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Comorbidity and Its Effect on Mortality in Nursing Home Patients with Dementia

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The relation between comorbidity and survival was investigated in an 8-year follow-up study of 606 nursing home dementia patients by means of proportional hazards analysis. Two-year survival rates for women (N = 437) and men (N = 169) were 60% and 39%, respectively. Parkinsonism, atrial fibrillation, pulmonary infection, and malignancies were powerful predictors: they more or less doubled the mortality chances. Stroke patients with a pulmonary infection had a particularly poor prognosis. More severely demented patients had more comorbidity than less severely demented patients, but the impact of comorbidity on survival did not depend on severity of dementia. Patients coming from a hospital had more comorbidity and were more severely demented than patients coming from home, but this did not modify the effects of age, gender, and comorbidity in a multivariate survival model. It was concluded that comorbidity and severity of dementia independently influence mortality. Thus a better prognostic judgment is obtained from their combination than from each separately.
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The prevalence of dementia in the population above 65 years may be more than 10% (Katzman, 1986). Many of the elderly will suffer from other diseases and impairments as well (comorbidity). Patients with dementia have a reduced life expectancy, but serious comorbidity also diminishes life span (van Dijk et al., 1991, 1992). Nevertheless, only few articles have reported figures about the effect of comorbidity on survival in dementia patients. In a recent article on survival in outpatients with Alzheimer dementia, "comorbid conditions" and "use of prescription drugs" were not related to survival (Walsh et al., 1990). The authors suggested that this could be due to the relatively small sample size (126 patients) and the measures used: they had coded only whether "comorbid conditions" were present or absent.

A description of prevalence rates of diseases at admission and a quantification of their influence on survival are important. It may contribute to the estimation of prognosis in dementia patients and it may offer a partial explanation for the large differences in survival rates between studies. For instance, hospital-based studies in patients with dementia demonstrated, on average, a 2-year survival rate of 40%, and outpatient-based studies demonstrated a 2-year survival rate of 75% (van Dijk et al., 1991). It was not possible to tell whether this difference was caused by differences in severity of dementia, in amount of comorbidity, or both.

In this article we describe the pattern of comorbidity in patients with dementia admitted to a nursing home, and we assess the effect on survival over an 8-year follow-up period. The results allow for a comorbidity-adjusted prediction of survival chances. Finally, the place of living before admission and its relation to comorbidity, severity of dementia, and survival were investigated.

Methods

Subjects

The study population consisted of 606 patients consecutively admitted between January 1, 1982, and December 31, 1988, to Stadzicht, a Dutch nursing home for demented patients. Every patient underwent a multidisciplinary examination before admission by a team, which consisted of a nursing home physician, a psychologist, and a social psychiatric nurse. Only patients with a diagnosis of dementia were admitted. The moment of admission depends very much on the capability and willingness of the family or other caregivers to give appropriate care. Of the 606 patients admitted, 437 were women. Mean age (± SD) at admission was 80.8 ± 6.8 years for all patients (79.6 ± 7.3 years for men

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and 81.3 ± 6.6 years for women). A more detailed description of the study population and the admission procedure has been presented elsewhere (van Dijk et al., 1992). Follow-up data were collected until death or discharge, or until January 1, 1990. During the follow-up period, 394 persons died and 58 persons left the institution. On January 1, 1990, 154 persons were still living in the nursing home.

Procedures

Comorbidity, secondary diagnoses. Information about comorbidity was obtained from a retrospective chart review of the patients' first 6 weeks in the nursing home. This information came from four sources: the examination before admission (see *Subjects*, above); letters about the medical history before admission from the general practitioner, specialists, and hospital admissions; a complete physical examination by the nursing home physician, a chest x-ray, an electrocardiogram, and several laboratory tests at admission; and observations during the first 6 weeks after admission, when the patients stay in a special observation department, where they are evaluated functionally, psychologically, and medically. The diseases which are typically evanescent, such as pulmonary infections, urinary tract infections, and pressure sores, were only considered present if they occurred during the first 6 weeks after admission. Comorbid illness diagnosed after the first 6 weeks was not included in the analysis. The diagnosis of Parkinsonism includes idiopathic Parkinson's disease and drug-related Parkinsonism, as well as the Parkinsonism appearing in the later stages of dementia. Pulmonary infections include bronchitis and pneumonia. A distinction was made between pulmonary infections in stroke and in nonstroke patients, because we assumed that these infections in stroke patients were more often dangerous aspiration pneumonias. Sporadic diagnoses include diseases (such as epilepsy, seizures, and gastrointestinal diseases) with a prevalence of less than 5% in the 606 patients. Incontinence was rated as present if the nursing staff considered it a persistent problem.

