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Predictor Index of Mortality in Dementia Patients Upon Entry Into Long-term Care

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Background. The purpose of this study was to develop an algorithm that predicts survival in patients with dementia upon entry into long-term care. There are, as yet, no predictive equations developed for those in the late stages of Alzheimer's disease (AD).

Methods. This was a prospective, observational study of 132 patients with dementia (61% with AD) followed for up to 5.0 years (median of 41.0 months) after admission to a long-term care facility for dementia patients. Information on demographic characteristics, physical health, and cognitive, emotional, and behavioral characteristics was collected shortly after admission and entered as predictors of time until death in Cox regressions. Findings were used to derive an index predicting mortality.

Results. There were 60 deaths among the 132 patients (45.4% mortality), with an average survival of 22.4 months in those who died. Better physical health and the presence of delusions were associated with longer survival. These two variables were aggregated into the Copper Ridge Index (CRI). Each one-point increase on the CRI was associated with a four-fold greater likelihood of death over 5 years.

Conclusions. A predictive equation incorporating measures of general physical health and delusions accurately predicted time to death in dementia patients in long-term care.

THE life expectancy of long-term care residents is strongly related to age, degree of functional disability, and the presence of dementia (1–3). Among residents with dementias such as Alzheimer's disease (AD) the factors most often associated with shorter survival include being male (2–6, but see 7,8), presence of hallucinations, delusions, or behavioral abnormalities (8–10), and severity of cognitive impairment (8). One study (11) identified four such variables as significant predictors of time until death in outpatients with early-stage AD: sex, duration of illness, cognitive impairment, and extrapyramidal symptoms. A given patient's standing on these four variables was entered into an equation to derive a "predictor index" that differentiated early-stage AD patients with shorter and longer survival times.

An important question remains as to whether those factors that predict survival in the early stage of progressive dementia predict longevity in middle and late stages of the illness. Put another way, do the factors that predict survival in patients living in the community predict survival in long-term care facilities? This question is important given the great costs associated with late-stage care and given the growing number of older adults who will require such care (12). To address this question, we assessed the value of demographic, physical health, neurologic, and psychiatric factors as predictors of survival in 132 patients with dementia admitted to a long-term care facility. We thus developed a predictive algorithm to estimate the time to death in these patients.

Methods

Participants

Between July 1994 and July 1996, 132 consecutive patients, aged 55 and older, were studied shortly after admission to the 66-bed comprehensive care unit of Copper Ridge, a long-term care facility for patients with AD and other dementias. Eighty (61%) of these patients received a clinical diagnosis of either possible ($n = 8$) or probable ($n = 72$) AD according to NINDS-ADRDA criteria (13). Fifteen (11%) were diagnosed with probable vascular dementia (VaD) by NINCDS-AIRENS criteria (14), 14 (11%) with mixed AD/VaD, 11 (8%) with dementia not otherwise specified, 5 (4%) with depression and dementia, and 7 (5%) with dementia due to other causes (Pick's disease, Lewy body dementia).

Examination

Within 4 weeks of admission, all patients underwent comprehensive neuropsychiatric evaluation. They were tested on the Mini-Mental State Exam (MMSE; 15) and rated on the Clinical Dementia Rating Scale (CDR; 16), Extrapyramidal Rating Scale (17), Cornell Scale for Depression in

Dementia (18), Behavioral Pathology in Alzheimer's Disease Rating Scale (BEHAVE-AD; 19), Psychogeriatric Dependency Rating Scale (PGDRS; 20), and General Medical Health Rating (GMHR; 21). To minimize the possible bias associated with excluding patients with incomplete data, mean scores for the sample were imputed for missing scores on each scale. Historical information, including education, medical history, onset of dementia, and more than 5% weight loss in the 6 weeks preceding admission (available for the last 65 admissions), was obtained from patients' knowledgeable informants and from medical records. Other variables of interest, including sex and age, were recorded. Patients were followed until death or until the end of the study period (July 7, 1999), which was 5 years after the study started. Dates of death were recorded by staff physicians and obtained from in-house patient records.

Results

The demographic and clinical characteristics of the patient sample are presented in Table 1 and are consistent with middle- to late-stage dementia. There were 60 deaths among the 132 patients within the 5-year study period (45.4%). Between-group comparisons in Table 1 revealed that the deceased group was in poorer overall health (lower GMHR scores), was more physically dependent in activities of daily living (higher PGDRS physical subscale scores), and had fewer delusions (lower BEHAVE-AD delusion subscale scores) than those still living.

