The Effects of Specific Medical Conditions on the Functional Limitations of Elders in the Framingham Study

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ABSTRACT

Objectives. The purpose of this study was to identify associations between specific medical conditions in the elderly and limitations in functional tasks; to compare risks of disability across medical conditions, controlling for age, sex, and comorbidity; and to determine the proportion of disability attributable to each condition.

Methods. The subjects were 709 noninstitutionalized men and 1060 women of the Framingham Study cohort (mean age 73.7 ± 6.3 years). Ten medical conditions were identified for study: knee osteoarthritis, hip fracture, diabetes, stroke, heart disease, intermittent claudication, congestive heart failure, chronic obstructive pulmonary disease, depressive symptomatology, and cognitive impairment. Adjusted odds ratios were calculated for dependence on human assistance in seven functional activities.

Results. Stroke was significantly associated with functional limitations in all seven tasks; depressive symptomatology and hip fracture were associated with limitations in five tasks; and knee osteoarthritis, heart disease, congestive heart failure, and chronic obstructive pulmonary disease, were associated with limitations in four tasks each.

Conclusions. In general, stroke, depressive symptomatology, hip fracture, knee osteoarthritis, and heart disease account for more physical disability in noninstitutionalized elderly men and women than other diseases. (*Am J Public Health.* 1994;84:351–358)

Introduction

Medical comorbidity in the elderly is well documented.[1] Furthermore, an increase in the number of coexistent conditions among elders is directly associated with an increase in limitations in activities of daily living.[1] Associations between disease and physical disability in the elderly have been found for arthritis,[2–8] hip fracture,[9] low back pain,[8,10] diabetes,[6,7,11,12] hypertension,[8,12] coronary heart disease,[13,14] cardiovascular disease,[15] mild heart trouble,[6] heart attack,[11] shortness of breath,[6] peak expiratory flow rate,[16] leg cramps,[6] depression,[17,18] stroke,[6,7,11,19,20] visual impairment,[7] breast cancer,[21] and cognitive deficits.[22] There is, however, no reason to assume that all conditions have similar impacts on function.

Previously, the relationship between arthritis and physical functional limitations in the elderly has been shown to be limited to those activities that require the individual to use the afflicted joint.[2] Other conditions may also have task-specific impacts on function. For example, an individual with heart or lung disease may be limited in activities requiring endurance but not in those that require only dexterity. Thus, in a disabled elder with multiple chronic conditions, the inability to perform certain tasks may be related either to the broad effects of a single condition on most or all activities of daily living or to the independent effects of several conditions, each of which affects only a few activities. Although it is common to adjust for age, sex, and other sociodemographic variables when investigating the association between a particular medical condition and physical disability in the elderly, few investigators have attempted to sort out the independent impacts of specific diseases on the physical function of elders when these conditions coexist.[23] If one goal of medical care for the elderly is to control or diminish the effects of disease on physical functional status, then we must understand which specific medical conditions are associated with which specific functional limitations.

Many investigations of the relationship between disease and disability have relied on self-reported disease, potentially hindering accurate assessment of the connection between specific medical conditions and physical function. Previous investigations have also been limited by statistical approaches that count the number of comorbid conditions or the

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number of functional tasks affected, ignoring the potential task-specific nature of the relationship between disease and disability and the unequal effects of different conditions on function.

The overall aim of our investigation was to determine the independent effects of specific medical conditions on seven functional activities. Our study had three goals. The first was to identify the cross-sectional association in the Framingham cohort between specific medically validated diagnoses and functional limitations in two lower-extremity activities and five complex functional tasks. The second goal was to compare the risks of physical disability in elders for each medical condition, controlling for age, sex, and the presence of all other comorbid conditions. The final goal was to determine the proportion of disability in the cohort attributable to each medical condition, incorporating both the prevalence of the condition and the increased risk of functional limitation associated with it.

Method

Study Population

Our study population was the Framingham Study cohort. This cohort was enrolled between 1948 and 1951; the 5209 adults aged 28 through 62 constituted a one-third sample of Framingham residents in this age group. This group has been followed for more than 40 years; survivors are examined once every 2 years. With respect to mortality, fewer than 4% of the initial cohort of 5209 individuals have been lost to follow-up. At the time our data were collected, there were 2731 survivors. The data for this study are based on the 1826 elders who participated in the 18th biennial examination (1983 through 1985). The majority of nonparticipating survivors resided out of state and did not visit Framingham during the 2 years of the cohort examination.

