.018
4. Sociodemographic	0.011	−0.016	0.016	0.001	−0.032	−0.064	−0.011	−0.021	−0.011	−0.022	−0.051	−0.076
5. Chronic diseases	0.041	0.061	0.068	0.068	0.114	0.120	0.035	0.052	0.058	0.026	0.097	0.056
6. Obese	0.012	0.009	0.010	0.012	0.013	0.031	0.002	0.001	0.000	−0.003	−0.006	0.007
7. Smoke + drink	−0.003	0.000	0.002	0.001	−0.001	−0.006	−0.001	0.000	0.003	0.000	−0.003	0.002
8. Compositional	0.062	0.055	0.097	0.083	0.095	0.083	0.027	0.032	0.050	0.000	0.037	−0.011
9. Structural	−0.014	0.003	−0.070	−0.059	−0.115	−0.197	0.018	0.045	−0.067	0.022	−0.061	−0.007
			Mobility index						**Large muscle index**			
1. Predicted (2010)	0.820	0.966	1.106	1.286	1.540	1.989	1.133	1.278	1.336	1.445	1.597	1.752
2. Predicted (1996)	0.720	0.808	0.881	1.058	1.327	1.843	0.985	1.094	1.105	1.205	1.336	1.608
3. Difference (2010-1996)	0.100	0.158	0.224	0.228	0.213	0.145	0.148	0.184	0.231	0.240	0.260	0.143
4. Sociodemographic	0.004	−0.030	0.059	−0.019	−0.041	−0.097	−0.023	−0.041	0.015	−0.038	−0.050	−0.028
5. Chronic diseases	0.088	0.121	0.162	0.183	0.243	0.184	0.096	0.127	0.185	0.192	0.229	0.159
6. Obese	0.039	0.053	0.060	0.070	0.039	0.035	0.038	0.041	0.029	0.061	0.028	0.015
7. Smoke + drink	−0.010	−0.009	−0.003	−0.002	0.001	0.003	−0.007	−0.004	0.004	0.001	0.002	0.000
8. Compositional	0.120	0.136	0.278	0.233	0.240	0.126	0.104	0.122	0.234	0.216	0.208	0.143
9. Structural	−0.020	0.022	−0.054	−0.006	−0.028	0.019	0.044	0.062	−0.003	0.025	0.052	0.000
			Gross motor index						**Fine motor index**			
1. Predicted (2010)	0.365	0.431	0.464	0.576	0.771	1.190	0.144	0.178	0.175	0.243	0.323	0.466
2. Predicted (1996)	0.290	0.340	0.386	0.500	0.756	1.265	0.116	0.147	0.166	0.223	0.313	0.472
3. Difference (2010-1996)	0.075	0.091	0.078	0.076	0.015	−0.075	0.028	0.031	0.009	0.020	0.010	−0.006
4. Sociodemographic	0.008	−0.023	0.032	−0.008	−0.036	−0.090	0.005	−0.007	0.001	0.001	−0.021	−0.010

Continued

Table 3. *Continued*

	53–58	*59–64*	*65–70*	*71–76*	*77–82*	*83–88*	*53–58*	*59–64*	*65–70*	*71–76*	*77–82*	*83–88*
5. Chronic diseases	0.055	0.074	0.093	0.103	0.164	0.160	0.025	0.035	0.044	0.041	0.070	0.063
6. Obese	0.017	0.020	0.022	0.032	0.019	0.028	0.004	0.005	0.002	0.010	0.006	0.014
7. Smoke + drink	−0.007	−0.002	0.002	0.000	0.000	−0.002	−0.001	−0.001	0.001	0.000	−0.001	0.000
8. Compositional	0.075	0.069	0.148	0.127	0.147	0.098	0.033	0.031	0.047	0.052	0.054	0.066
9. Structural	0.000	0.022	−0.070	−0.052	−0.132	−0.172	−0.006	0.000	−0.039	−0.032	−0.044	−0.072
Observations	5,698	7,226	4,613	6,166	4,369	2,649	5,698	7,226	4,613	6,166	4,369	2,649

Increased obesity rates had minor impacts on trends in ADL and IADL limitations and the fine motor index, but the magnitudes of obesity's unfavorable effects on lower-body physical function, measured by the mobility, large muscle, and gross motor indexes were comparable to or even exceeded the favorable effects of sociodemographic shifts. The decline in smoking was a favorable development but had small impacts on disability trends.

