Time to Nursing Home Admission for Persons With Alzheimer's Disease: The Effect of Health Care System Characteristics

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Objective. To study the influence of state health care system characteristics on time to nursing home admission (NHA) for persons with Alzheimer's disease (AD).

Methods. Up to nine years of Consortium to Establish a Registry for Alzheimer's Disease (CERAD) data on 639 non-Latino White individuals were merged with longitudinal data from the 28 states in which the CERAD participants resided. The state variables reflected characteristics of each state's long-term care (LTC) system, including Medicaid LTC spending practices and the supply of LTC providers. Cox Proportional Hazards Models with time-varying covariates were used to evaluate the risk factors associated with time to NHA.

Results. There was differential influence of state variables by marital status. For unmarried non-Latino White persons with AD, a higher percentage of Medicaid LTC spending on home and community-based services (HCBS) was significantly associated with a longer time to NHA. For married persons, a greater number of home health agencies was associated with a longer time to NHA. Other associations also varied by marital status.

Conclusion. Study findings support the utility of targeted continued expanded provision of HCBS by states and provide a basis for future research regarding the impact of changing state health care systems on LTC utilization for persons with AD.

The adequacy and organization of the United States' long-term care (LTC) system (with its component state systems) is an increasingly debated public health issue. Experts, citing lack of needed home and community-based services (HCBS) and problems with nursing home (NH) bed accessibility, express concern regarding the inadequacies of the current LTC system in meeting the needs of older adults, especially those older adults with cognitive impairment/dementia and those who are disadvantaged (Abel, 1991; Brody, Lawton, & Liebowitz, 1984; Estes, Swan, & Associates, 1993; Kane, 1987; Mace, Whitehouse, & Smyth, 1993; National Institute of Mental Health, 1992; Niederehe, 1993). These concerns become more compelling in our aging society, where the prevalence of cognitive impairment/dementia increases with age (Cohen, Van Nostrand, & Furner, 1993; Larson, 1993; Niederehe, 1993). These concerns are more compelling in nursing home admission (NHA) rates for persons 85 years of age and older ranging between 25% and 48% (Larson et al., 1992). Nursing home admission (NHA) rates are high, and stays are long and costly for persons with AD and related disorders (Coughlin & Liu, 1989; Welch, Walsh, & Larson, 1992).

Of interest in this study is the evaluation of the association between state LTC system characteristics and NH utilization for persons with AD. State characteristics, if determined to be significant risk factors for institutionalization, have potential for mutability, especially in this era of state health care system reform. Studies have shown demographic and clinical variables to be strong predictors of NHA for persons with AD and related disorders (Drachman, O'Donnell, Lew, & Swearer, 1990; Haupt & Kurz, 1993; Heyman et al., 1987; Knope, Kitto, Deinard, & Heiring, 1988; Severson et al., 1994). These variables have no or low mutability potential. Caregiver variables have also been associated with NHA (Aneshensel, Pearlin, & Schuler, 1993; Cohen, Gold, et al., 1993; Colerick & George, 1986; Lieberman & Kramer, 1991; Pruchno, Michaels, & Potashnik, 1990; Wright, 1994). As shown by Broaday, McGilchrist, Harris, and Peters (1993) and others (Hébert, Giroudard, Leclerc, Bravo, & Lefrançois, 1996; Mittleman, Ferris, Shulman, Steinberg, & Levin, 1996), these variables are more mutable, but a major approach to modifying these variables lies in increased caregiver support, which is limited by availability of HCBS providers and funding.

Several studies have investigated the influence of the supply of health care resources and related measures on NH utilization (Greene & Ondrich, 1990; Nyman, 1993; Scanlon, 1980), but there has been limited study of the in-
fluence of these factors for persons with AD and related disorders. Demonstration studies incorporating case management and expanded access to HCBS, although yielding mixed results, have failed to support the hypothesis that the introduction of case-managed HCBS will reduce NH use (Wilkinson, 1997). Some research, however, has shown that the risk of NHA can be reduced when HCBS are targeted to cognitively impaired older adults (Greene, Lovely, Miller, & Ondrich, 1995; Jette, Tennstedt, & Crawford, 1995), and recent work has shown that the probability of living in a nursing home or personal care home was significantly reduced for frail unmarried elderly persons who received expanded HCBS in the Channeling experiment (Pezzin, Kemper, & Reschovsky, 1996). Additionally, with more stringent targeting and medically oriented home care interventions, the Channeling demonstration might have resulted in an overall reduction in nursing home use and LTC costs (Greene, Ondrich, & Laditka, 1998).

There have been mixed results from studies focusing on the association between HCBS and NH utilization for persons with AD and related disorders. In an experimental design study, increased HCBS for persons with moderate or severe dementia appeared to facilitate NHA (O’Connor, Pollitt, Brook, Reiss, & Roth, 1991). Two nonexperimental design studies also showed increased HCBS use to be associated with increased NHA for persons with AD and related disorders (Cohen, Gold, et al., 1993; Nygaard, 1991). An Italian study, however, showed a greater availability of HCBS (i.e., personal care, home health care, and meal programs) reduced the risk of NHA for persons with AD (Bianchetti et al., 1995).

