Dementia Is the Major Cause of Functional Dependence in the Elderly: 3-Year Follow-up Data From a Population-Based Study

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ABSTRACT

Objectives. The purpose of this investigation was to study the role of dementia and other common age-related diseases as determinants of dependence in activities of daily living (ADL) in the elderly.

Methods. The study population consisted of 1745 persons, aged 75 years and older, living in a district of Stockholm. They were examined at baseline and after a 3-year follow-up interval. Katz's index was used to measure functional status. Functional dependence at baseline, functional decline, and development of functional dependence at follow-up were examined in relation to sociodemographic characteristics and chronic conditions.

Results. At baseline, factors associated with functional dependence were age, dementia, cerebrovascular disease, heart disease, and hip fracture. However, only age and dementia were associated with the development of functional dependence and decline after 3 years. In a similar analysis, including only nondemented subjects, Mini-Mental State Examination scores emerged as one of the strongest determinants. The population-attributable risk percentage of dementia in the development of functional dependence was 49%.

Conclusions. In a very old population, dementia and cognitive impairment make the strongest contribution to both the development of long-term functional dependence and decline in function. (*Am J Public Health.* 1998; 88:1452–1456)

Functional dependence is an age-related condition leading to poor quality of life, increased health-related care costs, and increased mortality.[1,2] The reported prevalence of functional dependence in the elderly varies greatly, ranging from 5% to 35%.[3,4] Many of the discrepancies among these studies may be related to their use of different scales and different methodologies. In spite of these differences, increased age, female sex, low level of education,[5–7] and common age-related conditions such as cerebrovascular disease, heart disease, and hip fracture[2,6–13] have been found to be associated with functional dependence. However, most of these studies focused on relatively young elderly adults (65 years and above), raising the question of whether the findings are generalizable to the very old.

The relationship between cognitive status and functional dependence has been studied in representative samples of elderly people, mostly using cross-sectional data.[14–16] The few longitudinal studies that have considered the role of cognitive impairment as a predictor of future functional dependence have reported contradictory results.[17,18] Cognitive performance in demented subjects was highly correlated with daily functioning,[19–21] but initial cognitive scores were not significant predictors of future functional dependence in other investigations.[22,23]

In the present study, a population-based sample of adults aged 75 years and older living in a defined area of Stockholm was examined at baseline and after a 3-year follow-up. The purposes of this report are (1) to describe the prevalence of functional dependence in the very old and its relationship to chronic medical conditions, (2) to detect risk factors for developing long-term (3-year) functional dependence and functional decline, and (3) to contrast determinants of functional dependence between demented and nondemented subjects.

Materials and Methods

The subjects were gathered from a community-based study, the Kungsholmen Project.[24,25] The study population consisted of all persons older than 74 years who were living in their own homes or in institutions in the district of Kungsholmen, Stockholm, in October 1987. The 1810 subjects who participated were interviewed by trained nurses, who administered a structured questionnaire concerning demographic characteristics, activities of daily living (ADL), and cognitive status (Mini-Mental State Examination [MMSE]).[27,28] Sixty-five subjects did not have complete information on functional status. However, they did not differ from the other respondents in terms of age, sex, or education.

The first follow-up evaluation of the population was carried out on average 40.3 ± 7.0 months after the baseline interview; it consisted of a clinical examination and a nurse interview that assessed functional status with the same scale and procedure used at baseline.

Functional Status

Functional status was measured by the Katz index of ADL.[29] Good reliability and construct validity of this scale, when administered by nurses, have been reported previously.[30] This measure is based on a hierarchical scale formed by 6 activities: bathing, dressing, going to the toilet, transferring, conti-

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nence, and feeding. Level of dependence is expressed in numerical grades, ranging from 1 to 7; 1 is the most independent (requiring no personal assistance in all 6 activities) and 7 is the most dependent grade (requiring assistance in all 6 activities). In this study, patients who could not be fitted into one of these categories were given a score of 4.5.

Both baseline information and follow-up ADL information were obtained, in most cases, from the respondents. However, for individuals with MMSE scores of less than 24 points, a close relative was asked to provide the information. If the person lived in an institution, the staff member in charge was asked.

Functional dependence was defined as the need for assistance in 1 or more of the 6 basic ADLs. Those subjects with a Katz ADL index of 1 were classified as functionally independent, whereas subjects with a Katz ADL index greater than 1 were classified as functionally dependent.