Diagnosis of dementia. Dementia was diagnosed according to criteria of the DSM-III-R (American Psychiatric Association, 1987). Senile dementia of the Alzheimer's type was diagnosed after exclusion of other causes of dementia (*e.g.*, hyperthyroidism, hypothyroidism, vitamin deficiencies, neurosyphilis, electrolyte abnormalities, drug-induced dementia, and depression). Criteria are based on those for primary degenerative dementia in DSM-III-R. The diagnosis of multi-infarct dementia was based on the presence of a stepwise deterioration, a fluctuating course, a patchy loss of functioning, and focal neurological symptoms and signs (Russell, 1983).

Severity of dementia. Scores on the dependency subscale of the Beoordelingsschaal voor Oudere Patiënten (Rating Scale for the Elderly [BOP]), a Dutch behavioral rating scale, were used as a measure of the severity of the dementia (Diesfeldt, 1981). Like the behavioral rating scale of the Clifton Assessment Procedure for the Elderly (Pattie, 1988), the BOP is derived from the Stockton Geriatric Rating Scale (Meer and Baker, 1966). The scales have 25 items in common. The dependency subscale contains the 23 items that loaded more than .45 on the first factor in a factor analysis (van der Kam et al., 1971). Examples of items are: "needs assistance when eating," "incontinent during the day," "does not make himself understood," "unable to find his way around the ward," "not occupied in useful activity," "urinates and defecates in inappropriate places," "needs assistance when dressing," "needs protection from falling out of bed," and "restless at night." The scale gives an overall indication of impairment on daily functioning. Each item is scored on a 0 to 2 scale depending on severity (no help, little help, much help) or frequency (never, sometimes, often). Thus, subscale scores can take values between 0 (no impairment at all) and 46 (severe impairment at all 23 items). To investigate whether the prevalence of comorbidity depended on the severity of dementia, the cohort was divided into two severity subgroups according to the score on the dependency subscale: 274 patients had a score below 20, and 295 patients had a score of 20 or more.[4]

Survival analyses. Univariate analyses were performed for a first impression of the influence of separate diagnoses on survival. Survival chances during follow-up were estimated by the product-limit method so that the entire follow-up of all patients could be used. Detailed results are reported for the 2-year survival chances. Statistically significant differences in survival between subgroups were identified using the log-rank test ($p < .05$, Kalbfleisch and Prentice, 1980; Lee, 1980). Multivariate analyses

[4] Because the BOP contains all items of the apathy and orientation subscales of the Clifton Assessment Procedure for the Elderly, scores on these two subscales were calculated for the convenience of readers who know the Clifton procedure. The mean scores of the 569 patients on the apathy (range, 0 to 10) and the orientation (range, 0 to 4) subscales were 5.0 (SD 2.6) and 1.3 (SD 1.2), respectively. The 274 patients with a score of less than 20 on the dependency subscale of the BOP had mean scores of 3.3 (SD 2.1) and .6 (SD .8) on the apathy and the orientation subscales of the Clifton scale. These means were 6.6 (SD 1.9) and 1.9 (SD 1.1) for the 295 patients with a score of at least 20 on the dependency subscale of the BOP.

TABLE 1
Two-Year Survival Rates in Dementia Patients for Various Types of Comorbidity

	Two-year survival (relative frequency of the comorbid condition)	
	Men (N = 169)	Women (N = 437)
All patients	39% (100%)	60% (100%)
Diagnostic Categories		
Previous myocardial infarction	33% (9%)	26% (5%)*
Heart failure	80% (7%)	20% (8%)*
Atrial fibrillation	19% (12%)	37% (8%)*
Hypertension	53% (8%)	54% (11%)
Previous stroke	39% (20%)	56% (12%)
Previous TIA	26% (10%)	43% (7%)
Parkinsonism	18% (19%)*	41% (11%)*
Chronic lung disease	38% (18%)	51% (5%)
Diabetes mellitus	68% (6%)	34% (12%)*
Hip fracture	20% (3%)	50% (9%)
Pulmonary infection	16% (15%)*	36% (8%)*
Urinary tract infection	35% (14%)	56% (17%)
Anemia	0% (5%)	34% (5%)
Pressure sores	36% (7%)	28% (7%)
Malignancies	11% (5%)*	40% (5%)
Previous hip operation	55% (18%)	58% (29%)
Number of Diseases[a]		
No diagnosis	48% (21%)*	80% (29%)*
1 diagnosis	42% (28%)	66% (30%)
2 diagnoses	39% (31%)	54% (22%)
3 or more diagnoses	25% (20%)	27% (19%)
Sporadic diagnoses	37% (27%)	47% (37%)*
Chronic Impairment		
Hearing impairment	17% (17%)*	51% (15%)
Visual impairment	25% (22%)	50% (27%)*
Fecal incontinence	39% (25%)	57% (25%)
Urinary incontinence	34% (50%)	52% (44%)*

