

# Physical, Cognitive, and Psychosocial Variables From the Disablement Process Model Predict Patterns of Independence and the Transition Into Disability for the Oldest-Old

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**Purpose:** This study used the Disablement Process Model to predict whether a sample of the oldest-old maintained their disability or disability-free status over a 2- and 4-year follow-up, or whether they transitioned into a state of disability during this time. **Design and Methods:** We followed a sample of 149 Swedish adults who were 86 years of age or older over a period of 4 years; we grouped them by ability in activities of daily living as being functional survivors (nondisabled over time), increasingly disabled (initially nondisabled but later disabled), chronically disabled (disabled at all waves), or deceased. We used variables from baseline to predict group membership into these four longitudinal outcome groups. **Results:** Results indicated that demographic factors, physical impairments, physical and cognitive limitations, and psychosocial variables at baseline predicted membership into the functional survivor group after 2 years and most continued to distinguish between functional survivors and other groups after 4 years. **Implications:** These findings indicate key variables that may be useful in predicting shorter term longitudinal changes in disability. By understanding the physical, cognitive, and psycho-

logical variables that predict whether a person develops a disability within the next 2 or 4 years, we may be better able to plan for care or implement appropriate interventions.

*Key Words:* Disability trajectories, Late-life functioning, Oldest-old, Predictors of disability

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The oldest-old (generally defined as people over the age of 85 years; Suzman, Manton, & Willis, 1992) vary considerably in their ability to function in everyday life. As a group, people aged 85 years or older have the highest levels of physical and cognitive disability compared with adults of other ages (Beckett et al., 1996; Kunkel & Appelbaum, 1992), yet some of the oldest-old maintain high levels of functioning and do not develop disabilities. Understanding differences between people who develop functional impairments in late life and those that remain free of disabilities may lead to the development of more effective strategies for maintaining independence and a higher level of functioning in late life.

In the current study we merge two areas of disability research together. The study builds on past research on patterns of change in disability in the oldest-old (Johnson & Barer, 1997; Romoren & Blekeseaune, 2003), and it advances these studies by incorporating demographic, physical functioning, cognitive functioning, and psychosocial variables from the Disablement Process Model (Verbrugge & Jette, 1994) as predictors of disability trajectories.

## *Empirical Evidence on Disability Trajectories*

Several studies of the oldest-old have found evidence of differential patterns of change in disability over time. Johnson and Barer (1997), for example, performed an in-depth longitudinal analysis of the

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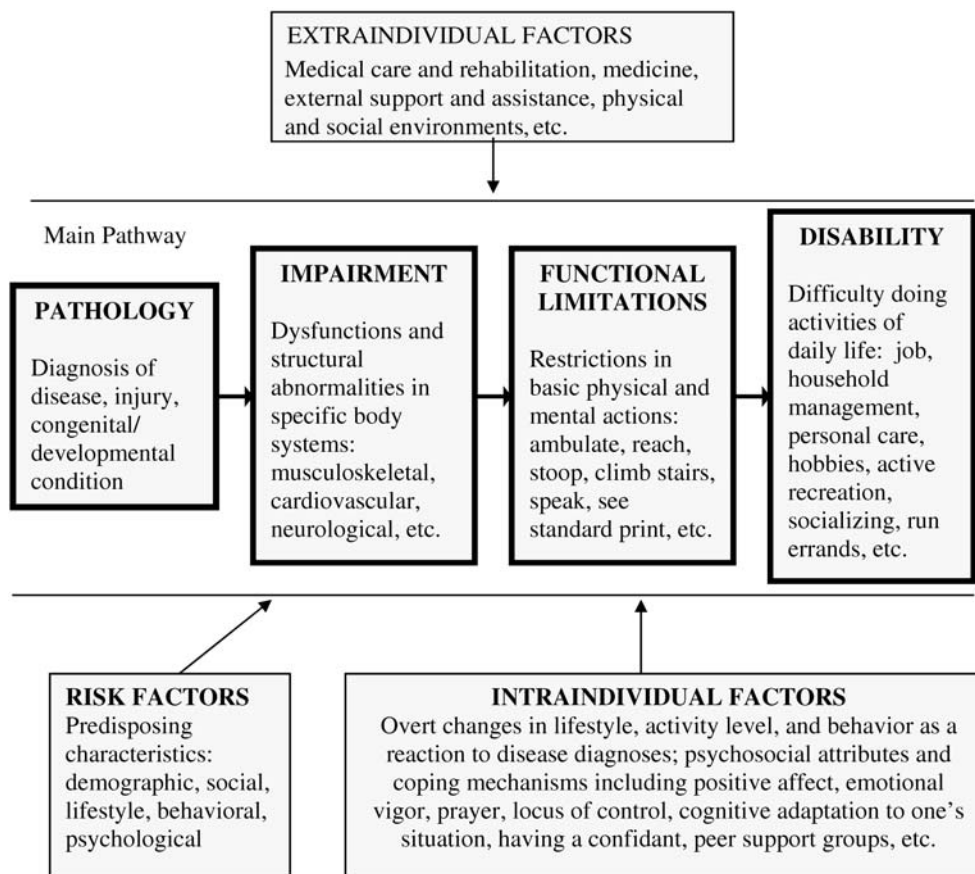


Figure 1. Schematic representation of the Disablement Process Model (adapted from Verbrugge & Jette, 1994).

oldest-old and proposed three distinct trajectories of change in functioning. Over the course of 15 months, some people were able to continually function without being hindered by disabilities; they were referred to as the “functional survivors.” Another group, termed the “chronically disabled,” consisted of those individuals who had high but stable levels of disability over the course of the study; the “increasingly disabled” group included those who experienced decline in their ability to function over 15 months. Johnson and Barer also found that the increasingly disabled group was at the greatest risk for mortality, morbidity, and institutionalization. Subsequent research supports the presence of these kinds of groups. In Norway, Romoren and Blekesaune (2003) also found distinct trajectories of disability; however, these authors labeled their groups as (a) serious dementia, (b) severely dependent, (c) frail, and (d) fairly healthy. Results from this study found that age and gender predicted membership into disability trajectories.

