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Abstract

This study considers the dependence between functional decline and depression in a nationally representative sample of older Americans from the Survey on Assets and Health Dynamics among the Oldest Old (AHEAD) covering the years from 1993 to 2002. Previous research has shown that depression is a significant predictor of functional decline and, conversely, functional limitations lead to more depressive symptoms. While this cross-dependence is an established fact in the literature, relatively few prior papers formally modeled the association between functional decline and depression.

In this paper, functional decline is defined as 2 or more limitations in 5 Activities of Daily Living (ADL) and 2 or more limitations in 5 Instrumental Activities of Daily Living (IADL) from the baseline to the last available follow-up interview. Depression is defined as 3 or more points on the 8-item Center for Epidemiological Studies Depression (CES-D) Scale over the same range of

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time. In the analytic sample of 5,470 oldest Americans, each of the three measures is initially estimated in the univariate probit model controlling for a rich set of available risk factors identified in the previous studies.

Then it is argued that univariate probit models are incapable of capturing individual differences (for example, predisposition to both physical and emotional ill health) that may link functional decline and depression in the oldest Americans. Thus, a more advanced multivariate probit model is employed, and three discrete equations are estimated jointly. In this way, unmeasured factors specific to the individual will become part of the error terms, and statistically significant correlations in the variance matrix will indicate dependence between functional decline and depression. Estimation of multivariate probit model reveals substantial unobserved heterogeneity in the dynamics of ADLs, IADLs, and CES-D score over time. Thus, previous results based on univariate methods should be interpreted with caution.

1. Introduction

Depression and functional disability represent serious challenges to older adults, and the association between the two health problems is an established fact in the literature (Bruce 2001). On the one hand, depression was found to be among the strongest contributing factors to functional decline in a systematic review of 78 longitudinal studies in Stuck et al. (1999) as well as in a more recent study of Covinsky et al. (2010). On the other hand, community-dwelling older adults with functional limitations are more likely to suffer from depression and depressive symptoms, as shown in another review article by Cole and Dendukuri (2003).

It should be noted, however, that most of the analyses in the aforementioned studies concentrate on the unidirectional effects of depression on functional limitations and vice versa. Strong evidence of the contribution of depression on functional limitations and, conversely, of functional limitations on depression led some researchers to suggest a mutually reinforcing relationship (Bruce 2001). It was not until the paper by Ormel et al. (2002) that the reciprocal (rather than unidirectional) association between developing depression and functional limitations over time was formally modeled.

Ormel et al. (2002) argue that "individual differences in generic liability to both physical and emotional ill health" may be a common cause linking depression and disability. The problem, of course, lies in identifying and properly accounting for such individual differences in statistical analyses. Fortunately, a recent implementation of the multivariate probit model employed in this paper allows testing for the presence of individual differences linking functional decline and depression in older Americans over time.

2. Methods

2.1 AHEAD Survey and Analytic Sample

This paper employs data from the Survey on Assets and Health Dynamics among the Oldest Old (AHEAD), which is a nationally representative longitudinal health and retirement study administered by the Survey Research Center at the University of Michigan. A complete

description of the AHEAD study can be found online at http://hrsonline.isr.umich.edu and in several review articles (Juster and Suzman 1995; Myers, Juster and Suzman 1997).

The original AHEAD sample includes 7,447 participants aged 70 years or older who completed the baseline interviews in 1993-1994 and were re-interviewed every two years thereafter (AHEAD Core 1993 public use dataset). Proxy respondents constitute 10.6% of the sample (793 people) and are excluded because they do not answer cognitive questions. This paper studies the long-term link between functional decline and depression by considering the difference between self-reported measures at the baseline interview and at the last available follow-up interview. In the analytic sample, 1,184 respondents (15.9% of the sample) have only one reading of self-reported functional status and/or depression at the baseline interview, and they are also excluded from the analysis.