[a]Number of diseases from the above 16 diagnostic categories
*$p < .05$, log-rank test.

provided a deeper insight into the influence of the separate diagnoses on survival, when adjusted for the influences of age, gender, and other diagnoses. To detect a possible interaction between pulmonary infections and stroke, two additional variables were constructed: pulmonary infection and stroke, and pulmonary infection without stroke. They were not considered in the analysis separately. The BMDP statistical program was used to perform multivariate proportional hazards regression analyses (Dixon, 1987). Again survival data from the entire follow-up period of 8 years were used. Age and gender were always included. The other variables were entered or removed in a stepwise forward selection on the basis of tail probabilities ($p < .10$ and $p > .15$, respectively) from a likelihood ratio test statistic: a variable is selected into the model only if it gives enough additional prognostic information above that provided by the variables already in the model. The rate ratios that result from such a model can be considered as relative risks.

The goodness-of-fit and the stability of the model were cross-validated by the split-half approach. The entire cohort was randomly split into two equal-sized groups, A and B. First, the stepwise forward selection procedure was carried out on group A (the training sample), and the resulting model was used to predict survival chances in group B (the test sample). Subsequently, group B functioned as the training sample and the resulting model was used to predict survival chances in group A. Thus, for every patient, survival chances were predicted by a model which did not use his data for its construction. The fit between observed and predicted numbers of deaths during the first 2 years after admission was assessed with chi-square goodness-of-fit statistics.

Results

Comorbidity and Survival

Univariate analyses. Several diagnoses were associated with a decrease in survival (Table 1). Men with Parkinsonism, pulmonary infection, anemia, and malignancies had less than the average 2-year survival rate of 39%. In women, myocardial infarction, heart failure, atrial fibrillation, Parkinsonism, diabetes mellitus, pulmonary infection, pressure sores, malignancies, and a previous hip operation all considerably decreased survival. Survival in stroke and hypertension patients was not statistically significantly decreased. Survival decreases steadily with an increasing number of diagnoses from 2-year survival rates of 48% for men and 80% for women without diagnoses to rates of 25% and 27% in men and women with three or more diagnoses. Myocardial infarction, heart failure, diabetes mellitus, and pressure sores affected survival more in women than in men: the better survival in women disappears when one of these diseases is present.

Multivariate analyses. The multivariate model consisted of age, gender, and the 10 comorbid variables that had been selected in the stepwise-forward process (Table 2). "Pulmonary infection and stroke" was selected first, because it gave the most additional prognostic information above the prognostic information of age and gender. Once "pulmonary infection and stroke" was selected, malignancy gave the most additional prognostic information and was therefore selected second. The results confirmed the univariate analyses: pulmonary infection, Parkinsonism, malignancies, and atrial fibrillation were significantly associated with increased mortality. Having any of these diagnoses doubled the mortality rate. The rate ratio of 1.7 for gender means that the mortality rate for men is almost twice the rate for women. The rate ratio of 1.04 for age means that the mortality rate increases by 4% for each year of age above 50 on admission.

The rate ratio of 16.4 (confidence interval: 7.4–36.3) for pulmonary infection and a previous stroke was particularly high. Pulmonary infection in patients without a previous stroke carried a rate ratio of 1.8 (see Table 2). Three other diagnoses (heart failure, diabetes mellitus, and pressure sores) had a rate ratio of about 1.5. Urinary incontinence and visual problems gave only about a 25% increased rate, but they were selected nevertheless because of their high prevalence. Several conditions that were statistically significant in the univariate analyses of Table 1 were not selected. Hearing impairment and previous hip operation did not add sufficient independent prognostic information once age and gender were forced into the model. For anemia, this was the case after "pulmonary infection and a previous stroke" was selected. The comorbidity index gives the physician an explanation of how to calculate a patient's prognosis based on individual characteristics.