Development of functional dependence was defined as a change in functional status from functionally independent to functionally dependent over the 3-year follow-up.

Functional decline was considered to be a worsening in ADL performance from baseline to follow-up among individuals with some functional dependence at baseline. Functional decline was defined as an increase in the Katz ADL index of 1 or more points.

Predictive Factors

Data concerning sociodemographic characteristics such as age, sex, educational attainment, and living arrangement were gathered during baseline data collection. Fourteen subjects did not have information concerning educational attainment.

Dementia cases were detected with a 2-phase design that has been reported elsewhere.[24,25] *Diagnostic and Statistical Manual of Mental Disorders, Revised Third Edition* (*DSM-III-R*) criteria[31] for dementia and different types of dementia were used, with some modifications.[25] A total of 101 subjects refused the clinical examination after the initial screening phase. We adopted the most conservative strategy regarding the effect of dementia on functional disability at baseline by considering these persons nondemented.

Information on the occurrence of cerebrovascular disease, heart disease, cancer, and hip fracture was obtained from the Computerized Stockholm Inpatient Register System. The hospital discharge diagnoses from 1969 to 1987 and from 1982 to 1987 were reviewed. Disease diagnoses were based on the *International Classification of Diseases, Eighth Revision* (*ICD-8*)[32]: heart disease (*ICD-8* codes 410–414, 427, 428), cerebrovascular disease (*ICD-8* codes 430–438), hip fracture (*ICD-8* code 820), and cancer (*ICD-8* codes 140–208, 230–239).

Statistical Analysis

Logistic regression models were used to estimate the association between functional dependence and common diseases, as well as to investigate the effect of these conditions on the development of functional dependence and decline after a 3-year follow-up. Moreover, models were constructed separately for the whole population, as well as for demented and nondemented subjects separately. The baseline variables included in the models were age, as a continuous variable, as well as the following dichotomous variables: sex, educational level (elementary school or high school/university), dementia, heart disease, cerebrovascular disease, cancer, and hip fracture. Occurrences of diseases other than dementia during a 15-year-period and a 5-year-period before baseline were analyzed separately; similar results were obtained. Thus, only models including disease occurrence in the previous 15-year period are reported here. When demented and nondemented subjects were examined separately, MMSE score was entered in the models as a continuous variable, scored from 0 to 30 points (higher scores denoting increasing cognitive function). Finally, interaction terms including different comorbidity combinations were also entered in additional models.

To verify the magnitude of possible bias due to dropouts, baseline variables between participants and dropouts were compared by means of a logistic regression model in which refusal was the dependent variable. Additionally, sensitivity analyses simulating 2 extreme imputations[33] were performed.

Results

Study Population

The study population consisted of 1745 subjects, of whom 76% were women and 13% were living in institutions. The mean age was 81.7 ± 4.9 years. At baseline, 1182 subjects were functionally independent and 563 subjects were disabled, leading to a prevalence of disability of 32%. The prevalence of dementia, heart disease, cerebrovascular disease, cancer, and hip fracture was 12%, 17%, 9%, 12%, and 11%, respectively. Twenty-eight percent of the participants had at least 1 disease, whereas 14% had more than 1. Distribution of diseases at baseline by age, sex, education, and functional and cognitive status is reported in Table 1.

Functional Dependence at Baseline

The association between age-related conditions and sociodemographic factors and ADL dependence is reported in Table 2.

The effect of chronic diseases on functional dependence was further analyzed by considering comorbidity. We constructed different models with interaction terms, taking into account the most frequent combinations of multiple diseases. Only the interaction between dementia and heart disease showed a significantly increased odds ratio (OR) of 3.8 (95% confidence interval [CI] = 1.2, 11.9). Moreover, when the presence of both dementia and at least 1 other chronic condition was analyzed with absence of any disease as the reference category, the odds ratio for having at least 1 of the other conditions, but not dementia, was 1.8 (95% CI = 1.4, 2.3); the odds ratio for having dementia and no other chronic condition was 4.0 (95% CI = 2.4, 6.6); and the odds ratio for having dementia and at least 1 of the other conditions was 20.7 (95% CI = 11.9, 36.0).