2.2 Measures of Functional Decline and Depression

This paper uses two common measures of functional decline: number of difficulties in performing 5 Activities of Daily Living (getting across a room, dressing, bathing or showering, eating, and getting into or out of bed) and number of difficulties regarding 5 Instrumental Activities of Daily Living (using a telephone, taking medication, handling money, shopping, and preparing meals). Since functional status is a highly dynamic process, functional decline is defined as at least 2 limitations in ADLs and IADLs at the final follow-up interview. Using 2 or more limitations reduces the possibility of measurement error in self-reported functional status.

Depression is measured using a shortened 8-item version of CES-D (Center for Epidemiological Studies Depression Scale), which was used in all waves of the AHEAD study (Sheffick 2000). Prior studies indicate that a shorter version of the original 20-item CES-D is appropriate for assessing depressive symptoms in older population, and it can also alleviate respondent burden (Kohout et al., 1993; Fonda and Herzog, 2001). In the previous studies, the cutoff of 3 or more on the 8-item CES-D was found to be a threshold of depression (Sheffick 2000, Choi and Kim 2007). Thus, depression was defined as having three or more CES-D items at the last follow-up interview.

In the final sample of 5,470 older Americans used in the analysis, relatively few had any difficulties with ADLs (812, or 14.8%) and IADLs (754, or 13.8%), but more than half had CES-D scores of 1 or more (3,272 or 59.8%) at the baseline interview in 1993-1994. At the last available follow-up interview, 933 respondents (17.1%) reported 2 or more new ADL limitations, 921 respondents (16.8%) reported 2 or more new IADL limitations, and 793 (14.5%) reported 3 or more new items in their CES-D score. It should be noted that the last follow-up interview could have taken place as early as 1995 or as late as 2002, with the average time spent in the sample being 7.6 years.

2.3 Control Variables

The list of risk factors for functional decline includes important predictors identified in the previous literature (Stuck et al. 1999, Gill et al. 2004, Boyd et al. 2005). To separate the aging effects from the cohort effects, 2 timing variables are used: exposure time, defined as years in the

survey (centered at the mean), and age at the baseline interview. Additionally, to account for any nonlinear effects, squared terms for both variables are included. The problem of sample selection is accounted for by including a marker regarding whether a respondent survived until the end of the study (39.6% of the analytic sample).

Men constitute 37.3% of the sample. 23% of respondents completed grade school only, and 29% attended college (reference category is completing high school). Functional status is measured by indicators for good to excellent vision (76.7%) and engaging in rigorous activity in 1995 (31.0%). Self-reported numbers for visits to medical doctors and hospitalizations are used to measure health care utilization at the wave prior to the final one. In particular, upper quintiles for each measure are introduced to control for high users of health services. Three markers identify patients who were ever told by a doctor that they had diabetes (18.3%), arthritis (67.1%), and stroke (17.0%). Cognitive status is defined by the TICS (Telephone Interview for Cognitive Status) scores with the average being 12.1 (out of 15).

Similarly, control variables for depression include available predictors found in previous studies using the CES-D scale as identified in Cole and Dendukuri's (2003) review article. African-Americans and Hispanics constitute 12.4% and 4.9% of the analytic sample, respectively. Good to excellent self-rated health characterizes 68.9% of the sample. Of the respondents, 39.7% were widowed, 3.1% never married, 5.7% separated, and 37.8% living alone. Approximately 11% of respondents reported ever having psychological problems. Univariate and multivariate analyses are weighted by the AHEAD sample weights following two previous studies that used HRS data to study depression and disability (Covinsky et al. 2010, Choi and Kim 2007).