Changes in prevalence of the above factors mostly explained predicted changes in disability among near-elderly persons in ADL and IADL limitations, gross motor and fine motor function, but had a lesser role in explaining disability trends among elderly persons on the same disability measures. Some unexplained changes in predicted values for the elderly groups, that is, empirical counterparts of $\sum_{k=1}^{K} \bar{X}_{k,2010}(\hat{\beta}_{k,2010} - \hat{\beta}_{k,1996})$ from equation (2), were as large or exceeded the explained changes.

The three most important single causes of the explained part of disability changes corresponding to $\sum_{k=1}^{K} = (\bar{X}_{k,2010} - \bar{X}_{k,1996})\hat{\beta}_{k,1996}$ in equation (2) are listed in Table 4. Among all the disability indices for all age groups, increased educational attainment was usually among the top three individual causes of disability declines. Other common individual causes of disability changes were changes in prevalence of self-reported diabetes mellitus, psychiatric conditions, and arthritis, all of which tended to increase disability prevalence. Changes in psychiatric disease prevalence over time had an important role in explaining disability changes in the younger age groups, but they had little effect on such changes for the eldest group. By contrast, changes in arthritis prevalence were always major causes of disability changes among the older cohorts, but they had only minor effects for near-elderly individuals. Changes in obesity prevalence were a major cause of decreased mobility, and large muscle and gross motor function. The other causes of disability changes only appeared among the top three occasionally: age; black race; female; and hypertension.

Changes in the underlying parameters between 1996 and 2010 (structural changes) were statistically significant at the 5 percent level or better in only a minority of cases (Table 5). The marginal protective effect of educational attainment, when significant, increased over time. For example, an added year of school reduced the number of ADL limitations for the 71–76 age group on average by 0.222 more in 2010 than in 1996. The other statistically significant changes in parameters were for self-reported chronic diseases. The largest changes were for arthritis. Thus, although the prevalence of arthritis increased markedly between 1996 and 2010, its disabling effect diminished

Table 4: Three Most Important Causes of Disability Changes, 1996–2010

	53–58	*59–64*	*65–70*	*71–76*	*77–82*	*83–88*	*53–58*	*59–64*	*65–70*	*71–76*	*77–82*	*83–88*
			ADL limitations						**IADL limitations**			
Age										−0.009		
Black												−0.016
Education		−0.019	−0.015			−0.053	−0.013	−0.024	−0.024	−0.019	−0.040	−0.057
Diabetes	0.010	0.013		0.015	0.022	0.060	0.010				0.026	0.047
Stroke								0.009				
Psychiatric	0.024	0.033	0.028	0.012	0.022		0.021	0.031	0.035	0.014		
Arthritis			0.020	0.028	0.049	0.037					0.025	
Obesity	0.012											
			Mobility index						**Large muscle index**			
Female			0.042									−0.017
Education	−0.021	−0.040				−0.073	−0.029	−0.040	−0.044		−0.033	
Hypertension					0.040					0.026		
Diabetes	0.021		0.042	0.032		0.069			0.033			
Heart disease												0.017
Psychiatric	0.043	0.059					0.051	0.066				
Arthritis			0.045	0.088	0.122	0.067			0.093	0.135	0.144	0.091
Obese	0.039	0.053	0.060	0.070	0.039		0.038	0.041		0.061	0.028	
			Gross motor index						**Fine motor index**			
Education		−0.030	−0.030			−0.070		−0.009			−0.013	
Hypertension					0.022							−0.017
Diabetes	0.012		0.025	0.021	0.024	0.068	0.008	0.009	0.009			
Psychiatric	0.030	0.041	0.036				0.013	0.015	0.018	0.006	0.013	
Arthritis				0.042	0.072	0.051			0.016	0.022	0.036	0.025
Obese	0.017	0.020		0.032			0.004			0.010		0.014
Observations	5,698	7,226	4,613	6,166	4,369	2,649	5,698	7,226	4,613	6,166	4,369	2,649

Note. All coefficients are significant at the 5% level or better.