Although the aforementioned studies focused on samples of the oldest-old, additional research has found evidence for similar trajectories of change and transition in disability within younger-old samples — those aged 65 and older (Clipp, Pavalko, & Elder, 1992; Fonda, Clipp, & Maddox, 2002; Liang

et al., 2003; Wolinsky, Stump, Callahan, & Johnson, 1996). The main difference between these patterns in younger-old samples and those in oldest-old samples is that younger-old samples tend to include a pattern of “decline and recovery,” whereas studies of the oldest-old do not report this pattern of change.

### *The Disablement Process Model as a Framework to Predict Disability Trajectories*

Although identifying different patterns of change in disability is important, it is also essential to understand predictors of these differences. Past studies of disability trajectories tend to focus more on describing patterns of change, as opposed to predicting them. When predictor variables have been included in such research, they have been limited, and not always driven by identifiable theory. In the current study we propose to enhance research on disability trajectories and transition by utilizing a comprehensive set of predictors of change that are drawn from a prominent theory on disability. The Disablement Process Model (see Figure 1; Verbrugge & Jette, 1994) provides a framework for investigating individual differences in the development of disability. This model describes the general process of how chronic disease may or may not lead

to functional impairments and functional limitations in a person, and, in turn, impact future levels of disability. A person may, for example, have diabetes (a chronic disease), which first leads to systemic problems in his or her circulatory system (impairment), and which eventually may lead to difficulty in walking (limitation). These functional limitations, in turn, can interfere with this person's ability to carry out activities of daily living, and therefore they may cause the person to be disabled by the disease. Past research has found support that functional impairments and functional limitations predict disability. Functional impairments, such as lower lung function (De Filippi, Tanab, Vanzatia, Balzarinia, & Galetta, 2003; Femia, Zarit, & Johansson, 1997), weaker grip strength (Femia et al., 1997; Femia, Zarit, & Johansson, 2001), and poorer vision (Femia et al., 2001), are significant predictors of increased levels of disability. Functional limitations including poorer performance on tests of physical ability (Femia et al., 2001; Gill, Richardson, & Tinetti, 1995) and cognitive function (see Stuck et al., 1999 for a review) also significantly predict disability outcomes.

It is important to acknowledge that the Disablement Process Model does not assume that everyone with a diagnosis of a chronic disease eventually becomes disabled. In fact, the advantage of this model is that it includes variables such as risk factors, intraindividual factors, and extraindividual factors that can help explain why one person with a disease such as diabetes becomes immobile, whereas another with diabetes has no disabilities at all. Certain risk factors, such as gender, socioeconomic status, or obesity, may make one person with a chronic condition more susceptible to disability. Psychological resources, such as mastery, may help deter disability, whereas other intraindividual factors, such as depression, may increase the risk for disability. Finally, environmental and contextual factors may also influence whether a person becomes disabled. People with severe arthritis in the hips, for example, may have their daily functioning compromised and be considered disabled if they are unable to climb stairs to reach their third-floor apartment, or they may not be considered to be disabled if an elevator is present and their daily functioning is not affected. The strength of the Disablement Process Model, then, is that it incorporates the psychological and environmental contexts surrounding biological decline in order to have additional explanatory power for differential outcomes in disability.

The concept that psychosocial variables affect disability outcomes is not merely theoretical, and past research has found evidence to support these relationships. Social support, for example, may play a key role as a protective factor against disability. Mendes de Leon and colleagues (1999) found that specific aspects of participants' social network were related to the risk of developing disability in personal activities of daily living (PADLs) and were also

related to recovery from disability over a 9-year period. There is also evidence that psychological variables act as risk and protective factors. In studies of the oldest-old, the risk factor of depression was significantly related to lower functioning in activities of daily living (Bauco et al., 1996; Camancho, Strawbridge, Cohen, & Kaplan, 1993). Lower levels of subjective health and mastery (a protective factor) have also predicted the onset of disability in a longitudinal study of Swedish adults aged 84 and older (Femia et al., 1997).

Guided by the Disablement Process Model, in this current study we examine the relation of demographic, physical functioning, cognitive functioning, and psychosocial variables to longitudinal patterns of stability and transition in disability status. As measures of external factors were unavailable in the current data, we were unable to include them as predictors; thus, these analyses represent a partial test of the full Disablement Process Model. The analyses focus on predicting outcomes over 2 years; we include a follow-up analysis of change over 4 years to observe whether baseline predictors maintain their ability to distinguish among groups over a longer time frame. We hypothesize that variables from all levels of the Disablement Process Model included in these analyses (risk factors, pathology, functional impairments, functional limitations, and psychosocial variables) will predict differing disability transitions and trajectories. Although we expect the ability for predictor variables to distinguish among disability outcomes to be most evident over a shorter time frame (2 years), we expect that most significant predictors will continue to have a significant relationship with disability outcome groups over a longer time frame (4 years). Understanding the predictors of whether a person is likely to maintain independence or likely to transition into a disabled state within the upcoming 2 years may be helpful in planning for care of individuals, and it may also guide future interventions that can extend independence for a longer period of time.

## Methods

### *Participants*

Using a cohort-sequential design, we used the Swedish population registry to identify 300 people aged 86, 90, and 94 (100 persons in each age group) living in the municipality of Jönköping, Sweden. The municipality has a population of about 110,000 people, consisting of those living in the city of Jönköping as well as in surrounding towns and rural areas. We chose the cohort-sequential design as a method of reducing this population of the oldest-old into a manageable sample size, while oversampling for those in the oldest ages, in this case those aged 94. In those cases in which participants

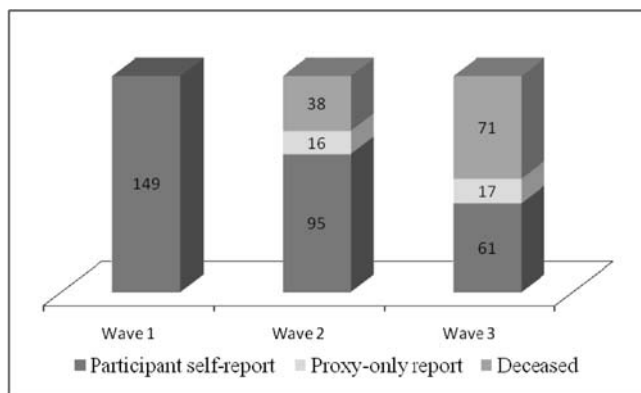


Figure 2. Attrition over three waves.