2.4 Analyses

The purpose of this article is to study unobserved factors linking functional decline and depression in older Americans over time. First, three univariate probit models are estimated for the probability that a respondent has developed from the baseline to the last available follow-up: (i) 2 additional ADL limitations, (ii) 2 or more IADL limitations, and (iii) 3 or more items on a shortened CES-D scale. It is argued that the univariate probit model is incapable of capturing individual differences that may link functional decline and depression in the oldest Americans. Thus, a more advanced multivariate probit model is employed and three discrete equations are estimated jointly. In this way, unmeasured factors specific to the individual will become part of the error terms, and statistically significant correlations in the variance matrix will indicate dependence between functional decline and depression.

Despite the fact that Ashford and Sowden (1970) popularized the multivariate probit model quite a long time ago, reliable implementations of this model have not been available in commercial software until recently due to computational difficulties associated with evaluations of multivariate normal integrals (Chib and Greenberg 1998). However, Cappellari and Jenkins (2003) recently developed a Stata® program *mvprobit* that has already been used in the closely-related field of health economics (Balia and Jones 2008).

The marginal effect of a change in a continuous variable (such as age) x_i in the probit model is equal to $\phi(x'\beta)\beta_i$, where x' is 1-by-k vector of independent variables, β is k-by-1 vector of estimated parameters, and ϕ is standard normal density. Unlike ordinary least squares, this

marginal effect clearly depends on the value of x'. Current practice seems to favor the averaging of marginal effects across all individuals instead of taking a mean or a median value of each variable in x' (Greene 2003). The partial effect of an indicator variable (such as gender) x_j is calculated as the difference in the probability of a non-zero dependent variable with x_j set to 1 versus x_j set to 0. Cappellari and Jenkins (2003) provide a Stata® post-estimation command *mvppred*, and further details about calculating average partial effects are available from Jones et al. (2007).

3. Results

Pearson's correlation coefficients for the three binary variables of interest (2 new ADL or IADL limitations and 3 new CES-D limitations) are all significant at 0.1% and are equal to 0.436 (ADL-IADL), 0.146 (ADL-CES-D), and 0.120 (IADL-CES-D). Estimation of multivariate probit model reveals substantial unobserved heterogeneity in the dynamics of ADLs, IADLs, and CES-D scores over time, which was not captured by included control variables. In particular, the correlation coefficient between the error terms in the ADL and IADL equations is 0.654 with standard error (s.e.) of 0.022, with a coefficient between ADL and CES-D equations of 0.291 (s.e. of 0.032), and 0.243 (s.e. of 0.032) between IADL and CES-D equations. All three coefficients are significant at less than 0.1%. The likelihood ratio test also strongly rejects the null hypothesis of independent error terms at less than 0.1% significance level.

This correlation also affects the importance of certain control variables on the probability of 2 additional ADL or IADL limitations or 3 additional CES-D items (Table 1). Prior stroke is the

strongest predictor of ADL decline, with, on average, a 13.9% higher probability of 2 more ADL limitations if common unobserved factors are ignored (univariate probit). However, when unobserved heterogeneity is properly accounted for, this probability is only 8.2% higher. Similarly, the univariate probit model overestimates the average partial effects of the upper quintile of hospitalizations by 2.5 times, and of being one year older by one half. On the other hand, the protective effects of surviving until the end of the study and of vigorous exercise on ADL decline are not affected by correlations in the three measures. Similar but somewhat weaker effects of common unmeasured factors can be found in the equations for IADL and CES-D decline. For example, being in the upper quintile of hospitalizations on average implies an 11.4% higher probability of 2 additional IADL limitations in the univariate probit and only 10.6% in the multivariate case. The effect of being one year older on the probability of depression is overestimated by 22% in the univariate probit case.

4. Conclusions

Older Americans, who surpassed their 70^{th} birthday, are characterized by a substantial dependence between their functional status and depression over time that could not be identified in univariate models. The multivariate probit model, on the contrary, locates those individual differences and places them into the error terms, effectively accounting for unobserved individual heterogeneity. This dependence remains significant even if initial numbers of limitations in ADLs, IADLs, and CES-D scores are included in all equations together with a rich set of previously identified risk factors. Thus, previous results based on univariate methods should be interpreted with caution.