Severe functional limitations in even the most basic activities of daily living have been documented for institutionalized elders.[24] We proposed to study higher levels of physical functional status, including instrumental activities of daily living such as grocery shopping and housekeeping, in noninstitutionalized elders. We limited our analyses to 1769 individuals who were not institutionalized at the time of their on-site participation in the 18th examination.

Definitions of Disease

All disease data were collected by trained study physicians and nurses and verified by a panel of physicians. We initially identified 20 medical conditions of potential interest in the data set available for study (Appendix A). We studied two musculoskeletal conditions: knee osteoarthritis and hip fracture. We allowed for two clinical presentations in our definition of knee osteoarthritis: (1) at least grade 2 radiographic changes according to the Kellgren and Lawrence criteria[25] with pain in or around the knee lasting at least a month in the year prior to examination; or (2) at least grade 3 radiographic changes (joint space narrowing plus osteophytes) with infrequent pain. In a previous study of knee osteoarthritis in the elders of the Framingham Study, it was found that those with infrequent symptoms and severe radiographic changes had increased odds of lower-extremity disability comparable to those of elders with symptoms but less severe radiographic changes.[2] Hip fracture was defined as fracture of the proximal femur prior to the 18th biennial examination.

There is evidence that obesity enhances the effects of arthritis on disability.[4] Therefore, we included obesity, defined as a body mass index (weight in kilograms divided by height in meters squared) of 30 or more, as the third medical condition in our preliminary analyses. Elders who used either insulin or oral hypoglycemics were counted as persons with diabetes.

Eight cardiovascular conditions were considered in the preliminary analysis of the relationship between a disease and disability. Hypertension was defined as a systolic blood pressure greater than or equal to 160 mm Hg and a diastolic blood pressure greater than or equal to 95 mm Hg at examination 18, without reference to treatment. Elders with cerebral vascular accidents, excluding transient ischemic attacks, prior to examination 18 were counted as persons with stroke. Specific criteria for angina pectoris, myocardial infarction on electrocardiogram, coronary insufficiency, and congestive heart failure have been developed for use at Framingham and are published elsewhere.[14] For the purposes of this study, we defined heart disease as any history of angina or myocardial infarction on electrocardiogram. We also included physician-diagnosed intermittent claudication as the final cardiovascular condition.

Three pulmonary disorders were defined for our preliminary analyses. First we examined dyspnea on exertion, although we recognized that it might be related to conditions other than lung diseases. Using spirometry performed at the previous biennial examination (1981 through 1983), we defined chronic obstructive pulmonary disease as ratio of forced expiratory volume in 1 second to forced vital capacity of less than 60%.[26] The third condition, symptomatic chronic obstructive pulmonary disease, was defined as chronic obstructive pulmonary disease on spirometry as defined above with dyspnea on exertion. Cancer was defined as any prevalent cancer except nonmelanoma skin cancer within the 5 years prior to an individual's visit at examination 18.

Mental status examinations are routinely conducted at Framingham.[27] As recommended by its developer, a score of less than 24 of a possible 30 on the Folstein Mini-Mental Status Examination was used to indicate cognitive impairment.[28] The 10-item Framingham screening measure of depressive symptoms is based on the CES-D (Center for Epidemiologic Studies–Depression Scale).[29] Each self-report item is scored dichotomously, indicating presence or absence of the symptom. We considered a score of 4 or higher at examination 18 as evidence of depressive symptomatology.

Data on cataracts and visual acuity were used to identify any association between visual impairment and functional limitations. We considered cataracts in either eye or both eyes. Although data on visual acuity at examination 18 were not available, we used data gathered at the 19th biennial exam on a subsample of elders and defined impairment as best-corrected vision worse than 20/40 in either eye.