were still alive but were unable to respond to the researchers (usually because of severe cognitive impairment), we contacted a spouse or adult child to obtain permission and gather limited information about the participant's disability status. Of the 300 original people contacted to be in the study, 18 (6%) died before the initial interview, 62 (20.7%) refused participation, 18 (6%) were unable to be interviewed because of a lack of ability *and* lack of proxy, 8 (2.6%) started but were unable to complete the interview because of frailty, and 9 (3.0%) were unable to participate for other reasons. Thirty-six of these participants (12%) had only proxy data available at baseline; because baseline predictor variables for the current analyses required self-report or physical performance from the participants themselves, we could not include these 36 participants in the analyses. Therefore, the final sample size for the current analysis was  $N = 149$ . Figure 2 represents the sample attrition over three waves for the 149 participants included in this analysis.

### Procedure

For each wave of data collection, a trained nurse interviewed participants (or proxies) in their place of residence (including private homes, nursing homes, and service apartments, which are similar to assisted-living-style communities). The participants were first interviewed in 1999, again in 2001, and for the last time in 2003. There were telephone calls placed to participants in 2000 and 2002 to maintain contact in between interview sessions.

### Measures

**The Main Dependent Variable: Independence and Transition Into Disability.**—We measured disability by using two scales of people's ability to perform activities of daily living. We measured PADLs (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963) by asking participants how much of a problem

it was for them to bathe or shower, dress or undress, use the toilet, transfer from chair to a bed, and feed themselves. We measured instrumental activities of daily living (or IADLs; Lawton, 1971) by asking the participants how much of a problem it was to clean, shop for food, manage transportation, and prepare meals. Although disability is generally treated as a continuous construct, our focus was not on predicting the *level* of disability; rather, we focused on predicting the *status* of disability (independent or disabled), as well as the transition from a non-disabled state to a disabled state. Because the shift from a state of independence to a state of disability necessitates important changes in receiving care, we argue it is a particularly important change point, and thus it is appropriate when one is studying these conditions to dichotomize the construct around this transition point. Therefore, in the current study, we used the ADL scales to recode individuals as being disabled or nondisabled at each wave. On the basis of prior work with this age group (Zarit, Johansson, & Berg, 1993; Zarit, Johansson, & Malmberg, 1995), we coded responses for each ADL ability into two categories: 0, the participant is able to perform the activity with little or no difficulty, or 1, the participant is able to perform the activity only with great difficulty or is unable to perform the activity at all. We defined a participant as being disabled at each wave if they reported Category 1 (significant impairment) on two or more ADL activities.

Past studies have tended to define disability or dependence as impairment on any one IADL or PADL ability (Ishizaki, Kai, Kobayashi, & Imanaka, 2002; Konno, Katsumata, Arai, & Tamashiro, 2004) or as impairment on one PADL ability (Guralnik, Alexih, Branch, & Weiner, 2002; Seeman, Bruce, & McAvay, 1996). We defined disability as significant impairment on two or more ADL items (both IADL and PADL) because we felt it was important to include impairment on both personal and instrumental activities in the definition, and because using impairment on two abilities as a cutoff yielded to us a greater confidence that the underlying construct of disability was present. In our opinion it was possible for a person to be unable to do one ADL activity because of a lifestyle decision (e.g., doesn't like to drive, doesn't know how to cook), whereas impairment on two or more ADLs is more likely to be caused by disability. In a post hoc analysis we reran all analyses by using one ADL as a cutoff for disability to observe how sensitive the findings were to the way we defined disability status. Results did not differ to a large extent depending on the criteria used for the definition; therefore, we retained the stricter definition of impairment on two ADL abilities as the cutoff.

After determining the criteria for who was disabled at each wave, we observed participants' longitudinal outcomes related to their disability



status over time, both for two waves of data (labeled here as “shorter term”) and for three waves (labeled here as “longer term”). We made the decision to base the trajectories of change in the current study on the patterns identified in the oldest-old by Johnson and Barer (1997). The patterns were as follows: (a) functional survivors, or participants who remained disability free over time; (b) increasingly disabled people, or people who transitioned from nondisabled status at Wave 1 to disabled status at Wave 2 (shorter term trajectory), or between Wave 1 and Wave 3 (longer term trajectory); (c) chronically disabled persons, or those individuals with significant levels of disability at baseline and at subsequent waves; and (d) deceased persons. By including and predicting a category of those who died in between waves of measurement, we could appropriately deal with issues related to selective attrition. In contrast to prior research using young-old samples, in the current study only one individual recovered from disability between waves; thus, as in the study by Johnson and Barer, there were not enough people to form a group defined by disability recovery. We excluded this person from the regression analyses. In the research by Romoren and Blekesaune (2003) on patterns of disability in the oldest-old, they included a trajectory called “serious dementia.” In the present study, however, most people with severe dementia required a proxy report at baseline as they were unable to perform tests of physical function or respond to self-report questions. Because they had only a proxy report at baseline, we excluded them from the analyses. Therefore, there would be too few of them included in the analyses to form a separate group.

*Independent Variables: Risk Factors, Disease Level, Functional Impairments, and Functional Limitations From the Disablement Process Model.*

—We used the Disablement Process Model of Verbrugge and Jette (1994) to select predictors of disability trajectories. We drew potential predictors from each level in the model: risk factors, pathology, functional impairments, and functional limitations. Risk factors in the current analyses included gender, years of education, age, and body mass index (measured in kilograms per square meter). We measured the pathology component by assessing disease level, which was adapted from work by Gold, Malmberg, McClearn, Pederson, and Berg (2002). Gold provided a categorization of major disease diagnoses that used three categories: very life threatening, somewhat life threatening, and non life threatening. We coded participants’ diagnoses in the following way to create a disease-level scale: if no diagnoses were present, we assigned a score of 0; if there was one or more non-life-threatening disease but no somewhat or very life-threatening conditions, we assigned a score of 1; if there was one or more

somewhat life-threatening diseases but no very life-threatening diseases, we gave a score of 2; and if there was one or more very life-threatening diseases, we assigned a score of 3.