The cohort's mean survival duration was 42.3 months with an estimated median of 54 months. Univariate Cox proportional hazard models for each of 19 predictor variables on time to death are presented in Table 2. They replicate the pattern of effects observed in between-group comparisons above. Specifically, being healthier, more physically independent, and having delusional beliefs, was each associated with longer survival. None of the remaining variables was significantly associated with time to death.

The three variables significant in univariate models (BEHAVE-AD delusion subscale, GMHR, and PGDRS physical activities of daily living [ADL] subscale scores) were then entered into a multivariate Cox regression model to assess the adjusted effects of these measures. Results of this model are presented in Table 3 indicating that the BEHAVE-AD delusion subscale score was the most significant predictor variable, while GMHR approached significance and the PGDRS physical ADL subscale score did not. This last measure probably did not achieve significance in the multivariate model because it was highly correlated with GMHR ($p = -.404$; $p < .001$). Thus, a more parsimonious model including only the BEHAVE-AD delusion subscale score and the GMHR (Table 3) was examined. Using this second model, a patient's score on each variable was multiplied by its beta

Table 1. Baseline Demographic and Clinical Characteristics of 132 Dementia Patients Upon Admission to a Long-term Care Facility for Dementia Patients, Stratified by Vital Status at the End of the 5-Year Study Interval

Characteristics	Total Sample	Living	Deceased
n	132	72	60
Age	79.4 (7.8)	78.4 (8.1)	80.6 (7.4)
Sex (% Female)	72.1	76.1	65.4
Education†	12.6 (3.4)	12.5 (3.5)	12.8 (3.4)
Years Ill	5.4 (3.3)	5.6 (3.0)	5.3 (3.8)
Diagnosis (% Alzheimer's disease)	61.1	64.8	56.7
Clinical Dementia Rating (median)	2.0	2.0	2.0
Mini-Mental State Exam	9.1 (7.2)	9.7 (6.8)	8.3 (7.6)
Cornell Scale for Depression	7.7 (5.9)	7.5 (5.9)	8.0 (6.0)
Weight Loss (%)	10.8	10.0	12.0
Extrapyramidal Rating Scale	2.2 (2.3)	2.1 (2.3)	2.4 (2.2)
General Medical Health Rating (median)	3.0	3.0	2.0*
PGDRS Subscales‡			
Behavior	6.1 (5.3)	6.9 (5.6)	5.0 (4.8)
Orientation	4.6 (3.0)	4.5 (3.0)	4.8 (3.0)
Activities of Daily Living (ADL)	15.4 (8.9)	13.5 (8.0)	17.8 (9.4)*
BEHAVE-AD Subscales			
Delusions	1.0 (1.8)	1.4 (2.3)	0.5 (1.0)*
Hallucinations	0.1 (0.6)	0.1 (0.6)	0.2 (0.6)
Activity disturbance	1.7 (1.9)	1.9 (2.0)	1.4 (1.8)
Aggressiveness	1.4 (2.0)	1.6 (2.2)	1.2 (1.8)
Diurnal disturbance	0.5 (0.8)	0.4 (0.9)	0.5 (0.8)
Affective disturbance	0.9 (1.5)	1.0 (1.6)	0.8 (1.3)
Anxiety and phobias	0.3 (0.8)	0.4 (0.9)	0.2 (0.7)

Notes: Numbers represent means (standard deviations), unless otherwise specified. PGDRS = Psychogeriatric Dependency Rating Scale; BEHAVE-AD = Behavioral Pathology in Alzheimer's Disease Rating Scale.

†$N = 98$.

‡Lower scores reflect better functioning.

*$p < .05$ in *t* tests and chi-square tests.