Development of Functional Dependence

Of the 1182 initially nondisabled subjects, 739 were reexamined after an average follow-up of 3 years; 187 had died during the follow-up, 205 refused the follow-up examination, and 51 persons did not provide ADL data. Results from logistic regression analysis showed that dropouts were similar to participants on all baseline variables but were more cognitively impaired. The sensitivity analysis assumed that all dropouts became disabled (imputation 1) or that all dropouts were functionally independent at follow-up (imputation 2). In the case of imputation 1, very similar results were found for all the variables; in the case of imputation 2, the results differed only in the strength of the association between dementia and the outcome (OR = 6.2, 95% CI = 2.6, 14.8). Dementia was still the main contributor to the development of functional dependence.

Fourteen percent of those who were initially independent and survived 3 years had become dependent. Risk factors for developing functional dependence after the 3-year follow-up are shown in Table 3. The population-attributable risk percentage of dementia in the development of functional dependence was 49.2%.

The same models were constructed for demented and nondemented separately. Among demented people (n = 30), no variables were found to be statistically associated with functional dependence.

Comorbidity was analyzed also in relation to development of functional depen-

TABLE 1—Study Population at Baseline: Distribution of Common Age-Related Conditions by Age, Gender, Education, ADL, and MMSE Score

Disease	Number of Cases	Age in Years (Mean ± SD)	Female Gender (%)	High Level of Education* (%)	ADL Dependence† (%)	MMSE Score (Mean ± SD)
Dementia						
Yes	210	84.9 ± 5.5	80.5	24.0	77.6	12.6 ± 8.2
No	1535	81.2 ± 4.7	75.5	40.3	26.1	26.8 ± 3.3
Heart disease						
Yes	305	83.0 ± 5.3	70.2	30.9	43.3	22.8 ± 7.2
No	1440	81.4 ± 4.8	77.4	39.9	29.9	25.0 ± 7.2
Cerebrovascular disease						
Yes	149	83.5 ± 5.4	71.1	30.9	63.1	20.8 ± 8.2
No	1596	81.5 ± 4.9	76.6	39.1	29.4	25.0 ± 5.8
Cancer						
Yes	206	81.6 ± 5.1	69.9	36.1	34.0	24.3 ± 6.2
No	1539	81.6 ± 4.9	77.0	38.7	32.0	24.7 ± 6.1
Hip fracture						
Yes	190	84.9 ± 5.3	89.4	32.4	65.8	19.0 ± 9.7
No	1555	81.2 ± 4.7	74.5	39.1	28.2	25.3 ± 5.2

*Fourteen subjects did not have data on education.
†Requiring personal assistance in at least 1 of the 6 basic activities.

dence, using the same approach as described for the cross-sectional data analysis. As expected, no interaction term showed a statistically significant increased odds ratio, and the combination of dementia and at least 1 other chronic condition showed a smaller odds ratio (18.1; 95% CI = 4.0, 81.4) than that for having dementia alone (28.3; 95% CI = 8.5, 93.7) when having any disease was the reference category.

Functional Decline

From the 563 initially disabled subjects, 242 subjects were reexamined after an average follow-up of 3 years; 222 had died during the follow-up, 68 refused the follow-up examination, and 31 persons did not provide ADL data. Results from logistic regression analysis showed that dropouts were similar to participants on all baseline variables, but they were older and more functionally impaired. Similar sensitivity analysis, as described before, was used to study functional decline. This analysis assumed either that all dropouts had declined in function at follow-up (imputation 1) or that no dropouts declined (imputation 2). In the case of imputation 1, the effect of dementia disappeared (OR = 1.1, 0.6, 2.0) and the risk due to hip fracture became statistically significant (OR = 2.2, 1.1, 4.2). In the case of imputation 2, all variables showed odds ratios similar to those found among the participants (OR for dementia = 3.1, 95% CI = 1.6, 5.8).

Among survivors, 31% showed increased disability. Risk factors for functional decline after the 3-year follow-up for the entire group and for nondemented subjects are reported in Table 4. No significant risk factors of functional decline were found for demented subjects.

Finally, similar models were constructed for noninstitutionalized subjects only. As the results were very similar to those for the whole population (the odds ratios were slightly lower), these data are not reported here.