Functional impairments were described by Verbrugge and Jette (1994) as “dysfunctions and structural abnormalities in specific body systems: musculoskeletal, cardiovascular, neurological, etc.” (p. 2). Here we assessed five such systems, including visual, auditory, pulmonary, muscular, and circulatory systems. The self-rated vision ability scale had scores ranging from 1 to 4, with 1 indicating blindness and 4 indicating no vision problems. Self-rated hearing ability also had scores ranging from 1 to 4, with 1 indicating deafness and 4 indicating no problems. We assessed participants’ pulmonary systems by measuring their peak expiratory flow. While seated, participants placed a spirometer in their mouths and were asked to blow as forcefully as possible in three separate trials. We measured the maximum lung function score by taking the trial with the highest lung force, measured in liters per second. We assessed the functional impairments of the muscular system by using a measure of maximum grip strength. Participants squeezed a dynamometer three times with each hand, and information on their maximum grip strength score was gathered. Finally, we assessed participants’ circulatory systems by using a pulse oximeter on their finger. While participants were seated, information on oxygen saturation in the blood and pulse per minute were gathered in two trials. We computed their final oxygen saturation and their final pulse scores by averaging information from these two trials.

Functional limitations are defined in the Disablement Process Model as “restrictions in basic physical and mental actions” (Verbrugge & Jette, 1994, p. 2). For the eight physical functional tests, participants were asked to (a) lift a 1-kg weight with their dominant hand, (b) pick up a pen from the floor, (c) bring their right hand around the back of their head to touch their left ear, (d) bring their left hand around the back of their head to touch their right ear, (e) walk 3 meters, turn around, and walk back, (f) bring their right index finger down to touch their left big toe while they were in a seated position, (g) bring their left index finger down to touch their right big toe while they were in a seated position, and (h) cross their arms and try to stand up from a chair. The nurses administering the tests coded the participants’ ability on each test by using a scale in which 1 indicated no difficulty, 2 indicated some difficulty, 3 indicated a great deal of difficulty, and 4 indicated wholly unable or not feasible. Thus, higher scores indicated more problems with the tasks.

Past research on the disablement process has sometimes defined these measures of limitations in terms of separate upper body and lower body limitations (Femia et al., 2001); however, we

performed a factor analyses (varimax rotation) on the current data to determine if this upper–lower body division was appropriate. We excluded the “left hand to right ear” test from the factor analysis because it was highly correlated with the “right hand to left ear” test, and we excluded the “left hand to right toe” test from the factor analysis because it was highly correlated with the “right hand to left toe” test. The factor analysis indicated that these items were best defined by only one factor, with factor loadings ranging from .60 to .89. Therefore, we combined these eight items into one scale measuring physical limitations ( $\alpha = 0.915$ ).

We also included two measures of cognitive ability to assess cognitive functional limitations. The first, the Mini-Mental State Exam, or MMSE (Folstein, Folstein, & McHugh, 1975), is a 30-item test asking questions related to orientation of time and place, the ability to recall objects over time, and the ability to follow specific instructions, as well as other basic memory and cognitive tasks. Higher scores are indicative of better cognitive functioning. The second cognitive functional limitation test that we included was the recall portion of the Memory in Reality test (MIR test; Johansson, 1988–1989). In this test, participants were asked to memorize 10 everyday household objects, and the participants were given a replica of an apartment and asked to place the objects in the correct room that the objects would be used in. After about 30 minutes had passed, the participants were asked to recall the 10 items they used, and their score on this test is the number of items they could correctly recall.

### *Independent Variables: Psychosocial Factors*

We used the Center for Epidemiologic Studies–Depression scale to measure depressive symptoms (Radloff, 1977). This scale assesses the frequency with which 20 depressive symptoms occur in 1 week, with higher scores indicating the presence of more depressive symptoms. We assessed feelings of mastery by using Pearlin’s Mastery Scale (Pearlin & Schooler, 1978). This was an eight-item scale asking participants to agree “not at all,” “to a small extent,” “to a large extent,” or “extremely” to a series of statements about personal control. We coded scores such that higher scores indicated that the person felt more control over his or her life. A sample item from this scale is as follows: “You have little control over the things that happen to you.”

A three-item scale measured loneliness (the extent to which participants felt lonely, abandoned, and lacked companionship; called “social isolation” in Femia et al., 2001), with scores ranging from 1 (low loneliness) to 4 (high loneliness). A two-item scale measured subjective support (the extent to which participants felt they had someone to talk to and the extent to which they felt they were part of a circle of

friends; called “social integration” in Femia et al., 2001), with scores ranging from 1 (low support) to 4 (high support). The final psychosocial variable included in the current analyses was one item assessing how important God and spirituality was to the person. Scores ranged from 1 (not at all important) to 5 (very important).

### *Analysis*

We assessed participants’ trajectories of disability and categorized people as being either a functional survivor, increasingly disabled, chronically disabled, or deceased, both for over the shorter term (two waves, or 2 years), and over the longer term (three waves, or 4 years). Shorter term and longer term group trajectory memberships were dependent variables included in two separate series of models. For each dependent variable, we used multinomial logistic regressions to predict membership into the four groups, with functional survivors used as the reference group in all models.

Prior to running any models, we ran correlations within subcategories of predictor variables (risk factors, functional impairments, functional limitations, and psychosocial variables) to indicate variables that were highly correlated with each other (at a level of .50 or higher). We used this information to eliminate predictor variables from the final analyses that had high levels of overlapping variance with other variables. Given the relatively small sample size, eliminating highly correlated variables would lead to a more parsimonious test of the model.

We determined the sequence of predictor variables included in the multinomial logistic regression models by the organization of the Disablement Process Model. We first entered risk factor variables together. We then carried forward significant risk factors in the next step, with disease level as an additional predictor. We added each subsequent set of variables in similar steps, retaining only the significant variables from the previous step. The benefits to carrying forward only the significant variables in the stepwise process are explained in Neter, Kutner, Nachtsheim, and Wasserman (1996). If a variable was significant at one step, but later became nonsignificant, it was kept in the final model. The two models presented here are the final models predicting membership into the shorter term (two-wave) trajectory groups and the longer term (three-wave) trajectory groups.