Measures of Physical Disability

Data were collected on 16 measures of physical disability at examination 18. Six items measuring the most basic activities of daily living (e.g., bathing and toileting) were rejected for inclusion because we found little disability on these items, as might be anticipated in a sample of elders living independently in the community. Three items measuring

more complex activities (e.g., dialing a telephone) were rejected for the same reason. Of the seven remaining functional measures, two items covered activities explicitly involving the lower extremities: walking up and down stairs to the second floor and walking a mile. Each of these items was adapted from the Rosow-Breslau Functional Health Index[30] and had been used previously at Framingham. Five measures covered functional tasks requiring both upper and lower extremities: housekeeping; heavy home chores, including shoveling snow and washing windows; cooking; grocery shopping; and carrying bundles weighing 10 pounds. The item on heavy home chores came from the Rosow-Breslau Functional Health Index; the last item was taken from an instrument developed by Nagi.[31] The items on housekeeping, cooking, and grocery shopping had also been previously used at Framingham.[32]

For items from the Rosow-Breslau instrument, subjects were recorded as able or unable to do without help. The items on housekeeping, cooking, and grocery shopping asked whether the respondent could perform that activity entirely without help from another person. The item on carrying bundles was part of a physical performance battery administered by a study nurse.[33] For this item, subjects were scored as independent, dependent on an assistive device, dependent on human assistance, or unable to do. To make the definition of the dependent variable comparable across items, we chose the need for human assistance as the criterion of functional limitation for each of the seven dependent variables.

Data Analysis

To pare our list of diagnoses using both clinical and statistical criteria, we evaluated the strength of the association of each of the initial 20 conditions with disability in each of the seven functional tasks. We considered whether the condition had clinical relevance to any one of the functional activities (e.g., intermittent claudication and walking) and whether the age- and sex-adjusted relative risk was at least 1.5. On the basis of these criteria, we identified 10 prevalent medical conditions associated with physical disability in the Framingham cohort: knee osteoarthritis, hip fracture, diabetes, stroke, heart disease, congestive heart failure, intermittent claudication, chronic obstructive pulmonary disease, depressive symptomatology, and cognitive impairment. The specific criteria for these diagnoses are found in Appendix B.

We used logistic regression analyses to calculate prevalence odds ratios for dependence in performing each of the seven functional tasks. All elders were used as the referent group in these calculations so that these odds ratios are estimates of relative risk. An odds ratio was defined as the odds of functional dependence in performing a functional task among subjects with a specific medical condition divided by the odds of dependence in that task among all subjects. Because we had noted a high degree of association between heart disease and congestive heart failure, we did not adjust for the presence of heart disease in the sample when calculating the odds of disability for elders with congestive heart failure. We did, however, include both conditions when adjusting for all noncardiac conditions.

In each of the seven logistic regression equations for a particular condition, we controlled for sex, for age as a continuous variable, and for the presence of each of the 10 medical conditions to calculate an adjusted odds ratio (aOR). The adjusted odds ratio was computed with 95% confidence intervals based on maximum likelihood–derived standard errors.

To understand the impact of each condition in terms of its prevalence as well as its odds of disability, we also computed the proportion of dependence in a particular task attributable to each condition as an adjusted attributable fraction (AF).[34] We calculated the adjusted attributable fraction in this study using the formula

$$AF = [(p)(aOR - 1) \div aOR],$$

where p is the proportion of functionally limited elders with a specific disease.

We had obtained knee radiographs on 1416 subjects in our sample. To maintain the size of our sample for this study, we used age, sex, and knee symptoms to impute knee osteoarthritis to elders who had participated in examination 18 but did not have radiographs. Our data on osteoarthritis includes the imputation of knee osteoarthritis to 61 elders. We compared analyses with and without these imputed cases and found no differences; therefore, imputed cases of knee osteoarthritis are included in the results below.

TABLE 1—Age Breakdown of Study Sample (n = 1769)

	Men (n = 709)		Women (n = 1060)	
	No.	%	No.	%
≤69 y	260	36.7	353	33.4
70–79 y	328	46.3	518	48.9
≥80 y	121	17.1	188	17.7
Mean ± SD	73.4 ± 6.3		73.9 ± 6.4	
Range	64.1–92.1		63.8–94.6	

Results

The age breakdown of the sample is shown in Table 1. There were 1060 women and 709 men; the mean age was 73.7 years. The prevalence of the 10 medical conditions included in our analyses and the proportion of elders with at least one comorbidity for each disease are found in Table 2. We found heart disease and knee osteoarthritis the most prevalent and hip fracture and congestive heart failure the least prevalent of these diseases.