TABLE 2
A Multivariate Model for Predicting Survival in Nursing Home Patients with Dementia

Variables	Regression coefficient	Rate ratio (95% confidence interval)	Sequence of selection
Gender[a]	.52	1.7 (1.4–2.1)	Forced
Age at admission (years)	.038	1.04 (1.02–1.06)	Forced
Diagnoses[b]			
Pulmonary infection and stroke	2.79	16.4 (7.4–43.8)	1
Malignancy	.77	2.2 (1.4–3.3)	2
Atrial fibrillation	.68	2.0 (1.4–2.7)	3
Pressure sores	.58	1.8 (1.2–2.6)	4
Parkinsonism	.62	1.9 (1.4–2.5)	5
Pulmonary infection, no stroke	.57	1.8 (1.3–2.4)	6
Urinary incontinence	.28	1.3 (1.1–1.6)	7
Heart failure	.53	1.7 (1.2–2.4)	8
Diabetes mellitus	.45	1.6 (1.2–2.1)	9
Visual problems	.23	1.3 (1.0–1.6)	10

[a]Female = 0, male = 1.
[b]Absent = 0, present = 1.

Model evaluation. For all 606 patients, 2-year survival chances were calculated from the results of the split-half approach. These chances were used for classifying each patient in one of four (equal-sized) prognostic groups (see Figure 1). Their predicted 2-year survival chances were 76%, 66%, 52%, and 25%. The observed survival curves resembled the expected ones, but there was an overestimation of survival in the groups with a moderate and with a poor prognosis, and an underestimation of survival in the group with a good prognosis. The statistical assessment of the goodness-of-fit is illustrated in Figure 2. For this purpose, the patients were divided into nine groups with predicted 2-year survival chances between 0% and 10%, 10% and 20%, . . . , and 80 and 90%. Nobody had a predicted survival chance above 90%. For every group the observed number of deaths closely fits the expected number ($\chi^2 = 3.6$, 9 *df*, $p > .9$). For instance, 24 of the 32 patients with a predicted survival chance below 10% died, while 29.1 deaths were expected. Of the 21 patients with a predicted survival chance between 80% and 90%, one patient died, while 3.3 deaths were expected according to the model.

Figure 2 also gives an impression of the predictive power, *i.e.*, the power to identify patients with a very good or a very poor prognosis: the model gives, *e.g.*, a predicted 2-year survival chance of less than 10% to 32 patients, and a chance of more than 80% to 21 patients. In contrast, a model based only on gender and age identifies no patient at all with a predicted 2-year survival chance of less than 10%, and only six patients with a chance of more than 80%. For every patient, a comorbidity index for prognostic purposes can be calculated by multiplying the patient's values on the selected variables with 10 times the regression coefficients of the variables in the model, and adding them to a sumscore (see Table 3). Survival chances for several values of the comorbidity index can be read from Figure 3. The predicted 2-year survival can be estimated according to the equation $S_i(2) = .56^{exp(CI_i-40)/10}$, where $S_i(2)$ is the chance for an individual i of at least surviving for 2 years, .56 is the mean 2-year survival chance, CI_i is the comorbidity index for an individual i, and 40 is the mean CI for the 606 patients. For instance, a man 85 years old at admission with atrial fibrillation and heart failure has a comorbidity index of $5 + (85 \times .4) + 7 + 5 = 51$. His $S_i(2) = .56^{exp(51-40)/10} = .56^3 = .18$. A woman of 75 years at admission with only diabetes mellitus has a comorbidity index of $(75 \times .4) + 5 = 35$. Her $S_i(2) = .56^{exp(35-40)/10} = .56^{.6} = .69$.

For the calculation of survival chances for other periods, the value of .56 should be replaced as follows: 1 year = .71, 3 years = .38, and 5 years = .19. The comorbidity index coefficient does not change for other follow-up periods.

Comorbidity, Severity of Dementia, and Survival

In order to explore whether the prevalence of comorbidity and the impact on survival depended on severity of dementia, two severity subgroups were constructed (see *Methods*). From the diagnoses selected in the model, pulmonary infection, Parkinsonism, pressure sores, urinary incontinence, and visual problems were more frequently present in the group of more severely demented patients ($p < .05$). The other diagnoses of the model did not show statistically significant differences in prevalence rates.