## **Results**

### *Demographic and Attrition Information*

Demographic information for the sample at baseline is provided in Table 1. The majority of participants were women; the average age was

**Table 1. Demographic Information for the Sample**

Demographic Variable	Value
Gender: % women	69.8
Married: %	22.1
Education in years of schooling: <i>M (SD)</i>	6.81 (1.75)
Age: <i>M (SD)</i>	89.50 (3.28)
MMSE score: <i>M (SD)</i>	25.74 (6.63)
Living in independent housing: %	65.8
Living alone: %	56.4

*Notes:* Being married is shown versus being unmarried, widowed, or divorced; living in independent housing is shown versus living in an institution, service apartment, or the like. MMSE = Mini-Mental State Examination; *SD* = standard deviation.

around 90. Most participants were unmarried (usually widowed), about half lived alone, and about one third lived in institutional housing, including service apartments. As can be expected from a sample of people with such advanced age, there was significant attrition over the 4 years of data collection. The participants' status and reason for attrition are provided in Figure 2. Sixteen participants at Wave 2 and 17 participants at Wave 3 were too impaired to provide self-reports in a full interview; however, data on the dependent variable (disability) could be gathered from a proxy, so we did not eliminate them from the analyses. Participants' deaths caused all longitudinal attrition in the study; no person included in baseline analyses refused participation at follow-up waves.

### Disability Trajectory Groups

Table 2 describes the percentages of people classified into functional survivor, increasingly disabled, chronically disabled, and deceased groups for both short and longer term trajectories. We excluded the one participant who was disabled at Wave 1 and not disabled at Waves 2 and 3 from the analyses, as *N* = 1 is too small to warrant the creation of an additional group. For patterns of change over the shorter term, 30.9% of participants were functional survivors, around 24.8% were chronically disabled, 18.1% were increasingly disabled (meaning they transitioned from being nondisabled at Wave 1 into being disabled at Wave 2), and the remaining 25.5% died between Waves 1 and 2. As compared with these shorter term trajectories, for the longer term trajectories there were fewer participants in the functional survivor group (14.1%) and fewer in the chronically disabled group (14.8%), but a greater percentage in the increasingly disabled group (22.8%) and in the deceased group (47.7%). Because participants in the shorter term trajectory groups were also included in the longer term trajectory groups, Figure 3 describes the extent to which people stayed in the same group across both trajectory

**Table 2. Frequency Distribution for Disability Trajectories**

Group	Wave 1 to Wave 2		Wave 1 to Wave 3	
	Frequency	%	Frequency	%
Functional survivors	46	30.9	21	14.1
Increasingly disabled	27	18.1	34	22.8
Chronically disabled	37	24.8	22	14.8
Deceased	38	25.5	71	47.7
Total for analyses	148	99.3	148	99.3
Excluded: disability-recovery	1	0.7	1	0.7
Total	149	100.0	149	100.0

categorizations and the extent to which they changed groups. Two thirds of the sample (67.0%) stayed in the same trajectory group from the 2-year analysis to the 4-year analysis; however, when we do not include those deceased at Wave 1, this figure changes to 41.3%. Thus, even when we exclude those individuals who had died by Wave 2, much of the sample maintained the same pattern of disability from the 2-year analysis to the 4-year analysis. Around 10% of the sample transferred from the functional survivor group into the increasingly disabled group between Waves 2 and 3. Of the three nondeceased groups at Wave 2, a greater percentage of people from the chronically disabled group (10.1%) than from the functional survivor (6.8%) and increasingly disabled groups (5.4%) died before Wave 3.

### Bivariate Statistics and Multinomial Logistic Regression Analyses

Table 3 displays the means and standard deviations for the potential predictor variables included in

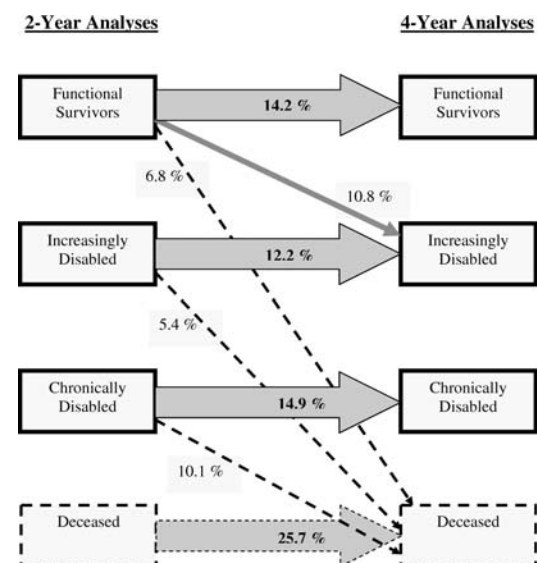


Figure 3. Stability in 2-year and 4-year trajectory groups.