The prevalence of dependence in each of the seven functional activities is found in Table 3. Dependence was substantially more frequent for heavy home chores, which require upper and lower extremity use, and walking a mile, one of the two lower-extremity items; dependence in cooking was found least often.

The age-, sex-, and comorbidity-adjusted odds ratios for dependence in each activity are found in Table 4. Only stroke was significantly associated with dependence on human assistance for all seven tasks. Depressive symptomatology and hip fracture were each significantly associated with functional limitations in five tasks. Four conditions were associated with dependence in four tasks each and posed risks of similar magnitude: knee osteoarthritis, heart disease, congestive heart failure, and chronic obstructive pulmonary disease.

The largest proportions of subjects dependent on others in stair climbing were among elders with hip fracture or congestive heart failure. Increased odds of dependence in stair climbing were also seen for elders with knee osteoarthritis, diabetes, stroke, chronic obstructive pulmonary disease, and depressive symptomatology. The proportion of elders

TABLE 2—Prevalence of Conditions

Condition	No. Affected/ Total n	%	% with at Least One Other Condition
Knee osteoarthritis	318/1726	18.4	50.0
Hip fracture	62/1769	3.5	69.4
Diabetes	110/1758	6.3	69.1
Stroke	122/1769	6.9	71.3
Heart disease	324/1769	18.3	66.4
Congestive heart failure	56/1769	3.2	92.9
Claudication	124/1769	7.0	77.4
Chronic obstructive pulmonary disease	113/1724	6.6	58.4
Depressive symptomatology	152/1668	9.1	57.2
Cognitive impairment	139/1704	8.2	67.6

Note. "Total n's" may not equal 1769 because of missing data.

TABLE 3—Prevalence of Dependence on Human Assistance

Activity	No. Affected/ Total n	%
Stair climbing	101/1733	5.8
Walking a mile	301/1690	17.8
Heavy home chores	531/1712	31.0
Housekeeping	131/1567	8.4
Cooking	69/1558	4.4
Grocery shopping	113/1558	7.3
Carrying bundles	89/1643	5.4

Note. "Total n's" may not equal 1769 because of missing data.

dependent in walking a mile was substantial for every condition. Elders with hip fracture and stroke had the greatest odds of limitation in this activity.

For each of the 10 conditions, more elders were limited in performing heavy home chores than in any other activity. The odds of dependence in performing heavy home chores were particularly striking for elders with stroke, heart disease, and congestive heart failure. Dependence in light housekeeping was not common. The strongest associations were found for elders with hip fracture, stroke, and congestive heart failure. Elders with knee osteoarthritis, heart disease, chronic obstructive pulmonary disease, and depressive symptomatology also had substantial odds of dependence in this activity.

Few elders with any medical condition were functionally limited in cooking. The strongest associations between a medical condition and a functional limitation in cooking were found for elders with stroke or diabetes. The largest proportion of elders who were dependent in grocery shopping were subjects who had sustained a hip fracture at some time prior to examination 18. Dependence in grocery shopping was most strongly associated with stroke. Elders with hip fracture, heart disease, and depressive symptomatology also had increased odds of dependence in grocery shopping. The risk of dependence in carrying bundles was greatest for elders with congestive heart failure, who also constituted the largest proportion of elders limited in this activity. Knee osteoarthritis, stroke, and depressive symptomatology were also strongly associated with dependence in carrying bundles.

The percentage of functional limitation in each task attributable to each medical condition after adjustments were made for age, sex, and comorbidity is found in Table 5. Most conditions account for at least 7% of the disability in at least one activity. Comparisons of the magnitude of these fractions across all activities, however, draw attention to one diagnosis in particular: stroke. Although attributable fractions of similar magnitude in every functional task were found for some other conditions, depressive symptomatology accounts for a substantial proportion of the limitations in each of the five functional tasks. Knee osteoarthritis and heart disease each contribute to limitations in at least four tasks, only two of which (walking a mile and light housekeeping) are the same for both conditions. The proportion of limitations in either of these activities that is associated with knee osteoarthritis is substantially greater than the proportion attributable to heart disease.