Table 5: Changes in Disabling Effects of Education and Chronic Conditions

	53–58	59–64	65–70	71–76	77–82	83–88	53–58	59–64	65–70	71–76	77–82	83–88
			ADL limitations						**IADL limitations**			
Education				−0.222	−0.310	−0.440				−0.218		−0.610
Hypertension												
Diabetes						−0.122						−0.090
Cancer												
Lung disease			−0.031			−0.042						
Heart disease		0.022									−0.053	
Stroke		−0.022		−0.023	−0.037			−0.013		−0.025		
Psychiatric disease									−0.030			
Arthritis					−0.151						−0.178	
			Mobility index						**Large muscle index**			
Education	−0.421	−0.288		−0.503								
Hypertension											−0.139	
Diabetes	−0.041						−0.037					
Stroke		−0.015					−0.014	−0.015				
Psychiatric disease										0.033		
Arthritis												
			Gross motor index						**Fine motor index**			
Education				−0.344			−0.143	−0.151		−0.202	−0.171	
Hypertension											−0.054	
Diabetes						−0.095						−0.058
Cancer	0.018								0.019			
Lung disease	0.021								−0.016			
Heart disease		0.029										
Stroke		−0.019						−0.007		−0.020		−0.027
Psychiatric disease												
Arthritis					−0.159						−0.075	
Observations	5,698	7,226	4,613	6,166	4,369	2,649	5,698	7,226	4,613	6,166	4,369	2,649

Note. All coefficients are significant at the 5% level or better.

markedly as well. Disabling effects also decreased for other chronic diseases, but there were one or two increases for cancer, lung diseases, heart problems, and psychiatric. There were nonsignificant or only small changes in marginal effects of being obese, smoking, and heavy drinking over time.

To investigate whether a change in eligibility criteria for Supplemental Security Income (SSI) and Social Security Disability Insurance (SSDI) may have led to an increase in self-reported impairment rates, especially for persons under age 65, we redid the decomposition analysis, adding a covariate for whether the respondent was an SSI or SSDI recipient.[2] We limited our sensitivity analysis to near-elderly groups since SSI/SSDI enrollment data were not available for older age groups for the baseline year. Results are similar to those reported in Table 3.

An appreciably higher percentage of respondents were interviewed in person in 2010 than in 1996 when a majority of respondents were interviewed by telephone. In another sensitivity analysis, we added a covariate for interview mode.[3] The addition of mode led to minor changes in the decomposition results, but no changes were of sufficient magnitude to affect our substantive findings.

DISCUSSION

With the exception of ADL limitations among persons aged 83–88, the mean number of limitations increased or remained unchanged for both near-elderly and elderly persons in the United States during 1996–2010. The increases were more apparent for near-elderly than for the elderly population, especially for the ADL and IADL limitations. The most consistent increases in limitations were for lower-body function, as reflected in unfavorable trends in the mobility, large muscle, and gross motor function indexes. Such limitations place older persons at increased risk of falls (Hernandez, Goldberg, and Alexander 2010).

If anything, changes in sociodemographic mix during 1996–2010 should have led to decreased disability among both near-elderly and elderly persons. Notable among these changes was an increased educational attainment of a year or more over a time span of only 14 years. However, these favorable effects were offset by the growth of self-reported chronic disease prevalence. Smoking and heavy drinking rates decreased, but these factors contributed little to disability changes. Increased obesity prevalence generated sizable effects on the measures of lower-body function, that is, the mobility, large muscle, and gross motor indexes. Protective effects of educational attainment increased during the observational period. Moreover, disabling effects of some self-reported chronic diseases declined. Such declines were the largest for arthritis.

Our results are consistent with recent studies demonstrating nondeclining disability trends among the elderly and increasing disability rates for the near-elderly (Weir 2007; Martin et al. 2010; Seeman et al. 2010; Lin et al. 2012; Freedman et al. 2013). Such results are potentially important for several reasons. First, early retirement due to disability may place an additional financial burden on already financially distressed social insurance programs, such as SSDI (Autor and Duggan 2006). Second, if the increase in disability among the near elderly portends more disability when these individuals turn 65, this will impose an increased financial burden on Medicare as well as on long-term care and public programs that finance such care, especially Medicaid. But such concern may be mitigated by the low actual rates of limitations among the near-elderly persons.