Table 2. Univariate Cox Proportional Hazard Analyses Predicting Time Until Death in Patients With Dementia Upon Admission to a Nursing Home

Characteristics	β Weight	Hazard Ratios (95% CI)	*p* Value
Age	.0222	1.02 (0.99–1.06)	.184
Sex (female = 0; male = 1)	−.4718	0.62 (0.30–1.30)	.198
Education	−.0034	1.00 (0.90–1.10)	.948
Years Ill	−.0387	0.96 (0.87–1.07)	.473
AD vs Other Diagnosis	−.0011	1.00 (0.52–1.91)	.998
Mini-Mental State Exam	−.0498	0.95 (0.89–1.02)	.148
Weight Loss (<5% = 0; ≥5% = 1)	−.248	0.79 (0.32–1.40)	.433
Cornell Scale for Depression	.0206	1.02 (0.98–1.07)	.350
Extrapyramidal Rating Scale	−.0433	0.96 (0.82–1.13)	.600
General Medical Health Rating	−.4850	0.62 (0.42–0.90)	.012*
PGDRS Subscales†			
Behavior	−.1091	0.90 (0.78–1.02)	.109
Orientation	−.0688	0.93 (0.80–1.10)	.401
Activities of Daily Living (ADLs)	.0415	1.04 (1.01–1.07)	.006*
BEHAVE-AD Subscales			
Delusions	−.3332	0.72 (0.54–0.95)	.023*
Hallucinations	−.1473	0.86 (0.44–1.69)	.667
Activity disturbance	−.0524	0.95 (0.75–1.20)	.658
Aggressiveness	.1752	1.19 (0.90–1.58)	.220
Diurnal disturbance	.0389	1.04 (0.67–1.62)	.863
Affective disturbance	.0004	1.00 (0.77–1.30)	.998
Anxiety and phobias	−.4064	0.67 (0.41–1.08)	.099

Note: CI = confidence interval; PGDRS = Psychogeriatric Dependency Rating Scale; AD = Alzheimer's disease; BEHAVE-AD = Behavioral Pathology in Alzheimer's Disease Rating Scale.

†Lower scores reflect better functioning.

*$p < .05$.

Table 3. Multivariate Cox Proportional Hazard Models

	β Weight	Hazard Ratio (95% CI)	*p* Value
Model 1			
BEHAVE-AD Delusions	−0.2708	0.763 (0.599–0.972)	.0285
General Medical Health Rating	−0.3757	0.687 (0.446–1.056)	.0873
PGDRS Physical Subscale (ADLs)	0.0056	1.006 (0.972–1.041)	.7487
Model 2			
BEHAVE-AD Delusions	−0.266	0.766 (0.613–0.958)	.0195
General Medical Health Rating	−0.496	0.609 (0.416–0.891)	.0107

Notes: Those variables significant in univariate models to predict time until death in patients with dementia upon admission to long-term care have been entered. BEHAVE-AD = Behavioral Pathology in Alzheimer's Disease Rating Scale; PGDRS = Psychogeriatric Dependency Rating Scale; ADLs = activities of daily living; CI = confidence interval.

weight and the resulting products summed to derive the Copper Ridge Index (CRI). The equation is as follows:

$$\text{CRI} = [(\text{BEHAVE-AD delusion subscale} \times -0.266) + (\text{GMHR} \times -0.496)].$$

Scores ranged from −4.11 to −0.11 and were transformed by adding 4.11 to each individual's score so that the lowest score was 0 and the highest score was 4.0. Lower scores on the CRI predicted longer survival. The scatterplot in Figure 1 shows the association between CRI scores and the number of months lived in patients as a function of their vital status at the end of the 5-year study interval. A cut-off score of 2.3 (solid vertical line) accurately differentiated those who survived the 5-year study interval with 82% sensitivity and 53% specificity. Reduced specificity represents an overestimation of mortality in the ≥2.3 group and likely stems from the fact that numerous patients with a score of approximately 2.6 survived the interval. Because CRI scores and times to death were continuous variables, we also evaluated the sensitivity and specificity of the CRI in predicting vital status over the 5-year interval using logistic regression and receiver-operating characteristic analyses (22). Results showed that, for every one-point increase in the CRI, there was over a four-fold increase in the odds of mortality during the study interval: odds ratio 4.38, confidence interval (CI) 1.91–10.29; $p < .001$. Predictive accuracy was 70.1%.