Discussion

We identified 10 prevalent medical conditions associated with disability in elders: knee osteoarthritis, hip fracture, diabetes, stroke, heart disease, congestive heart failure, intermittent claudication, chronic obstructive pulmonary disease, depressive symptomatology, and cognitive impairment. Our findings indicate that these 10 medical conditions impose functional limitations on the elderly that are specific to each disease and to each activity. After adjustment for coexisting medical conditions, stroke, depressive symptomatology, hip fracture, knee osteoarthritis, heart disease, congestive heart failure, and chronic obstructive pulmonary disease demonstrated significant and substantial associations with limitations in at least four of the seven functional activities studied. The largest proportions of disability were attributable to knee osteoarthritis, heart disease, depressive symptomatology, and stroke.

The results of this study corroborate the findings of other studies. Despite its low prevalence, stroke, which limits a broad array of functional activities, is one of the main disabling conditions of the elderly. Our sample included only noninstitutionalized survivors of stroke and excluded those who may have been functionally incapacitated by stroke to the point of needing nursing home placement. Thus, with respect to all elders, the disabling effects of stroke may be even greater than our results indicate. Previous studies, including those done at Framingham,[19,20] have indicated a relationship between stroke and disability in the total number of activities that were limited. The data presented above clarify the magnitude of this relationship. Our study also demonstrates the global effect of stroke on function, which follows from the pattern of upper- and lower-extremity neuromuscular impairments typically seen in the patient with stroke. Similarly, our findings support the observations of Harris et al.[15] and Guralnik and Kaplan[8] regarding arthritis and cardiovascular disease and their relationship to disability in the elderly.

The conclusions on the relationship of cardiovascular diseases to physical disability in the elderly that are supported by our data are somewhat differ-

TABLE 4—Odds of Disability, Adjusted for Age, Sex, and Comorbidity, by Condition and by Activity