Table 3. Frequency Information for Predictor Variables

Information	Wave 1 to Wave 2 Sample									
	Baseline Sample		Deceased		Functional Survivors		Increasingly Disabled		Chronically Disabled	
	<i>N</i>	<i>M (SD)</i>	<i>N</i>	<i>M (SD)</i>	<i>N</i>	<i>M (SD)</i>	<i>N</i>	<i>M(SD)</i>	<i>N</i>	<i>M (SD)</i>
Risk factors										
Education (years)	148	6.81 (1.75)	37	7.00 (1.67)	47	6.83 (1.37)	27	6.85 (2.84)	37	6.57 (1.19)
Age (years)	149	89.50 (3.28)	38	90.00 (3.37)	47	88.55 (3.06)	27	88.70 (3.21)	37	90.78 (3.09)
BMI (in kg/m <sup>2</sup> )	135	24.54 (4.29)	32	23.37 (3.91)	47	25.30 (3.11)	26	24.53 (3.19)	30	24.61 (6.48)
Pathology										
Disease level	141	1.82 (1.03)	36	2.19 (1.01)	47	1.57 (1.02)	27	1.70 (0.99)	31	1.87 (0.96)
Functional impairments										
Vision	148	3.40 (0.78)	37	3.24 (0.83)	47	3.74 (0.57)	27	3.30 (0.82)	37	3.19 (0.81)
Hearing	149	3.52 (0.63)	38	3.45 (0.69)	47	3.55 (0.54)	27	3.67 (0.56)	37	3.43 (0.73)
Lung function	133	259.19 (115.80)	29	228.62 (130.29)	47	321.06 (100.28)	27	235.00 (88.24)	30	213.57 (108.97)
Grip strength	142	0.57 (0.20)	33	0.55 (0.18)	47	0.65 (0.22)	27	0.61 (0.15)	35	0.45 (0.16)
Blood oxygen	146	95.14 (3.96)	37	94.47 (3.87)	47	95.39 (5.06)	27	95.02 (3.42)	35	95.59 (2.54)
Pulse	146	70.43 (12.19)	37	74.85 (14.10)	47	66.54 (10.91)	27	68.74 (10.10)	35	72.29 (11.65)
Functional limitations										
Physical Limitations	149	1.84 (0.97)	38	2.36 (1.12)	47	1.22 (0.35)	27	1.51 (0.51)	37	2.35 (1.03)
MMSE	147	25.75 (6.63)	36	22.42 (7.02)	47	28.28 (1.85)	27	27.41 (5.80)	37	24.57 (8.88)
MIR recall	133	5.19 (2.57)	29	4.21 (2.23)	45	6.40 (2.35)	26	5.38 (2.65)	33	4.24 (2.42)
Psychosocial attributes										
Depression	133	9.37 (8.01)	32	12.41 (8.99)	47	6.17 (6.38)	26	10.02 (6.96)	28	10.67 (8.68)
Mastery	132	2.09 (0.64)	31	1.85 (0.75)	47	2.43 (0.42)	26	2.10 (0.45)	28	1.80 (0.72)
Subjective support	141	3.07 (0.90)	36	2.90 (0.88)	47	3.40 (0.89)	27	3.02 (0.81)	31	2.79 (0.87)
Loneliness	140	1.57 (0.62)	35	1.69 (0.63)	47	1.52 (0.50)	27	1.46 (0.56)	31	1.62 (0.80)
God-spirituality	138	4.12 (1.29)	34	3.79 (1.59)	47	4.09 (1.28)	27	4.37 (1.12)	30	4.33 (1.03)

Notes: Wave 1 to Wave 2 sample shows the 2-year analyses. BMI = body mass index; MMSE = Mini-Mental State Examination; MIR = Memory in Reality (test); SD = standard deviation.

the multinomial logistic regressions. They are provided for the whole sample at baseline, and then they are also broken down by the Wave 1 to Wave 2 (2-year) trajectory groups. Because some participants were unable to respond to all items in the test battery, the sample sizes of those able to or willing to respond to these items is also provided.

As noted, we explored correlations among measures within a subcategory of the model to identify highly correlated predictor variables ( $r > .50$ ). Correlations within the risk factor variables (age, gender, education, body mass index) ranged from  $-.024$  to  $-.237$ . Functional impairment variables (lung function, grip strength, vision, hearing, pulse, and blood oxygen) were correlated with each other at levels ranging from  $-.016$  to  $.325$ . Correlations between the functional limitation variables of MMSE, MIR recall, and physical functioning ranged from  $-.320$  to  $-.364$ . No variables needed to be removed from any of these three categories. Finally, we conducted correlations between psychosocial variables (depression, mastery, subjective support, loneliness, and spirituality), revealing that mastery and depression were highly correlated at  $r(132) = -.517$ ,  $p < .05$ . Depression was the variable we removed from the regression models because it shared statistically significant variance with other

psychosocial variables as well, whereas mastery did not. Once we removed depression, the remaining psychosocial variables had correlations with each other ranging from  $-.017$  to  $-.214$ .

Table 4 provides information on the final model used to predict membership into the shorter term trajectory groups. Recall that the final model presented is a result of a stepwise process in which variables were entered in order of their placement in the Disablement Process Model. If variables were significant at initial entry but later became nonsignificant in future steps, then we carried the variables through to the final model. Results from the model of 2-year change indicated that age was the only significant predictor among the risk factor variables. Older aged individuals were significantly more likely to be in the chronically disabled group as compared with the functional survivor group. The pathology variable (disease level) was also significant, with the deceased group having significantly higher levels of disease severity than the functional survivors. Both age and disease level were significant predictors early on in the stepwise process, but later they became nonsignificant (with age becoming nonsignificant when functional impairment variables were entered, and disease level becoming nonsignificant when psychosocial variables were entered). For



**Table 4. Final Multinomial Logistic Regression Model for Predicting Trajectories of Disability from Waves 1 to 2**

Group	$\beta$	SE	<i>p</i>	OR
<b>Deceased</b>				
Intercept	3.69	12.89	0.77	
Age	0.14	0.13	0.31	1.15
Disease level	0.45	0.37	0.22	1.57
Vision ability	-0.39	0.62	0.53	0.68
Lung function	-0.01	0.00	0.10	0.99
Grip strength	0.05	2.06	0.98	1.05
Physical limitations	2.45*	0.87	0.01	11.57
MMSE	-0.25	0.14	0.08	0.78
MIR recall	-0.57*	0.18	0.00	0.56
Mastery	-2.46*	0.76	0.00	0.09
Loneliness	-1.59*	0.81	0.01	0.20
<b>Increasingly disabled</b>				
Intercept	24.94*	12.14	0.04	
Age	-0.10	0.12	0.43	0.91
Disease level	-0.13	0.33	0.70	0.88
Vision ability	-1.43*	0.52	0.01	0.24
Lung function	-0.01*	0.00	0.00	0.99
Grip strength	-0.13	1.72	0.94	1.14
Physical limitations	-2.01*	0.88	0.02	7.46
MMSE	-0.04	0.12	0.76	0.96
MIR recall	-0.43*	0.61	0.01	0.65
Mastery	-2.01*	0.72	0.01	0.13
Loneliness	-2.23*	0.82	0.01	0.11
<b>Chronically disabled</b>				
Intercept	7.89	12.67	0.53	
Age	0.12	0.13	0.38	1.12
Disease level	0.08	0.37	0.83	1.09
Vision ability	-1.37*	0.58	0.02	0.26
Lung function	-0.01	0.00	0.10	0.99
Grip strength	-3.16	2.12	0.14	0.04
Physical limitations	2.33*	0.89	0.01	10.26
MMSE	-0.08	0.13	0.55	0.93
MIR recall	-0.49*	0.18	0.01	0.61
Mastery	-2.42*	0.77	0.00	0.09
Loneliness	-2.49*	0.88	0.01	0.08

*Notes:* The reference category is functional survivors. Model fit:  $\chi^2 = 97.96$ ,  $df = 30$ . MMSE = Mini-Mental State Examination; MIR = Memory in Reality (test); OR = odds ratio; SE = standard error.