The relatively less dependent patients had a 2-year survival rate of 72%. For the more dependent

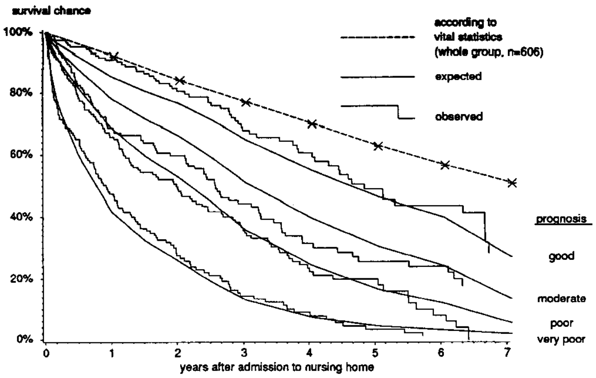

FIG. 1. Observed and expected survival according to the model for subgroups of patients with a good, moderate, poor, or very poor prognosis according to their predicted survival chances on the model, obtained from the cross-validation with the split-half approach. The asterisks represent the expected survival chances for the entire cohort according to the Dutch national vital statistics.

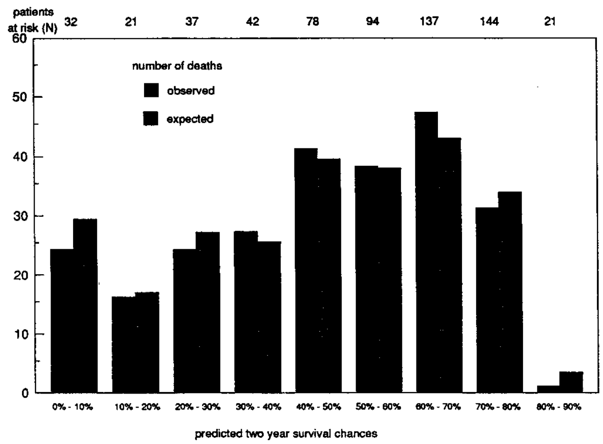

FIG. 2. Observed and expected number of deaths within 2 years after admission according to the predicted 2-year survival chances of the model. The predicted 2-year survival chances are the chances obtained from the cross-validation with the split-half approach.

patients this rate was 42%. For both groups, survival decreased evidently with the number of diagnoses: from 86% and 55% if there is no comorbidity to 57% and 32% when at least two diagnoses are present.

The influence of comorbidity on survival seemed greater for women than for men: 2-year survival rates for relatively less and the relatively more dependent women with no comorbidity were much higher (90% and 63%) than rates for their male counterparts (66% and 33%). These differences were much smaller when there were two or more diagnoses present (60% and 35% *vs.* 50% and 28%).

Place of Living Before Admission

From the 569 patients with dependency scores, 241 patients came from their own home, 108 patients came from a hospital, 106 patients were from a home for the aged, 97 patients were from another nursing home, and 17 patients were from other places. Patients coming from their own home had the lowest mean number of diagnoses (1.2 ± 1.3) and the highest 2-year survival rate (60%), and those coming from a hospital had the highest mean number of diagnoses (2.1 ± 1.5) and the lowest 2-year survival rate (51%). The mean dependency score for hospital patients (20.9 ± 8.9) was significantly higher than that score for patients coming from home (18.0 ± 9.0). For both groups, survival decreased evidently with the number of diagnoses: from 86% and 55% if there is no comorbidity to 57% and 32% when at least two diagnoses are present.

Stratified for severity of dependency and number of diseases, the survival rates in hospital patients were not significantly lower than in patients coming from home. For instance, the 2-year survival rates for the relatively less demented patients with at least two diseases from Table 1 who came from the own home (N = 52) and who came from the hospital were 61% and 52%, respectively. These rates were 24% (N = 41) and 40% (N = 43), respectively, for the more severely demented patients. This suggests that the diseases in hospital patients were not more severe than in patients coming from home.

When the variables "coming from hospital" and "coming from own home" were added to the multivariate model (Table 2), neither had a significant independent influence on survival: the rate ratios were 1.2 (95% confidence interval: .9–1.5) and .95 (.8–1.2), respectively.

Discussion and Conclusions

Univariate and multivariate analyses confirmed and quantified the association between comorbidity and reduced survival in dementia patients after admission to a nursing home. Several conditions diagnosed at admission evidently increased the mortality risk during 8 years of follow-up. The relatively more severely demented patients had more comorbid illness than patients in whom the dementia was less severe, but the impact of comorbid illness on survival did not differ between the two severity clusters.