	Stair Climbing		Walking a Mile		Heavy Home Chores		Housekeeping		Cooking		Grocery Shopping		Carrying Bundles	
	Proportion Disabled (%)	Adjusted OR (95% CI)	Proportion Disabled (%)	Adjusted OR (95% CI)	Proportion Disabled (%)	Adjusted OR (95% CI)	Proportion Disabled (%)	Adjusted OR (95% CI)	Proportion Disabled (%)	Adjusted OR (95% CI)	Proportion Disabled (%)	Adjusted OR (95% CI)	Proportion Disabled (%)	Adjusted OR (95% CI)
Knee osteoarthritis	32/315 (10.2)	1.98 (1.14, 3.43)	95/305 (31.2)	1.91 (1.38, 2.63)	106/311 (34.4)	0.98 (0.74, 1.30)	40/286 (14.0)	2.09 (1.29, 3.39)	15/285 (5.3)	1.02 (0.48, 2.19)	27/277 (9.8)	1.05 (0.58, 1.89)	28/296 (9.5)	2.02 (1.15, 3.54)
Hip fracture	13/58 (22.4)	3.39 (1.56, 7.34)	28/56 (50.0)	2.12 (1.22, 3.67)	37/58 (63.8)	1.65 (1.02, 2.66)	17/57 (29.8)	2.49 (1.21, 5.12)	9/58 (15.5)	2.19 (0.70, 6.90)	15/56 (26.8)	2.30 (1.06, 4.99)	13/58 (22.4)	2.01 (0.85, 4.73)
Diabetes	15/109 (13.8)	2.90 (1.45, 5.77)	31/104 (29.8)	1.70 (1.05, 2.73)	46/105 (43.8)	1.33 (0.89, 1.98)	11/100 (11.0)	1.43 (0.68, 3.04)	8/103 (7.8)	2.33 (1.01, 5.35)	10/101 (9.9)	1.62 (0.76, 3.45)	9/102 (8.8)	1.82 (0.79, 4.21)
Stroke	20/118 (17.0)	2.82 (1.40, 5.70)	50/116 (43.1)	2.27 (1.46, 3.53)	74/115 (64.4)	1.93 (1.35, 2.75)	25/109 (22.9)	2.95 (1.59, 5.45)	17/108 (15.7)	2.48 (1.12, 5.49)	26/111 (23.4)	3.63 (1.98, 6.67)	17/108 (15.7)	2.93 (1.39, 6.20)
Heart disease	28/315 (8.9)	1.23 (0.67, 2.24)	85/308 (27.6)	1.49 (1.06, 2.09)	167/316 (52.9)	1.95 (1.51, 2.51)	39/289 (13.5)	1.82 (1.10, 3.01)	21/291 (7.2)	1.41 (0.71, 2.80)	33/294 (11.2)	1.80 (1.06, 3.06)	22/296 (7.4)	1.10 (0.58, 2.11)
Congestive heart failure	12/56 (21.4)	2.76 (1.19, 6.38)	21/52 (40.4)	1.52 (0.81, 2.84)	40/55 (72.7)	2.06 (1.27, 3.35)	14/50 (28.0)	2.52 (1.14, 5.58)	6/49 (12.2)	1.61 (0.46, 5.72)	7/51 (13.7)	1.36 (0.49, 3.79)	9/51 (17.7)	2.89 (1.17, 7.14)
Claudication	11/121 (9.1)	1.39 (0.63, 3.08)	42/120 (35.0)	1.96 (1.25, 3.09)	52/119 (43.7)	1.14 (0.78, 1.68)	12/114 (10.5)	1.00 (0.47, 2.11)	7/115 (6.1)	1.43 (0.60, 3.43)	11/114 (9.7)	0.93 (0.42, 2.07)	9/116 (7.8)	1.43 (0.61, 3.34)
Chronic obstructive pulmonary disease	12/111 (10.8)	2.34 (1.08, 5.07)	32/111 (28.8)	1.86 (1.15, 3.00)	52/109 (47.7)	1.59 (1.09, 2.34)	14/106 (13.2)	2.31 (1.16, 4.62)	6/106 (5.7)	0.88 (0.29, 2.61)	11/106 (10.4)	1.38 (0.61, 3.10)	56/135 (41.5)	2.14 (0.91, 5.05)
Depressive symptomatology	22/149 (14.8)	2.35 (1.27, 4.33)	58/146 (39.7)	1.98 (1.34, 2.90)	74/147 (50.3)	1.36 (0.97, 1.88)	31/136 (22.8)	2.38 (1.39, 4.09)	8/135 (5.9)	1.44 (0.57, 3.69)	22/130 (16.9)	2.31 (1.30, 4.11)	17/128 (13.3)	2.53 (1.38, 4.64)
Cognitive impairment	15/136 (11.0)	0.82 (0.33, 2.06)	39/136 (28.7)	0.99 (0.60, 1.61)	56/135 (41.5)	0.96 (0.64, 1.44)	23/123 (18.7)	1.21 (0.59, 2.47)	16/131 (12.2)	1.37 (0.59, 3.20)	22/130 (16.9)	1.54 (0.79, 3.02)	17/128 (13.3)	1.65 (0.76, 3.56)

Note. OR = odds ratio; CI = confidence interval.

TABLE 5—Percentage of Disability Attributable to Specific Conditions after Adjustment for Age, Sex, and Comorbidity, by Condition and Activity

Activity	Knee Osteo-arthritis	Hip Fracture	Diabetes	Stroke	Heart Disease	Congestive Heart Failure	Claudication	Chronic Obstructive Pulmonary Disease	Depressive Symptomatology	Cognitive Impairment
Stair climbing	16.7	9.1	9.8	12.8	5.2	7.6	3.1	7.4	15.4	. . .[a]
Walking a mile	15.4	4.9	4.3	9.3	9.3	2.4	6.8	5.2	10.4	. . .[a]
Heavy home chores	. . .[a]	2.8	2.2	6.7	15.3	3.9	1.2	3.8	4.0	. . .[a]
Housekeeping	16.7	7.8	2.6	12.6	13.4	6.5	0.0	6.5	15.9	3.4
Cooking	0.5	7.1	6.8	14.7	8.9	3.3	3.1	. . .[a]	4.3	7.3
Grocery shopping	1.2	7.5	3.5	16.7	13.0	1.6	. . .[a]	4.5	15.4	7.8
Carrying bundles	16.6	7.3	4.6	12.6	2.3	6.6	3.0	4.0	16.6	8.6

[a]Adjusted odds ratio < 1.

ent from those reached by other investigators at Framingham.[14] We found substantial effects for cardiovascular disease including congestive heart failure. Previous analyses of physical disability in the Framingham cohort may have been unable to detect relationships when the cohort was younger and therefore less disabled. Furthermore, our analyses indicate that there is some task-specificity in the disability associated with cardiovascular disease. Summating the number of functionally limited activities may obscure the relationship between some cardiovascular diseases and limitations in particular activities.