Some variation in results on different disability measures may reflect the different nature of these measures. For example, ADL and IADL limitations are more likely to be affected than gross motor index by changes in use of assistive technology and environmental changes, such as availability of ramps and wider door sizes. Obesity may be more strongly associated with mobility than fine motor limitations.

The sociodemographic composition of the older population has changed considerably in the United States in recent decades, and this shift has played a substantial role in improving disability trajectories, especially for older elderly persons. Most important, the large increase in educational attainment and in advantages of higher education attainment for functioning accounted for considerable declines in disability rates, particularly in the older age groups. More highly educated persons are more likely to work in white-collar jobs, which expose them to fewer job-related health risks (Kanjilal et al. 2006; Fisher-Hoch et al. 2010). Additionally, more highly educated persons tend to be more efficient in managing illness (Grossman 1972), more likely to use higher-quality assistive technology, and be more willing and able to adjust environment to cope with disability (Hoenig, Taylor, and Sloan 2003; Cutler, Landrum, and Stewart 2009a). The increased marginal effect of educational attainment over 1996–2010 could reflect larger marginal effects at higher levels of such attainment and/or more widespread health knowledge among the population.

The declining debilitating effects of chronic diseases, which are consistent with earlier studies (Cutler 2005; Freedman et al. 2007; Cutler, Landrum, and Stewart 2009b), may reflect increased treatment intensity (Kurtz et al. 2005; Mettler et al. 2009), including greater application of technologies existing in the base year and application of technologies introduced since then. Cutler (2005) inferred that use of treatments for acute myocardial infarction (AMI), for example, beta-blockers, aspirin, and ACE inhibitors at hospital discharge and reperfusion and other surgical procedures, may have increased the AMI survival probability of elderly persons in a nondisabled state up to 50 percent. Replacement rates of hip and knee joints per year in patients, mostly with osteoarthritis, roughly doubled during 1990–2002 (Kurtz et al. 2005). These procedures have advanced in both surgical techniques and materials, and are much less risky than in the past. There are concurrent increases in use of medications for arthritic and rheumatic conditions. These trends were reflected in our results that there were 0.066–0.158 declines in the average number of limitations among persons having arthritis from 1996 to 2010.

Or, not mutually exclusive with the declining debilitating effects, the declining marginal effects could reflect changes in rates of ascertainment of underlying chronic diseases, especially for chronic diseases at an earlier stage in the disease process. Higher rates of diagnosis may reflect the availability of new therapeutic interventions since more effective therapies provide a greater incentive for diagnosis. Given available data, it is not possible to distinguish the effects of greater ascertainment from the role of greater treatment intensity and technological change.

The declines in debilitating effects of chronic diseases were more likely to occur among elderly than near-elderly persons. Such trends may reflect better access to medical care among the elderly population as they have comprehensive health insurance coverage provided by Medicare.

Obesity rates increased dramatically, and this is reflected in increases in self-reported arthritis and in the indexes for lower-body function. Further increases in demand for such surgical interventions as total hip and knee arthroplasty can be anticipated for this reason. Smoking prevalence decreased, but it had little impact overall on disability trends.

The major strength of our study is the use of decomposition analysis to investigate explanations for increased disability trends, which allowed for consideration of both roles of trends in prevalence of examined factors, compositional changes, and in structural changes in disabling effects of the analyzed factors. Decomposition analysis is widely used and has many well-documented advantages (Fortin, Lemieux, and Firpo 2011). We also bridged gaps in earlier literature by explaining disability trends among the near-elderly population.

We also acknowledge several study limitations. First, a limitation of decomposition analysis is the assumption that the disability differentials between baseline and follow-up can be explained by the analyzed factors. To the extent that the underlying model is misspecified, this will affect the results of the decomposition analysis. Second, observations of persons aged 53 and 54 in 1996 were mainly spouses or partners of main respondents. This may have introduced a minor bias in baseline values for the 53–58 age group. Third, the increase in the percentage of persons institutionalized (1.7 percent in 1996 vs. 3.9 percent in 2010) over the study period may have led us to slightly underestimate disability among the older old in 2010.