\* $p < .05$ .

the functional impairment variables, vision ability significantly predicted differences between functional survivors and the increasingly disabled and chronically disabled groups (functional survivors had better vision than did both groups). Lung function predicted differences between functional survivors and the increasingly disabled group, with functional survivors having greater lung function. Grip strength originally was a significant predictor between the functional survivor and the chronically disabled groups (functional survivors had greater grip strength), but grip strength became nonsignificant when functional limitation variables were entered. For functional limitation variables, functional survivors had significantly fewer problems with physical limitations and had significantly higher cognitive

**Table 5. Final Multinomial Logistic Regression Model for Predicting Trajectories of Disability from Waves 1 to 3**

	$\beta$	SE	<i>p</i>	OR
<b>Deceased</b>				
Intercept	-25.40*	10.90	0.02	
Age	0.34*	0.13	0.01	1.40
Disease level	0.57	0.35	0.10	1.78
Lung function	-0.01	0.00	0.10	1.00
Physical limitations	2.90*	1.24	0.02	18.23
Mastery	-2.12*	0.83	0.01	0.12
Subjective support	-0.50	0.44	0.26	0.61
<b>Increasingly disabled</b>				
Intercept	-18.74	10.62	0.08	
Age	0.30*	0.12	0.02	1.34
Disease level	0.19	0.35	0.59	1.21
Lung function	-0.01	0.00	0.13	1.00
Physical limitations	1.34	1.26	0.29	3.83
Mastery	-2.00*	0.82	0.02	0.14
Subjective support	-0.74	0.41	0.07	0.48
<b>Chronically disabled</b>				
Intercept	-21.20	12.59	0.09	
Age	0.29*	0.14	0.04	1.34
Disease level	0.50	0.42	0.23	1.65
Lung function	-0.01*	0.00	0.02	0.99
Physical limitations	2.71*	1.28	0.03	14.98
Mastery	-1.42	0.95	0.14	0.24
Subjective support	-0.97*	0.49	0.05	0.38

*Notes:* The reference category is functional survivors. Model fit:  $\chi^2 = 69.48$ ,  $df = 18$ . MMSE = Mini-Mental State Examination; MIR = Memory in Reality (test); OR = odds ratio; SE = standard error.

\* $p < .05$ .

ability in recall than did all three other groups. They also performed better on the MMSE test of cognitive functioning as compared with the deceased group, but this finding was no longer significant when psychosocial variables were entered. Finally, for psychosocial predictors, functional survivors were significantly higher in mastery, but also significantly higher in loneliness, as compared with all three other groups.

The final model for predicting longer term trajectory groups is provided in Table 5. Age was a significant risk factor variable, with functional survivors being significantly younger than the individuals in all three other groups. For the pathology variable, originally the deceased group had significantly higher levels of disease severity than did the functional survivor group; however, this finding became nonsignificant when psychosocial variables were entered. For functional impairment variables, at the time of initial entry into the model, the functional survivor group had significantly higher lung function than did all three other groups; however, when psychosocial variables were entered, lung function only predicted differences between functional survivors and the chronically disabled. Of the functional limitation variables, only one variable, physical limitations, was a significant predictor. Functional

survivors had fewer physical limitations than did the individuals in the deceased and chronically disabled groups. Finally, of the psychosocial variables, the functional survivor group had higher mastery than did the deceased and the increasingly disabled groups, and it had higher subjective support than the chronically disabled group.

To summarize findings from both models, over shorter (2-year) and longer (4-year) time frames, age, disease level, lung functioning, physical limitations, and mastery were significant predictors of differences between a functional survivor group and one or more of the other disability outcomes. Vision, grip strength, the two cognitive predictors (MMSE and MIR recall), and loneliness were significant predictors in the shorter term models but not in longer term models, and subjective support emerged as a significant predictor in the longer term model but was not significant in the model predicting short-term change.

## Discussion

The current study combined research on patterns of disability status in the oldest-old with a subsection of predictors of disability described in the Disablement Process Model. Results indicated that age, disease level, and physical and cognitive functioning predicted patterns of change and stability in disability status. In addition, after controlling for these predictors, we found that lower levels of the protective factor of mastery predicted a transition into a state of disability, both over a 2-year and 4-year time frame. The remaining psychosocial variables had somewhat mixed findings, with functional survivors (over the short term) reporting higher loneliness at baseline, an unexpected finding, and with lower subjective support predicting disability group membership, but only over the long term. As a whole, however, the findings from this study indicate that key physical and cognitive variables may act as useful indicators of future shorter term and longer term decline, and that the psychological factor of mastery may, indeed, act as a protective factor in the disablement process.

By definition, the functional survivors were not disabled at baseline whereas the chronically disabled individuals were disabled at baseline. Thus, perhaps it is not surprising that baseline variables were able to distinguish these two groups from each other. What is of particular interest from these findings, however, is that baseline physical and cognitive indicators and mastery were able to distinguish between those persons that remained nondisabled (functional survivors) and those that became disabled (increasingly disabled) within the next 2- and 4-year time frames. This ability to take people free of disability and predict a transition into a disabled state in the near future has particularly important

implications for planning care. For example, by taking people who are not disabled and screening them on tests of vision, lung function, physical functioning, and cognitive recall, we may be able to identify people who are performing lower on these tasks and conclude that they are more at risk for developing disability over the next 2 years. We then can help these individuals think about options for care, accommodations to the home environment, and so on, which can help the individuals and family members adjust to the transition into disability, or perhaps prevent or prolong it. In addition, although the progression of physical or cognitive decline may be hard to slow or reverse, it may be possible to improve people's psychosocial protective factors by means of interventions.