As one would perhaps expect, the strongest correlation in the error terms is found between the two measures of functional decline: limitations in ADLs and IADLs. However, both ADL and IADL functional limitations are linked by common unobserved factors with depression, as identified by CES-D score. Both functional and emotional measures of disability can be used to describe the disablement process in later life (Lamb 1996). This study indicates that the inclusion of initial functional and emotional limitations is not sufficient for proper modeling of a disablement process in older adults. This conclusion seems to be an important addition to the previous research on the effects of depression in the disablement process such as, for example, van Gool et al. (2005).

This paper is not without limitations. First of all, the exclusion of proxy respondents is necessitated because the imputing of cognitive measures deprives them of any useful content. Previous work based on the AHEAD survey indicates that sample selection bias does not constitute a serious problem (Wolinsky et al. 2009). Secondly, the method employed in this paper confirms that depression and functional decline are linked over time by common unobserved factors, but it does not reveal a causal direction of this link. This is a very important question deserving of study in further work.

References

Ashford, J. and R. Sowden. (1970). Multi-variate probit analysis. *Biometrics* (26):535-546.

Balia S., and A.M. Jones. (2008). Mortality, lifestyle and socio-economic status. *Journal of Health Economics* 27:1–26.

Boyd C.M., Q.L. Xue, J.M. Guralnik, and L.P. Fried. (2005). Hospitalization and development of dependence in Activities of Daily Living in a cohort of disabled older women: The Women's Health and Aging Study I. *Journal of Gerontology: Medical Sciences* 60A(7):888–893.

Bruce M.L. (2001). Depression and disability in late life: Directions for future research. *Am J Geriatr Psychiatry* 9:102–112.

Cappellari L., and S.P. Jenkins. (2003). Multivariate probit regression using simulated maximum likelihood. *The Stata Journal* 3(3): 278–294.

Chib, S. and E. Greenberg. (1998). Analysis of multivariate probit models. *Biometrika* 85(2):347-361.

Cole, M.G., and N. Dendukuri. (2003). Risk factors for depression among elderly community subjects: A systematic review and meta-analysis. *American Journal of Psychiatry*, 50, 1147-1156.

Covinsky K.E., Yaffe K., Lindquist K., Cherkasova E., Yelin E., and D.G. Blazer. (2010). Depressive symptoms in middle age and the development of later-life functional

limitations: the long-term effect of depressive symptoms." *J Am Geriatr Soc*: 58(3), 551-556.

Choi, N.G., and F.S. Kim. (2007). Age group differences in depressive symptoms among older adults with functional impairments. *Health & Social Work:* 3(3), 177-188.

Fonda, S.J., and A.R. Herzog. (2001). Patterns and risk factors of change in somatic and mood symptoms among older adults. *Annals of Epidemiology*, 11, 361-368.

Gill T.M., H.G. Allore, T.R. Holford, and Z. Gui. (2004). Hospitalization, restricted activity, and the development of disability among older persons. *JAMA* 292(17):2115-2124.

van Gool C.H., G.I.J.M. Kempen, B.W.J.H. Penninx, D.J.H. Deeg, A.T.F. Beekman, J.Th.M. van Eijk. (2005). Impact of depression on disablement in late middle aged and older persons: results from the Longitudinal Aging Study Amsterdam. *Social Science & Medicine 60* (1): 25-36.

Greene, W. (2003). *Econometric Analysis*. 5th ed. Upper Saddle River, NJ: Prentice Hall.

Health and Retirement Study, AHEAD Core 1993 public use dataset. (1998). Produced and distributed by the University of Michigan with funding from the National Institute on Aging (grant number NIA U01AG009740), Ann Arbor, MI.

Jones A.M., N. Rice, T. Bago d'Uva, and S. Balia. (2007). *Applied Health Economics*. 1st ed.

NY: New York. Routledge.