CONCLUSION

In sum, using several alternative measures, we found the mean number of limitations increased or remained unchanged for both near-elderly and elderly persons in the United States during 1996–2010. Changes in sociodemographic mix overall tended to reduce disability. Increased prevalence of chronic diseases, as reported by respondents to the Health and Retirement Study, increased it, although the disabling effects of chronic diseases tended to diminish. Changes in smoking rates, although sizable, had a minor effect on disability among the elderly and near-elderly persons.

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Disclaimers: None.

Notes

1. The decomposition can also be written by exchanging the reference group:

$$Y_i^{2010} - Y_i^{1996} = (\hat{\beta}_{0,2010} - \hat{\beta}_{0,1996}) + \sum_{k=1}^{K} \bar{X}_{k,1996}(\hat{\beta}_{k,2010} - \hat{\beta}_{k,1996}) + \sum_{k=1}^{K} (\bar{X}_{k,2010} - \bar{X}_{k,1996})\hat{\beta}_{k,2010}$$

We preferred equation (2) since it frames the analysis in terms of population characteristics prevailing in the recent year (using $\bar{X}_{k,2010}$ rather than $\bar{X}_{k,1996}$ in the structural part). It first applies changes in the parameters between 1996 and 2010 to the composition of the follow-up population (the 2010 group), then adds the changes in disability that would have occurred because of these population composition shifts if there had been no changes in the parameters between 1996 and 2010. Alternatively, the less preferred specification begins with the population composition as it existed in 1996. However, it seems more relevant to focus on a population that existed in a recent year, which is the more interesting population currently.
2. Results are presented in Appendix Table 1.
3. See results in Appendix Table 2.

References

Al Snih, S., J. E. Graham, Y.-F. Kuo, J. S. Goodwin, K. S. Markides, and K. J. Ottenbacher. 2010. "Obesity and Disability: Relation among Older Adults Living in Latin America and the Caribbean." *American Journal of Epidemiology* 171 (12): 1282–8.

Alley, D. E., and V. W. Chang. 2007. "The Changing Relationship of Obesity and Disability, 1988-2004." *Journal of the American Medical Association* 298 (17): 2020–7.

Anderson, G., R. Herbert, T. Zeffiro, and N. Johnson. 2004. "Chronic Conditions: Making the Case for Ongoing Care " [accessed on January 14, 2015]. Available at http://www.partnershipforsolutions.org/DMS/files/chronic_book 2004.pdf.

Aranovich, G., J. Bhattacharya, A. M. Garber, and T. E. MaCurdy. 2009. *Coping with Chronic Disease? Chronic Disease and Disability in Elderly American Population 1982–1999.* NBER Working Paper Series Number w14811. Cambridge, MA: National Bureau of Economic Research.

Autor, D. H., and M. G. Duggan. 2006. "The Growth in the Social Security Disability Rolls: A Fiscal Crisis Unfolding." *Journal of Economic Perspective* 20 (3): 71–96.

Blinder, A. S. 1973. "Wage Discrimination: Reduced Form and Structural Estimates." *Journal of Human Resources* 8 (4): 436–55.

Crimmins, E. M., and H. Beltrán-Sánchez. 2011. "Mortality and Morbidity Trends: Is There Compression of Morbidity?" *Journal of Gerontology Series B: Psychological Sciences* 66 (1): 75–86.

Cutler, D. M. 2001. "Declining Disability among the Elderly." *Health Affairs* 20 (6): 11–27.

———. 2005. "Intensive Medical Technology and the Reduction in Disability." In *Analyses in the Economics of Aging*, edited by D. A. Wise, pp. 161–84. Chicago, IL: University of Chicago Press.

Cutler, D. M., M. B. Landrum, and K. A. Stewart. 2009a. "How Do the Better Educated Do It? Socioeconomic Status and the Ability to Cope with Underlying Impairment." In *Developments in the Economics of Aging*, edited by D. A. Wise, pp. 203–48. Chicago, IL: University of Chicago Press.