Comorbidity and Survival

A pulmonary infection clearly diminished survival chances in patients with a stroke. Eight of the nine

TABLE 3
Scoring Chart for Calculating the Comorbidity Index That Can Be Used in Predicting Survival Chances for Nursing Home Patients with Dementia[a]

		Score
Gender	If male	5
Age	years * .4	
Pulmonary infection and stroke	If present	28
Malignancy	If present	8
Atrial fibrillation	If present	7
Pressure sores	If present	6
Parkinsonism	If present	6
Pulmonary infarction without stroke	If present	6
Heart failure	If present	5
Diabetes mellitus	If present	5
Urinary incontinence	If present	3
Visual problems	If present	2
Add relevant scores	Comorbidity Index:	☐

[a]The comorbidity index can easily be obtained by circling relevant scores and adding them to the sumscore. See Figure 3 for the predicted survival changes according to the comorbidity index.

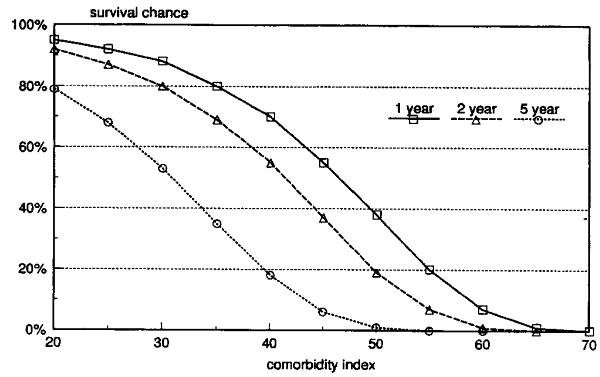

FIG. 3. Predicted 1-, 2-, and 5-year survival chances according to several values of the comorbidity index.

patients in our study with both diagnoses died within 2 months. The high rate ratio of 16.7 may be an overestimate, but nevertheless emphasizes the lethality of a pulmonary infection in these patients. Stroke patients often have swallowing problems and diminished cough reflexes, and thus are more prone to develop an aspiration pneumonia, which is clinically much more serious than an ordinary pneumonia or an upper respiratory tract infection. We were not able to recover whether an aspiration pneumonia was really the cause of death in the involved patients.

Stroke is frequently mentioned as an important immediate cause of death in dementia patients (Chandra et al., 1986; Molsa et al., 1986; Peck et al., 1978; Schoenberg, 1986). In our study, stroke (without a pulmonary infection) did not affect survival, because the majority of the strokes in our cohort were old strokes, and only a few patients had a stroke just before or just after admission. The same is true for myocardial infarction, and therefore its impact on mortality is also less than might be expected. Both diagnoses should be regarded as an indicator of vascular disease. Hypertension did not influence survival. This is in accordance with Mattila et al. (1988), who found that high blood pressure may not be associated with excess mortality in the very old. The relation between atrial fibrillation and poor survival in dementia patients has been described before (Zijlstra et al., 1986).

We do not know why myocardial infarction, heart failure, pressure sores, and diabetes mellitus had a small (or even absent) impact on survival in men. It may be a chance finding, because these findings are not in accordance with general opinion. These diseases might have been less severe in men at admission, but unfortunately this severity was often not registered. A systematic difference between criteria for admission for men and women is probably not an explanation for this finding: for most other diseases there is no clear difference between the two sexes. The increased mortality in patients with Parkinsonism is in accordance with general opinion. The increased mortality in case of pressure sores confirms the results of an earlier study (Berlowitz and Wilking, 1990). Probably, pressure sores indicate that the patient is in a generally deteriorated condition.

Performing multivariate analyses can be associated with many problems, such as interaction between variables on their effect on mortality, and nonproportional hazards (Concato et al., 1993). For instance, the rate ratios for pressure sores and pulmonary infection changed over time: during the first half year the risk of dying for patients with a pulmonary infection was 2.5 times the risk for patients without, and afterward this rate ratio was only 1.4. For pressure sores, the rate ratio was 3.2 during the first half year, and this ratio was 1 afterward. It is also possible that these diseases develop during the stay in the nursing home after the first 6 weeks. In theory, the proportional hazards model can cope with such "changes in prognostic status." This will probably increase the predictive power, and from a scientific point of view it may considerably contribute to the insight into the relation between dementia and intercurrent comorbidity, and life expectancy. In practice, such a model would become very difficult to interpret for the nursing home physician. If the physician wants to know the patient's prognosis, it would be much easier and more realistic to do this on a model based on data from the patient's situation at that moment.