The diminution of the effects of cognitive impairment after adjustment for comorbidity is striking. Although the relationship between cognitive and functional decline has been well accepted, it is clear that much of the disability associated with cognitive impairment among noninstitutionalized individuals may be due to other causes. It is also possible that the functional measures we chose do not capture the specific tasks that are most affected by cognitive impairment in a community-dwelling population. In contrast, however, the effects of depressive symptomatology on function remain even after adjustment for the comorbidities included in our study. Previously, Wells and colleagues found that adults with a current depressive disorder or depressive symptoms had worse physical, social, and role functioning than their peers without such conditions.[35] Our finding highlights the contributions of psychological factors to physical functional limitations in the elderly. Physical disability is not merely the end result of physical conditions. Successful performance of many functional activities, such as housekeeping, requires motivation and cognitive abilities as well as physical ones.

It is also important to comment on two of the conditions for which we were unable to find a relationship between disease and disability, namely cancer and visual impairment. It was surprising to us that prevalent cancers were not related to functional limitations in the elderly. Satariano et al., for example, have found difficulty in activities requiring primarily upper-extremity strength among women with breast cancer aged 55 through 74, but not among those aged 75 through 84.[21] Although our five complex activities of daily living required the use of both upper and lower extremities, we could not find any consistent relationship between cancer and disability in our preliminary analyses. The mean age of our sample approximates the age of the group in Satariano's sample who were no more disabled than the control subjects. It is quite possible that those elders in Framingham with the most disabling forms of cancer had died of it or did not participate in the study; therefore an older cohort such as ours may include only elders with less disabling cancer. Although visual impairment may increase the risk of falls and other accidents among the elderly, it does not appear to be related to functional limitations in the tasks we evaluated. It is also possible that the criterion of visual impairment we used (best-corrected vision of 20/40) may not be severe enough to identify those elders whose functional limitations may be associated with impaired ability to see.

Verbrugge and her colleagues reported on the relative impact of comorbid conditions on functional limitations in all adults aged 55 years or older included in the Supplement on Aging to the 1984 National Health Interview Survey.[36] Considering each disease separately and adjusting for age, sex, and race, Verbrugge et al. found that highly prevalent conditions generally had little impact on an elder's difficulty in performing functional activities. Conversely, several low-prevalence conditions were strongly associated with increases in the total number of gross mobility tasks and basic and instrumental activities of daily living that elders performed with difficulty or were unable to do. Arthritis was shown to be the sole exception to this general conclusion, as it was a highly prevalent disease with a moderate correlation with difficulty in performing an overall number of physical functional tasks. Our analyses corroborate and extend the conclusions of Verbrugge et al. However, it should be noted that our definition of medically verified arthritis was limited to the knee. If we had included hand, wrist, and hip arthritis, the functional impact of "all arthritis," the definition used by Verbrugge et al. for self-reported arthritis and in calculating the proportion of disability attributable to arthritis, would have been even greater.

The conclusions of our study are limited in several ways. Our data were collected at the Framingham study site. Therefore, some individuals may have been excluded because they were functionally limited by their medical conditions to the point of being unable to come to the site. The nonparticipation of these individuals would weaken the association of disease and disability in our results.

Another limitation of this study may be the definitions we chose to use for each of the medical conditions, despite the accuracy of data verified medically. As we have shown for knee osteoarthritis, the risks of disability change with the stringency of the definition of the disease.[2] We can assume that the risks of disability for any other condition we studied would change if the criteria for the condition were modified. When confronted with the possibility of defining a condition in several ways, we chose conservative criteria that we believed would also be clinically meaningful. Furthermore, our study was concerned only with the association between a single condition and physical disability after all other medical conditions were controlled. We did not examine how various combinations of medical conditions might be associated with increased risk for disability in the elderly. Our understanding of disability in the elderly should not, however, be confined merely to the study of disease and disability. Future research must also account for the contributions of psychological and social factors—for example, personal motivation and social support—to specific physical functional limitations.