———. 2009b. "Intensive Medical Care and Cardiovascular Disease Disability Reductions." In *Health at Older Ages: The Causes and Consequences of Declining Disability among the Elderly*, edited by D. M. Cutler and D. A. Wise, pp. 191–222. Chicago, IL: University of Chicago Press.

Daw, J., K. Nowotny, and J. Boardman. 2013. "Changing Patterns of Tobacco and Alcohol Co-Use by Gender in the United States, 1976-2010." *Demographic Research* 28 (22): 637–48.

Fisher-Hoch, S. P., A. R. Rentfro, J. G. Wilson, J. J. Salinas, B. M. Reininger, B. I. Restrepo, J. B. McCormick, A. Pérez, H. S. Brown, and M. M. Hossain. 2010. "Socioeconomic Status and Prevalence of Obesity and Diabetes in a Mexican American Community, Cameron County, Texas, 2004-2007." *Preventing Chronic Disease* 7 (3): A53–62.

Fortin, N., T. Lemieux, and S. Firpo. 2011. "Decomposition Methods in Economics." In *Handbook of Labor Economics*, edited by O. Ashenfelter and D. Card, pp. 1–102. Amsterdam: Elsevier.

Freedman, V. A., and L. G. Martin. 1998. "Understanding Trends in Functional Limitations among Older Americans." *American Journal of Public Health* 88 (10): 1457–62.

———. 1999. "The Role of Education in Explaining and Forecasting Trends in Functional Limitations among Older Americans." *Demography* 36 (4): 461–73.

Freedman, V. A., R. F. Schoeni, L. G. Martin, and J. C. Cornman. 2007. "Chronic Conditions and the Decline in Late-Life Disability." *Demography* 44 (3): 459–77.

Freedman, V. A., B. C. Spillman, P. M. Andreski, J. C. Cornman, E. M. Crimmins, E. Kramarow, J. Lubitz, L. G. Martin, S. S. Merkin, R. F. Schoeni, T. E. Seeman, and T. A. Waidmann. 2013. "Trends in Late-Life Activity Limitations in the United States: An Update from Five National Surveys." *Demography* 50 (2): 661–71.

Garrett, B. E., S. R. Dube, A. Trosclair, R. S. Caraballo, and T. F. Pechacek. 2011. "Cigarette Smoking—United States, 1965–2008." *Morbidity and Mortality Weekly Report Surveillance Summaries* 60 (Suppl): 109–13.

Grossman, M. 1972. "On the Concept of Health Capital and the Demand for Health." *Journal of Political Economics* 80 (2): 223–55.

Hernandez, M. E., A. Goldberg, and N. B. Alexander. 2010. "Decreased Muscle Strength Relates to Self-Reported Stooping, Crouching, or Kneeling Difficulty in Older Adults." *Physical Therapy* 90 (1): 67–74.

Hoenig, H., D. H. Taylor, and F. A. Sloan. 2003. "Does Assistive Technology Substitute for Personal Assistance among the Disabled Elderly?" *American Journal of Public Health* 93 (2): 330–7.

Jann, B. 2008. "The Blinder-Oaxaca Decomposition for Linear Regression Models." *The Stata Journal* 8 (4): 453–79.

Jemal, A., M. Thun, Q. Y. Xue, A. M. Hartman, V. Cokkinides, M. M. Center, H. Ross, and E. M. Ward. 2011. "Changes in Smoking Prevalence among US Adults by State and Region: Estimates from the Tobacco Use Supplement to the Current Population Survey, 1992-2007." *BMC Public Health* 11 (1): 512–21.

Kanjilal, S., E. W. Gregg, Y. J. Cheng, P. Zhang, D. E. Nelson, G. Mensah, and G. L. Beckles. 2006. "Socioeconomic Status and Trends in Disparities in Four Major Risk Factors for Cardiovascular Disease among US Adults, 1971-2002." *Archives of Internal Medicine* 166 (21): 2348–55.

King, D. E., E. Matheson, S. Chirina, A. Shankar, and J. Broman-Fulks. 2013. "The Status of Baby Boomers' Health in The United States: The Healthiest Generation?" *JAMA Internal Medicine* 173 (5): E1–2.

Kitagawa, E. M. 1955. "Components of a Difference between Two Rates." *Journal of the American Statistical Association* 50 (72): 1168–94.