A significant interaction between age and comorbidity occurred only with a malignancy: the influence on mortality rates was larger in younger patients, and a 5% adjustment for each year the patient was older was needed. The rate ratio of a malignancy was 2.5 for 80-year-old patients and for people of, *e.g.*, 70 and 90 years, this ratio was 4.2 and 1.5, respectively.

Model Evaluation

The goodness-of-fit of the comorbidity model was satisfactory (Figures 1 and 2). The model carries considerable prognostic information: Figure 2 shows groups of patients with a very favorable and with a very poor prognosis. A model based only on gender and age was hardly able to identify such patients. Furthermore, it can be seen in Figure 1 that the median survival time after admission was more than 4 years for the quarter of patients with the most favorable prognosis, and only 1 year for the quarter with the poorest prognosis.

The comorbidity model was better in identifying patients with a very poor prognosis than a model based on behavioral items that does not explicitly account for serious comorbidity (van Dijk et al., 1994). The behavioral prognostic model, which contained gender, age, and the items "needs help when walking," "restless at night," "occupied in useful activity," "utters physical complaints" and "socializes with other patients," was better able to identify the patients with a very favorable prognosis, probably because it can distinguish between the relatively mildly and the more severely demented patients.

Comorbidity, Severity of Dementia, and Survival

The hypothesis that dementia is especially associated with high mortality (Kay and Roth, 1955), and that the presence of physical illness in dementia patients is not sufficient to account for their shortened life span (Jarvik et al., 1980), is confirmed in our study: men and women with "no diagnoses" had 2-year survival rates of 44% and 73% (Table 1). Eighty-year-old men and women in the general population, which includes patients with multiple diseases, have rates of about 80% and 90%. Figure 1 indicates that the survival chances for the entire cohort according to the vital statistics (dotted line) are higher than those for the group of patients with the most favorable prognosis according to the comorbidity model.

We expected that the prevalence of comorbidity would be higher in the relatively more severely demented patients, because they are on average more often bedbound and apathetic, and they are more often in a poor physical condition. This hypothesis was confirmed. We also expected that the lethality of comorbidity would be higher in the relatively more severely demented patients, because they often cannot describe symptoms and complaints adequately, they will more often refuse water and food when they feel ill, and they are more often in a poor physical condition. This hypothesis was not confirmed: the decrease in survival rates with the increase of number of diagnoses was comparable for the two severity subgroups. Because relatively many of our patients suffered from severe cognitive decline according to the Global Deterioration Scale (Reisberg et al., 1982), the generalizability is probably not allowed for only slightly demented patients. It would be interesting to investigate whether the finding that the lethality of comorbidity was independent from severity of dementia can be extrapolated to the demented patients who still live in the community. Place of living did not contain independent prognostic information in the multivariate model, which implies that the model does not depend on case mix.

In conclusion, this study confirmed that both dementia and comorbidity had a considerable life-shortening effect on dementia patients. The influence of comorbidity on mortality seemed to be independent of the severity of the dementia.

In this study we analyzed data on comorbidity at admission, and not the influence of medical complications afterward. The data were collected retrospectively, and this made it impossible to take the severity or the stage of the comorbid conditions reliably into account. Nevertheless, we think that this study is an important step toward a detailed quantitative analysis of the influence of comorbidity on mortality in dementia patients. We have constructed a comorbidity index that indicates how much, according to our analysis, the survival chances of a patient change as a result of having one or more diagnoses.

Its clinical use could be the following: if a patient is severely demented, major surgery would hardly ever be justifiable. On the other hand, surgery can considerably improve the quality of life of a relatively mildly demented patient, and a nihilistic approach might not be justifiable. Especially in a patient in whom there is doubt about the usefulness of surgery, knowledge about life expectancy can play a role in decision making. For example, patients with senile cataract or osteoarthritis of the hip will be readier candidates for surgery if they have a relatively long life expectancy. The instantaneous risk and inconvenience of surgery then becomes relatively less important, because the patient can longer benefit from a lens implantation or a hip replacement. The clinician's estimation of life expectancy is normally largely based on clinical experience and intuition. Unfortunately, in the absence of systematic observations, this can lead to incorrect, or at least suboptimal, predictions (Evidence-Based Medicine Working Group, 1992). Systematic observation of survival time data, such as collected in our study, can increase the validity of predictions. The subsequent interpretation of the prediction, and the judgment of its value in view of other factors that play a role in the decision of whether to operate, remains the responsibility of the clinician.