TABLE 2—Sociodemographic Characteristics and Common Age-Related Conditions in Relation to Functional Dependence (Katz ADL Index >1)* at Baseline

	All Subjects (n = 1731)		Nondemented (n = 1527)		Demented (n = 204)	
	OR‡	95% CI‡	OR‡	95% CI‡	OR‡	95% CI‡
Baseline age (years)	1.1	(1.1–1.1)	1.1	(1.0–1.1)	1.1	(1.0–1.2)
Female gender	1.1	(0.8–1.4)	1.1	(0.8–1.5)	0.5	(0.2–1.4)
High level of education†	1.1	(0.8–1.3)	1.3	(0.9–1.6)	2.2	(0.8–6.0)
Dementia	5.9	(4.1–8.5)	. . .	. . .	. . .	. . .
Cerebrovascular disease	2.9	(1.9–4.3)	2.6	(1.7–4.1)	2.3	(0.8–7.3)
Heart disease	1.4	(1.0–1.9)	1.1	(0.8–1.5)	5.4	(1.4–21.1)
Cancer	1.0	(0.7–1.5)	1.0	(0.7–1.5)	0.5	(0.1–2.1)
Hip fracture	2.7	(1.9–3.8)	2.4	(1.6–3.6)	1.7	(0.5–5.2)
MMSE score	. . .	. . .	0.8	(0.8–0.9)	0.8	(0.7–0.9)

*Requiring personal assistance in at least 1 of the 6 activities.
†Fourteen subjects did not have data on education.
‡Odds ratios (ORs) and 95% confidence intervals (CIs) derived from multiple logistic regression analysis including all variables in the models.

Discussion

In our population-based study of people aged 75 and older, functional dependence in 1 or more activities of daily living was frequent, afflicting 32% of the population at baseline. Moreover, 14% of those initially functionally independent developed dependence within 3 years. Dementia was associated with functional dependence in the entire population and low MMSE performance was associated with functional dependence in nondemented subjects. These factors were also the major determinants of the development of dependence and decline over 3 years. Diseases associated with functional dependence at baseline, such as cerebrovascular disease, heart disease, and hip fracture, did not emerge as significant determinants of functional dependence at follow-up, aside from hip fracture (which was not statistically significant).

Cross-sectional studies have consistently reported that dementia is a powerful contributor to functional disability in the elderly.[11,12] However, this relationship has not been examined longitudinally in population-based samples. Our results indicate that dementia is the strongest determinant for

TABLE 3—Risk Factors for Developing Functional Dependence (Katz ADL Index >1)* After a 3-Year Follow-up Interval, According to Dementia Diagnosis

	All Subjects (n = 737)		Nondemented (n = 707)	
	OR†	95% CI†	OR†	95% CI†
Baseline age (years)	1.2	(1.1–1.3)	1.2	(1.1–1.3)
Female gender	1.2	(0.7–2.8)	1.0	(0.5–2.0)
High level of education‡	0.7	(0.4–1.1)	0.9	(0.3–1.6)
Dementia	25.2	(9.6–66.4)	. . .	. . .
Cerebrovascular disease	0.8	(0.3–2.7)	0.9	(0.2–3.3)
Heart disease	0.8	(0.4–1.8)	0.8	(0.4–1.7)
Cancer	0.6	(0.3–1.4)	0.4	(0.2–1.2)
Hip fracture	2.3	(1.0–5.4)	2.8	(1.1–6.9)
MMSE score	. . .	. . .	0.7	(0.6–0.8)

*Requiring personal assistance in at least 1 of the 6 activities.
†Odds ratios (ORs) and 95% confidence intervals (CIs) derived from multiple logistic regression analysis including all variables in the models.
‡Two subjects did not have data on education.

TABLE 4—Risk Factors of 3-Year Functional Decline for Those Who Already Had Functional Dependence at Baseline

	Total population (n = 239)		Nondemented (n = 182)	
	OR*	95% CI*	OR*	95% CI*
Baseline age (years)	1.1	(1.0–1.1)	1.1	(1.0–1.1)
Female gender	1.7	(0.8–3.7)	1.1	(0.4–3.0)
High level of education†	0.9	(0.5–1.7)	1.0	(0.4–2.3)
Dementia	2.2	(1.1–4.5)	. . .	. . .
Cerebrovascular disease	1.5	(0.7–3.5)	1.0	(0.3–3.6)
Heart disease	1.7	(0.8–3.9)	2.4	(0.8–7.3)
Cancer	0.7	(0.2–1.9)	1.4	(0.4–4.6)
Hip fracture	1.7	(0.8–3.9)	1.9	(0.5–7.7)
Baseline MMSE score	. . .	. . .	0.7	(0.5–0.8)

*Odds ratios (ORs) and 95% confidence intervals (CIs) derived from multiple logistic regression analysis including all variables in the models.
†Three subjects did not have data on education.

developing functional disability and functional decline, independent of the presence of other chronic diseases. Moreover, because of the high frequency of dementia in the very old, half of the functional dependence developed during the 3 years was attributable to this debilitating condition.