Our study is also limited by the functional tasks that were available for study. Although these items are traditionally used in broad epidemiological studies of disability in the elderly, they are only a very small sample of functional activities. Other data, not available at Framingham, might be able to demonstrate similarly strong associations between our 10 target conditions and other functional tasks. A change in dependent variables might also yield substantial odds of disability for some of the conditions that did not appear strongly associated with functional limitations in our study. For example, it is very likely that the odds of functional limitation in elders with cognitive impairment would have been greater if we had chosen basic hygiene and self-care activities of daily living as measures of disability.

The results of this study have public policy implications. The emphasis in geriatric health care and prevention has only recently been on functional morbidity. The relationship between stroke and functional limitations in the elderly is broad, involving a host of activities. Reductions in stroke and its aftereffects should yield improvements in the functional abilities of elders in a variety of tasks. Similar gains in physical function might be realized through prevention of depressive symptomatology and hip fracture. In contrast, the relationships of knee osteoarthritis and heart disease to function are more closely tied to specific activities. Thus, practitioners must carefully link a functional deficit to its most likely medical cause to diminish the effects of these diseases on function. Clinically, as demonstrated by the high degree of medical comorbidity in our subjects, these medical conditions are likely to be coexistent. Successful evaluation and treatment of an elderly patient will require a careful examination of the independent contributions of each of the patient's medical diagnoses to his or her physical functional status.

In summary, we investigated the effects of 10 medical conditions on seven functional limitations in the elderly. Only one condition, stroke, contributed to limitations in all seven activities. The proportions of disability in the elderly attributable to knee osteoarthritis, stroke, heart disease, and depressive symptomatology were greater than the proportions of disability attributable to other conditions. Efforts to reduce the effects of certain medical conditions on the functional status of the elderly will be enhanced by our understanding of the disease- and task-specificity of these relationships. □

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APPENDIX A—Medical Conditions Included in Preliminary Analyses

- Musculoskeletal
  - Knee osteoarthritis
  - Hip fracture
- Endocrine
  - Obesity
  - Diabetes
- Cardiovascular
  - Hypertension
  - Stroke excluding transient ischemic attack
  - Angina pectoris
  - Myocardial infarction
  - Coronary insufficiency
  - Heart disease
  - Congestive heart failure
  - Intermittent claudication
- Pulmonary
  - Dyspnea on exertion
  - Chronic obstructive pulmonary disease
  - Chronic obstructive pulmonary disease with dyspnea on exertion
- Oncologic
  - Cancers except nonmelanoma skin cancers
- Psychological
  - Depressive symptomatology
  - Cognitive impairment
- Visual impairment
  - Cataract
  - Visual acuity

APPENDIX B—Definitions of Medical Conditions

Knee osteoarthritis: Symptomatic osteoarthritis defined as pain in or around the knee lasting at least a month and at least grade 2 x-ray changes or asymptomatic osteoarthritis at least grade 3 on x-ray.

Hip fracture: Any hip fracture sustained prior to exam 18 visit.

Diabetes: Currently treated diabetes based on use of oral hypoglycemics or insulin.

Stroke: Sudden onset of a focal neurological deficit lasting more than 24 hours prior to exam 18 visit, excluding transient ischemic attacks.

Heart disease: Either angina pectoris or definite myocardial infarction on electrocardiogram any time prior to exam 18 visit.

Congestive heart failure: Condition meeting a minimum of two major criteria (e.g., paroxysmal nocturnal dyspnea or orthopnea, neck vein distension, cardiomegaly, acute pulmonary edema, rales, or S_3 gallop) or one major criterion and two minor criteria (e.g., bilateral ankle edema, dyspnea on exertion, tachycardia, or night cough).

Claudication: Intermittent claudication diagnosed by Framingham physicians.

Chronic obstructive pulmonary disease: $FEV_1 \div FVC < 60\%$ by spirometry at exam 16 or 17.[a]

Depressive symptomatology: A score of more than 4 of 10 on a modified CES-D scale with 10 questions.

Cognitive impairment: A score of less than 24 on the Folstein Mini-Mental Status Examination.

[a]FEV_1 = forced expiratory volume in 1 second; FVC = forced vital capacity.