Juster, F.T., and R.M. Suzman. (1995). An overview of the Health and Retirement Study. *J Hum Resources* 30: S7-S56.

Kohout, F., Berkman, L., Evans, D, and Cornoni-Huntley. (1993). Two shorter forms of the CES-D depression symptoms index. *Journal of Aging and Health*, 5, 179-193.

Lamb V.L. (1996). A cross-national study of quality of life factors associated with patterns of elderly disablement. *Social Science & Medicine* 42(3): 363-377.

Myers, G.C., F.T. Juster, and R. M. Suzman. (1997). Assets and Health Dynamics among the Oldest Old (AHEAD): Initial results from the longitudinal study. *J Gerontol Psychol Sci Soc Sci* 52B: Special Issue.

Ormel J., F.V. Rijsdijk, M. Sullivan, E. van Sonderen, and G. I. J. M. Kempen. (2002). Temporal and reciprocal relationship between IADL/ADL disability and depressive symptoms in late life. *J Gerontol B Psychol Sci Soc Sci* 57B:338–347.

Steffick, D.E. (2000). HRS/AHEAD documentation report: Documentation of affective functioning measures in the Health and Retirement Study. Ann Arbor: University of Michigan, Survey Research Center.

Stuck A.E., J.M. Walthert, T. Nikolau, C.J. Bula, C. Hohmann, and J.C. Beck. (1999). Risk factors for functional status decline in community-living elderly people: a systematic literature review. *Social Science & Medicine* 48:445-469.

Wolinsky F.D., S.E. Bentler, L. Liu, M. Obrizan, E.A. Cook, K.B. Wright, J.F. Geweke, E.A. Chrischilles, C.E. Pavlik, R.L. Ohsfeldt, M.P. Jones, K.K. Richardson, G.E. Rosenthal, and R.B. Wallace. (2009). Recent hospitalization and the risk of hip fracture among older Americans. *J Gerontol A Biol Sci Med Sci*, Feb, 64(2): 249-55.

Table 1. Average partial effects in univariate (exog) and multivariate (MVP) probit estimation (across 5,470 observations)

	ADL (exog)		ADL (MVP)		IADL (exog)		IADL (MVP)		CES-D (exog)		CES-D (MVP)	
Control Variable	APE	SD	APE	SD	APE	SD	APE	SD	APE	SD	APE	SD
ADL count at baseline	-0.049	0.025	-0.048	0.023	0.030	0.011	0.029	0.010	0.017	0.006	0.017	0.005
IADL count at baseline	0.057	0.024	0.065	0.024	-0.055	0.023	-0.051	0.021	0.006	0.002	0.009	0.003
CES-D count at baseline	0.009	0.004	0.010	0.004	0.009	0.003	0.010	0.004	-0.040	0.012	-0.039	0.011
Survived till end of study	-0.087	0.041	-0.092	0.040	-0.104	0.042	-0.099	0.039	-0.074	0.028	-0.072	0.027
Men					-0.046	0.017	-0.042	0.015	-0.029	0.010	-0.029	0.010
African American									0.019	0.006	0.018	0.006
Hispanic									0.002	0.001	0.011	0.004
Lives alone at baseline									0.003	0.001	0.006	0.002
Never married at baseline									-0.059	0.022	-0.063	0.023
Separated at baseline									-0.026	0.009	-0.029	0.010
Widowed at baseline									-0.041	0.014	-0.043	0.014
Grade school	0.035	0.016	0.032	0.013								
Attended college	0.021	0.010	0.017	0.007								
Stroke ever	0.139	0.050	0.082	0.030								
Diabetes ever	0.035	0.016	0.035	0.014								
Arthiritis ever	0.062	0.029	0.061	0.026	0.044	0.017	0.044	0.016				
Psychological problems ever									0.058	0.018	0.050	0.015
Vigorous activity (1995)	-0.077	0.037	-0.079	0.033	-0.065	0.024	-0.065	0.023				
GVGE vision at baseline	-0.034	0.015	-0.037	0.015	-0.076	0.024	-0.074	0.023				
GVGE self-rated health (1993)									-0.054	0.018	-0.048	0.016
Upper quintile of hosp-ns	0.086	0.034	0.085	0.031	0.114	0.034	0.106	0.031				
Upper quintile of MD visits	0.038	0.017	0.015	0.006								
Age (centered at mean)	0.040	0.019	0.026	0.011					0.028	0.009	0.023	0.007
Age squared (centered)	0.000	0.000	0.000	0.000					0.000	0.000	0.000	0.000
Years in survey (centered)	0.022	0.010	0.023	0.010	0.012	0.005	0.014	0.005	0.011	0.004	0.013	0.004
Sqrd yrs in survey (centered)	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TICS score					-0.013	0.005	-0.012	0.004				