Because dementia emerged as the strongest risk factor for functional dependence, we also sought to examine whether cognitive impairment, indexed by the MMSE, could also be a good predictor. Lower MMSE scores were associated with functional dependence in both demented and nondemented adults. Initial cognitive performance also predicted future functional dependence and decline among nondemented subjects. Small sample size limits our conclusions concerning the demented group. Thus, in a cognitive intact elderly population, scores on a brief cognitive test, such as MMSE, may be used as an indicator of subsequent functional status, independent of the presence of other chronic conditions.

Consistent with previous reports,[7–13,16] histories of heart and cerebrovascular disease were identified as factors associated with functional dependence in our study, but they were not related to new dependence after 3 years. This is probably due to (1) high mortality among subjects affected by these 2 chronic conditions and (2) possible recovery to normal functioning in mild cases. The role of hip fracture is more complex, because it was not only associated with current functional dependence but also with the development of dependence, especially among nondemented subjects. Persons with hip fracture can recover completely, but they have higher risk of recurrent fractures,[34] which may lead to new functional dependence.

In our study, cancer was not related to current and future functional dependence, in agreement with some previous reports[7,8,10,12] but in disagreement with others.[11] Owing to the advanced age of our population and the high mortality of cancer patients, the most severe and disabling forms of this disease probably were already eliminated from our baseline sample. Therefore the elderly people included in our study may be those with no disabling cancer.

With respect to sociodemographic characteristics and functional dependence, our findings are generally consistent with previous reports. Age has been consistently found to be associated with functional dependence.[5–7,16] It has been suggested that aging-related physiological changes play a relevant role in the development of functional disability.[6] Our results support this hypothesis, although we cannot exclude the possible influence of other age-related factors that were not investigated in our study, such as body mass index,[6,35] social factors,[7,8,18] or other diseases.[7,8,10,11] In addition, we failed to observe any relationship with sex, in either cross-sectional or longitudinal analyses, which is consistent with other reports.[7]

Finally, a number of methodological comments need to be addressed. First, information on medical conditions other than dementia was obtained from the Computerized Stockholm Inpatient Register System. Since most people with the studied diseases are likely to be hospitalized, we consider this information quite accurate. In fact, prevalence figures were comparable with those reported by other studies.[7,10,11]

Second, the dropout rate was relatively high (25.7% of the survivors for disability development and 29.0% for functional decline) and was perhaps influenced by functional status. To verify the magnitude of possible bias introduced by dropouts, we have compared the distribution of baseline variables between participants and dropouts and performed a sensitivity analysis simulating 2 extreme imputations.[33] Concerning development of functional dependence, participants and dropouts were similar on most baseline variables, and the results of the sensitivity analysis showed the same pattern. Thus, we are confident that the bias introduced by dropouts was minimal. Regarding functional decline, the possible bias due to refusals might be more serious. Dropouts were older and more disabled at baseline than participants, and one of the extreme imputations (that is, that all dropouts declined) led to results with a different pattern (dementia no longer had an effect on functional decline, but hip fracture emerged as relevant). Thus, the results concerning determinants of functional decline must be interpreted cautiously.

Third, our findings focused on long-term rather than transient functional dependence. Unfortunately, we could not study short-term functional disability, since functional assessment was not carried out during the follow-up

interval. Thus, the role of lethal diseases or diseases related to recoverable functional limitation is diminished in our study.

In conclusion, our study provides evidence that functional dependence is very common among very old adults, and that dementia and cognitive impairment explain a large proportion of current and future dependence. Diseases found associated with functional dependence in cross-sectional analysis, such as heart and cerebrovascular diseases, did not emerge as relevant for the development of long-term dependence. Although our data did not allow us to determine the precise pathway by which dementia leads to functional limitation, we believe that multiple factors may interact, including cognitive impairment, behavioral disturbances, medical complications, and comorbidity. □

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