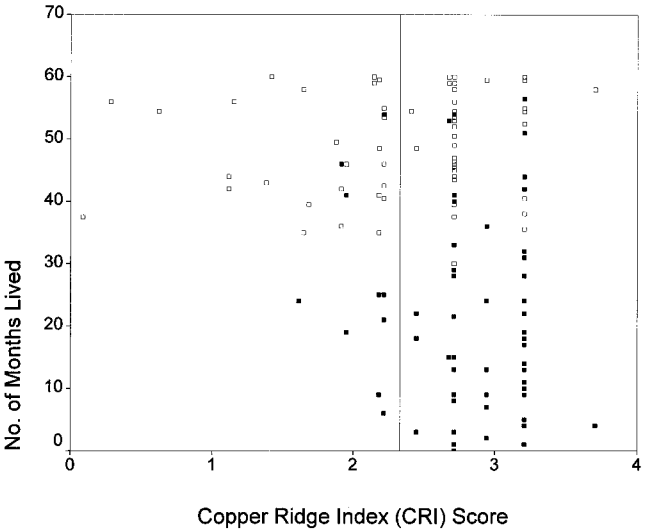

Figure 1. Scatterplot showing the association between CRI scores and the number of months lived in patients as a function of their vital status at the end of the 5-year study interval. Lower scores predict greater longevity. The solid line on the plot divides patients according to whether their scores fell above or below 2.3. ■ Deceased; □ living.

Discussion

This study identified predictors of survival in patients with dementia from information obtained upon admission to the comprehensive nursing unit of a long-term care facility. Of several clinical, health, and demographic variables assessed, better general physical health and the presence of delusions were most predictive of time to death. The strongest predictor of mortality in this sample is certainly not selective to dementia. Poor physical health is a well-known risk factor for mortality (23).

The second major predictor of mortality, the absence of delusions, was somewhat surprising. Delusions were among the more prevalent psychopathological symptoms observed here, as in other AD patient studies (19,24,25), and may have served as the basis for admission in some cases. They have been associated with higher MMSE scores and less functional disability (25). While delusions are present in all stages of AD (26), longitudinal investigation has shown them to be most prevalent in the moderate stage of cognitive impairment (27). These findings raise the possibility that the presence of delusions in dementia patients upon nursing home admission may serve as a marker of more moderate disease severity (MMSE and CDR notwithstanding) and, thus, longer expected survival.

The results of this study are important for two reasons. First, they reveal that variables predictive of mortality in the later stages of progressive dementia differ from those in the early stages. Given that dementia is, by definition, an impairment of cognition, a measure of severity of cognitive impairment was expected to predict those in the most advanced and end stages of the illness. MMSE score was not a significant predictor of survival here, perhaps because most patients scored very low (floor effects). Other instruments more sensitive to lower levels of cognitive functioning than the MMSE may be more appropriate cognitive predictors of mortality upon nursing home admission (28,29). Alternatively, severe cognitive impairment may have been captured, in part, by the positive association between delusions and survival duration. Delusional beliefs that are common in AD, such as feeling that people are stealing one's belongings or that the place in which one currently lives is not one's home, reflect partial insight into recent environmental changes and may represent a degraded memory of one's past. The loss of this degraded memory may signal the latest measurable stages of cognitive impairment and, thus, the later stages of the illness.

Overall, these results indicate that the predictive utility of clinical disease factors varies according to the stage of illness and builds on previous research by combining predictors of mortality into an aggregate predictive algorithm, the CRI. We examined predictors across a variety of domains to derive this simple aggregate measure that uses two rating

instruments that can be easily administered by a nurse or clinician regardless of a patient's dementia severity.

A significant limitation of this study lies in its uncertain generalizability. Patients in this study were treated in a university-affiliated dementia care facility, which might not be comparable to other long-term care environments. Specialized onsite treatment may have improved long-term survival. If so, this equation represents a conservative estimate of a patient's life expectancy in a general long-term nursing home setting. Mortality rates in institutionalized dementia patients have ranged from 31% to 40% over a 3-year period (6,30,31) and 43% over 5 years (32). The 3- and 5-year mortality rates in the present sample were comparable, at 28% and 45%, respectively. Nevertheless, the broader utility of this equation in dementia patients requires replication in other settings.

The CRI or a similar algorithm may ultimately have great prognostic value for families making individual health care decisions and for public health care planning. Individuals may find such an equation useful when planning not only for ill family members but also for their own possible eventualities following retirement. Financial planning, particularly for comprehensive care, may become critical given that the current average annual cost of a dementia patient's care is between $40,000 and $60,000 (15). On a broader public policy level, the proportion of Americans over the age of 65 is expected to double from 15% to 30% over the next 30 years (15), and the number of prevalent AD cases will nearly quadruple in the next 50 years (33). Thus, derivation of a predictive tool may serve as a useful initial step toward projecting demands that will be placed on individuals who are now living longer and on the public health care system.

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