Supplementary Table 1. Results of univariate (exog) and multivariate (MVP) probit estimation (5,470 observations)

	ADL (exog)		ADL (MVP)		IADL (exog)		IADL (MVP)		CES-D (exog)		CES-D (MVP)	
Control Variable	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Intercept	-1.230	0.097	-1.150	0.095	-0.024	0.135	-0.087	0.128	-0.457	0.090	-0.483	0.089
ADL count at baseline	-0.242	0.037	-0.234	0.036	0.125	0.034	0.121	0.033	0.075	0.037	0.075	0.038
IADL count at baseline	0.243	0.036	0.269	0.035	-0.261	0.042	-0.237	0.041	0.029	0.043	0.040	0.043
CES-D count at baseline	0.039	0.012	0.045	0.012	0.039	0.012	0.043	0.012	-0.181	0.016	-0.177	0.016
Survived till end of study	-0.412	0.152	-0.432	0.151	-0.465	0.149	-0.443	0.149	-0.349	0.153	-0.341	0.153
Men					-0.202	0.049	-0.186	0.045	-0.135	0.052	-0.136	0.052
African American									0.085	0.070	0.081	0.069
Hispanic									0.011	0.108	0.050	0.106
Lives alone at baseline									0.013	0.078	0.028	0.077
Never married at baseline									-0.318	0.160	-0.342	0.157
Separated at baseline									-0.127	0.121	-0.141	0.118
Widowed at baseline									-0.190	0.080	-0.202	0.079
Grade school	0.155	0.057	0.139	0.051								
Attended college	0.096	0.056	0.075	0.052								
Stroke ever	0.547	0.054	0.338	0.051								
Diabetes ever	0.153	0.058	0.153	0.053								
Arthiritis ever	0.295	0.053	0.288	0.052	0.198	0.052	0.197	0.051				
Psychological problems ever									0.242	0.074	0.211	0.073
Vigorous activity (1995)	-0.378	0.056	-0.385	0.055	-0.293	0.053	-0.293	0.052				
GVGE vision at baseline	-0.149	0.055	-0.162	0.054	-0.303	0.053	-0.297	0.052				
GVGE self-rated health (1993)												
Upper quintile of hosp-ns	0.357	0.056	0.351	0.055	0.436	0.054	0.408	0.054				
Upper quintile of MD visits	0.169	0.055	0.069	0.051								
Age (centered at mean)	0.183	0.096	0.120	0.089	0.054	0.056	0.058	0.055	0.127	0.104	0.104	0.104
Age squared (centered)	-0.001	0.001	-0.001	0.001	0.002	0.005	0.001	0.005	-0.001	0.001	-0.001	0.001
Years in survey (centered)	0.099	0.058	0.105	0.056					0.051	0.058	0.059	0.058
Sqrd yrs in survey (centered)	-0.002	0.005	-0.003	0.005					0.001	0.005	0.000	0.005
TICS score					-0.055	0.008	-0.052	0.008				
Log pseudolikelihood	-2127.82		-6256.51		-2269.35		-6256.51		-2160.86		-6256.51	