References

American Psychiatric Association (1987) *Diagnostic and statistical manual of mental disorders (DSM-III)* (rev). Washington, DC: Author.

Berlowitz DR, Wilking SVB (1990) The short-term outcome of pressure sores. *J Am Geriatr Soc* 38:748–752.

Chandra V, Bharucha NE, Schoenberg BS (1986) Patterns of mortality from types of dementia in the United States, 1971 and 1973–1978. *Neurology* 36:204–208.

Concato J, Feinstein AR, Holford TR (1993) The risk of determining risk with multivariable models. *Ann Intern Med* 118: 201–210.

Diesfeldt HFA (1981) The BOP, a report on ten years' experience with a Dutch geriatric rating scale [in Dutch]. *Gerontologie* 12: 139–147.

Dixon WJ (1987) *BMDP statistical software*. University of California Press.

Evidence-Based Medicine Working Group (1992) Evidence based medicine: A new approach to teaching the practice of medicine. *JAMA* 268:2420–2425.

Jarvik LF, Ruth V, Matsuyama SS (1980) Organic brain syndrome and aging. A six-year follow-up of surviving twins. *Arch Gen Psychiatry* 37:280–286.

Kalbfleisch JD, Prentice RL (1980) *The statistical analysis of failure time data*. New York: John Wiley and Sons.

Katzman R (1986) Alzheimer's disease. *N Engl J Med* 314:964–973.

Kay DWK, Roth M (1955) Physical accompaniments of mental disorder in old age. *Lancet* 2:740–745.

Korn EL, Simon R (1990) Measures of explained variation for survival data. *Stat Med* 9:487–503.

Lee ET (1980) *Statistical methods for survival analysis*. Lifetime Learning Publications. New York: John Wiley Interscience Publication.

Mattila K, Haavisto M, Rajala S, Heikinheimo R (1988) Blood pressure and five year survival in the very old. *Br Med J* 296: 887–889.

Meer B, Baker F (1966) The Stockton Geriatric Rating Scale. *J Gerontol* 21:392–403.

Molsa PK, Marttila RJ, Rinne UK (1986) Survival and cause of death in Alzheimer's disease and multi-infarct dementia. *Acta Neurol Scand* 74:103–107.

Pattie A (1988) Measuring levels of disability—The Clifton Assessment Procedures for the Elderly. In JP Wattis, Hindmarch I (Eds), *Psychological assessment of the elderly*. London: Churchill Livingstone.

Peck A, Wolloch L, Rodstein M (1978) Mortality of the aged with chronic brain syndrome: Further observations in a five-year study. *J Am Geriatr Soc* 26:170–176.

Reisberg B, Ferris SH, De Leon MJ, Crook T (1982) The Global Deterioration Scale for assessment of primary degenerative dementia. *Am J Psychiatry* 139:1136–1139.

Russell RWR (Ed) (1983) *Vascular disease of the central nervous system* (chap. 18, pp. 359–367). Edinburgh: Churchill Livingstone.

Schoenberg BS (1986) Epidemiology of Alzheimer's disease and other dementing illnesses. *J Chron Dis* 39:1095–1104.

van der Kam, Mol F, Wimmers MFHG (1971) *Beoordelingsschaal voor Oudere Patiënten*. Deventer: Van Loghum Slaterus.

Van Dijk PTM, Dippel DWJ, Habbema JDF (1991) Survival of patients with dementia. *J Am Geriatr Soc* 39:603–610.

Van Dijk PTM, Dippel DWJ, Habbema JDF (1994) A behavioral rating scale as a predictor for survival of demented nursing home patients. *Arch Gerontol Geriatr* 18:101–113.

Van Dijk PTM, van de Sande HJ, Dippel DWJ, Habbema JDF (1992) The nature of excess mortality in nursing home patients with dementia. *J Gerontol Med Sci* 47:M28–34.

Walsh JS, Welch HG, Larson EB (1990) Survival of outpatients with Alzheimer-type dementia. *Ann Intern Med* 113:429–434.

Zijlstra H, Trommel J, van der Weele LT (1986) Prognostic value of admission EKG in 582 patients in a psychogeriatric nursing home [in Dutch]. *Vox Hospitii* 10:105–107.