The mechanisms of how psychological and social factors impact the disablement process may be related to Baltes and Baltes theory of selective optimization with compensation (SOC; 1990). This theory posits that, as people age, their physical, cognitive, and social resources become more limited, but older adults can maintain functioning by using effective strategies for adapting to losses. In the context of disability, chronic disease may have caused an overall loss of physical functioning for older adults, but people may still maximize their everyday functioning by utilizing psychological resources. People with higher mastery, for example, may feel more in control of their disease and may be more proactive in seeking care; thus they may be affecting their disability outcomes by increasing their physical resources and medical options. They also may feel more confident in their own abilities and may push themselves to maintain peak performance in activities by using new mental or physical approaches; therefore, mastery may also be postponing disability by helping an individual maintain more adaptive psychological strategies. In these ways, individual differences in people's psychological attributes may lead them to be more or less effective in coping and adapting to losses in physical functioning resources, and it is through these methods that psychological attributes potentially impact the disability outcomes. Although the causal directionality of these findings on mastery and subsequent disability cannot be determined on the basis of this study alone, it is possible that higher levels of psychosocial resources at baseline buffered some of the negative effects of the disablement process and helped certain people in this sample of the oldest-old maintain a higher degree of independence.

Our main goal in the analyses was to predict stability and change in disability status over 2 years; we added the 4-year follow-up to observe whether variables were consistent in their ability to predict similar patterns of disability status over a more extended time frame. In our results we found that most of the variables that significantly distinguished between a functional survivor group and other

outcomes over 2 years also distinguished between a functional survivor group and other outcomes over 4 years; thus, these variables may be more consistent predictors of patterns of stability and change and less influenced by the duration over which change occurs. Future research should be conducted on the remaining variables that predicted shorter term trajectories, but not longer term trajectories, to see how time sensitive the variable is in predicting future disability outcomes.

When we found variables in the current study to be predictors of disability status, we also found that they all predicted status in the expected direction with the exception of loneliness. We assumed that if loneliness was an important indicator of stability or change over a 2-year time frame, then functional survivors would have lower levels of loneliness. Results found the opposite to be true, however. Functional survivors had higher levels of loneliness at baseline than did the individuals in the other disability outcome groups. It should be noted, however, that observations of mean levels of loneliness for functional survivors at baseline were still quite low. Loneliness was measured on a scale of 1 to 4, with 1 indicating the participant was not at all lonely, and the average score at baseline for the functional survivors was 1.52. As shown in Table 3, mean levels of loneliness were actually slightly higher for the deceased and chronically disabled group, although still low for all four groups. We have to explore these findings further to determine if results from the regression analyses are caused by having only a small amount of variability on this measure (with most people reporting no loneliness) or if this finding is not related to measurement and it replicates to other studies.

In addition to the unexplained finding related to loneliness, it is important to acknowledge potential limitations related to generalizability in the current analysis, and in nearly all studies using samples of the oldest-old. The original design called for contacting 300 individuals aged 86, 90, or 94 years, for participation in the study. Only 149 persons were able to complete self-report data at baseline, and even fewer were able at subsequent waves. Although we were able to gather some longitudinal data on ADL functioning from next-of-kin proxy participants enabling data for more participants to be retained over the longitudinal design of the study, we know that there were 36 people at baseline who were excluded from analyses because only proxy data were available. Therefore we know that the people most likely to be missing in these analyses are those people that are the most impaired, and the most disabled. It is quite possible that, had we been able to measure these people, they would have provided evidence both for a differing trajectory structure and for differing predictors of trajectory group membership. The important point here is that social science research on the oldest-old often only measures the

healthiest and most robust subsample of the oldest-old. Although this study was an improvement on many past studies in that it also included participants living in institutional housing, and it followed by means of proxy information those people over time who would otherwise have been lost to follow-up, we must still caution readers about the generalizability of our findings to *all* of the oldest-old, especially the most disabled.

In addition, although the use of proxy reports allows for less attrition, researchers in future studies may want to explore whether proxy reports and self-reports are consistently in agreement in this population. If they do agree, we have more confidence that using proxies in place of self-reports is acceptable; if they do not agree, using proxy reports interchangeably with self-reports for the oldest-old may introduce bias. In the current study we were unable to statistically control for whether information on disability levels was provided by proxy or self-report because the use of a proxy was perfectly correlated with the dependent variable (disabled status over time). It would be helpful for researchers of the oldest-old, however, to further explore the reliability of proxy and self-reports in future research.

Finally, we recognize that our analyses were limited by the need to exclude predictor variables related to external environmental factors as described by the Disablement Process Model. Although we included measures of many of the factors included in the model, these analyses represent only a partial test of the model. Future studies should seek to test the ability of such contextual factors to predict shorter and longer term outcomes related to independence and the transition into disability.

In conclusion, by combining research on disability status and the transition into disability with predictors theorized in the Disablement Process Model, we found in the current research that age, disease, physical and cognitive functioning, and mastery were effective in distinguishing between differing patterns of stability and change in disability. The ability to distinguish who becomes disabled over the next 2 or 4 years and who remains free of disability may be particularly helpful for practitioners who are planning future care needs. In addition, these findings provide evidence that the psychological resource of mastery may buffer the negative effects of loss of function. This finding may be of particular interest to practitioners looking for an area to target in future interventions aimed at preventing or delaying the onset of disabilities in very late life. A long-standing goal in gerontology has been the compression of morbidity at the end of life (Fries, 1983), which contributes to quality of life and reduces the financial burden on society. Much of the research on disablement in late life focuses on biomedical risks, yet findings from our work, as well

as those of previous studies (Femia et al., 1997, 2001), suggest that psychosocial factors such as mastery play an important role as well. It may be that interventions that bolster an older person's sense of control may help people continue to function independently, despite advancing age and chronic illness. The possibility that the period of disability at the end of life might be reduced through improvements in psychosocial dimensions of everyday life represents a new direction that warrants further exploration.

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