Kurtz, S., F. Mowat, K. Ong, N. Chan, E. Lau, and M. Halpern. 2005. "Prevalence of Primary and Revision Total Hip and Knee Arthroplasty in the United States from 1990 through 2002." *The Journal of Bone and Joint Surgery: American Edition* 87 (7): 1487–97.

Lin, S.-F., A. N. Beck, B. K. Finch, R. A. Hummer, and R. K. Master. 2012. "Trends in US Older Adult Disability: Exploring Age, Period, and Cohort Effects." *American Journal of Public Health* 102 (11): 2157–63.

Manton, K. G., X. Gu, and V. L. Lamb. 2006. "Change in Chronic Disability from 1982 to 2004/2005 as Measured by Long-Term Changes in Function and Health in the US Elderly Population." *Proceedings of the National Academy of Sciences* 103 (48): 18374–9.

Martin, L. G., and R. F. Schoeni. 2013. "Trends in Disability and Related Chronic Conditions among the Forty-and-Over Population: 1997–2010." *Disability and Health Journal* 7 (1): S4–14.

Martin, L. G., R. F. Schoeni, and P. M. Andreski. 2010. "Trends in Health of Older Adults in the United States: Past, Present, Future." *Demography* 47 (1): S17–40.

Martin, L. G., V. A. Freedman, R. F. Schoeni, and P. M. Andreski. 2010. "Trends in Disability and Related Chronic Conditions among People Ages Fifty to Sixty-Four." *Health Affairs* 29 (4): 725–31.

McLaughlin, S. J., C. M. Connell, S. G. Heeringa, L. W. Li, and J. S. Roberts. 2010. "Successful Aging in the United States: Prevalence Estimates from a National Sample of Older Adults." *Journal of Gerontology Series B: Psychological Sciences* 65 (2): 216–26.

Mettler, F. A., M. Bhargavan, K. Faulkner, D. B. Gilley, J. E. Gray, G. S. Ibbott, J. A. Lipoti, M. Mahesh, J. L. McCrohan, and M. G. Stabin. 2009. "Radiologic and Nuclear Medicine Studies in the United States and Worldwide: Frequency, Radiation Dose, and Comparison with Other Radiation Sources—1950–2007." *Radiology* 253 (2): 520–31.

Oaxaca, R. 1973. "Male-Female Wage Differentials in Urban Labor Markets." *International Economic Review* 14 (3): 693–709.

Reynolds, S. L., and E. M. Crimmins. 2010. "Trends in the Ability to Work among Men and Women in the Older American Population: 1997–2007." *European Journal of Ageing* 7 (4): 249–56.

Roerecke, M., and J. Rehm. 2010. "Irregular Heavy Drinking Occasions and Risk of Ischemic Heart Disease: A Systematic Review and Meta-Analysis." *American Journal of Epidemiology* 171 (6): 633–44.

Schoeni, R. F., V. A. Freedman, and L. G. Martin. 2008. "Why Is Late-Life Disability Declining?" *Milbank Quarterly* 86 (1): 47–89.

Seeman, T. E., S. S. Merkin, E. M. Crimmins, and A. S. Karlamangla. 2010. "Disability Trends among Older Americans: National Health and Nutrition Examination Surveys, 1988–1994 and 1999–2004." *American Journal of Public Health* 100 (1): 100–7.

Shah, R. S., and J. W. Cole. 2010. "Smoking and Stroke: The More You Smoke the More You Stroke." *Expert Review of Cardiovascular Therapy* 8 (7): 917–32.

Sturm, R., J. S. Ringel, and T. Andreyeva. 2004. "Increasing Obesity Rates and Disability Trends." *Health Affairs* 23 (2): 199–205.

Sundell, L., V. Salomaa, E. Vartiainen, K. Poikolainen, and T. Laatikainen. 2008. "Increased Stroke Risk is Related to a Binge Drinking Habit." *Stroke* 39 (12): 3179–84.

Weir, D. 2007. "Are Baby Boomers Living Well Longer." In *Redefining Retirement: How Will Boomers Fare?*, edited by B. Madrian, O. Mitchell, and B. Soldo, pp. 95–111. New York: Oxford University Press.

Supporting Information

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.