Many of the studies examining NHA for persons with AD and related disorders have used a prospective, follow-up design (using baseline covariate values and then follow-up outcome data; Cohen, Gold, et al., 1993; Pruchno et al., 1990; Colerick & George, 1986). These studies tend to have short follow-up periods (of 2 years or less) between time of origin and NHA and can only examine whether an NHA occurred (not when NHA occurred). Of the reviewed AD-related studies using person-time data and survival analysis techniques, and thus having the ability to assess time to NHA, only three included in their analyses measurement of time-varying covariates (Aneshensel et al., 1993; Broadaty et al., 1993; Mittleman et al., 1996), and only one updated variable values throughout the entire follow-up period (Mittleman et al., 1996). The study presented here improves on previous related research designs by (a) studying persons with probable or possible AD who were followed for as long as 9 years, (b) using a Cox Proportional Hazards Model with annually updated variable values for evaluating the risk factors associated with time to NHA, and (c) expanding upon the risk factors studied by including community-level variables reflecting state health care system characteristics.

As discussed by Jette and colleagues (1995), more focus on specific risk factors and subgroups is needed when examining NH utilization. Persons with AD, because of their high levels of impairment, intense care needs, and documented costly NH care costs, are a subgroup worthy of such a special focus. The study of the risk of NHA associated with specific state health care system characteristics is also important, for if state health care system characteristics are found to influence time to NHA for persons with AD, then changes in these characteristics (through new policy directions) can delay NHA and/or improve access to NH care as appropriate.

**METHODS**

This prospective cohort study merged National Institute on Aging Consortium to Establish a Registry for Alzheimer’s Disease (CERAD) longitudinal data and state health care system longitudinal data to yield answers to research questions. Andersen’s Behavioral Model of Health Services Utilization (Andersen & Newman, 1973) provided the conceptual framework for selecting and analyzing model variables. Andersen’s model views the individual determinants of health care service utilization as (a) the predisposition of an individual to use services (i.e., demographic, social structure, and belief variables), (b) the ability of the individual to secure services (i.e., enabling variables such as family and community characteristics), and (c) the individual’s need for services (i.e., perceived and/or evaluated need/illness level). The main hypothesis was that, when controlling for patient characteristics known to be risk factors for NHA, specific state health care system variables, reflecting characteristics of a state’s LTC system, are significantly associated with time to NHA for persons with AD.

The unit of analysis was the individual, with state health care system data linked via the state of residence of each person with AD. With this merging of individual-level variable values (for CERAD data) with ecologic-level variable values (for state data), use of a random effects model was preferred. Unfortunately, a random effects model was not available for use with the Cox Proportional Hazard. As an alternative, to control for regional heterogeneity and thus more accurately estimate standard errors for the state variables, eight of the nine U.S. census regions were entered as fixed effects in multivariate models.

**The Study Sample**

The CERAD project enrolled individuals between April 1987 and January 1995; follow-up data through March 1996 were available for this study. Participants were referred to CERAD from National Institute on Aging (NIA) Alzheimer Disease Research Centers (ADRCs) and other university program projects throughout the country. The CERAD mission was to standardize procedures used for the evaluation and diagnosis of elderly patients with AD and other dementias, and because of this mission, excellent multiple measures on AD severity and progression were available for study.

CERAD participants, at study entry, had a diagnosis of probable or possible AD per, with minor modifications, National Institute of Neurologic and Communicative Disorder and Stroke/Alzheimer’s Disease and Related Disorder Association (NINCDS/ADRDA) guidelines (McKhann et al., 1988). Also, all CERAD participants had an able and willing informant available at study entry, were assessed as willing and cooperative, were able to read and comprehend the language on the forms at entry, and were judged likely to return
for at least two annual follow-up visits. Exclusion criteria eliminated those with serious physical disease or major depression. For this study, we included only those individuals who had mild or moderate dementia (per Clinical Dementia Rating) at study entry. A more in-depth discussion of the CERAD project can be found elsewhere (Morris, Mohs, Rogers, Fillenbaum, & Heyman, 1988; Morris et al., 1989).

The CERAD database studied here included 785 non-Latino White CERAD participants. (Non-Latino African Americans are the subjects of a separate analysis. The number of Latinos was too small for meaningful analyses to be conducted.) After excluding those in nursing homes at study entry \((n = 11, 1\%)\) and CERAD sites with poor follow-up or poor NHA data \((n = 71, 9\%)\), 703 individuals from 20 CERAD sites and 28 states remained for study. Of these, 43 \((6\%)\) were lost to follow-up prior to one year, and were thus excluded. Participants lost to follow-up before the Year 1 follow-up were more frequently female and had fewer years of education than those not lost to follow-up. All other CERAD variables were comparable between the two groups.

For most baseline variables of interest (see analysis below), less than 3\% of the participants were missing values. For these variables, persons with missing baseline values were excluded from analyses \((n = 21, 3\%)\) and the effective sample size became 639. No important differences were evident when descriptive statistics were compared between the samples of 639 and 660.

**Data Sources and Variables Studied**

**Predisposing Variables.**—Figure 1 displays the variables studied. Predisposing demographic variables included patient age and gender.

**Enabling Variables.**—Because of large amounts of missing data, family enabling variables were unavailable for study. Marital status, however, served as a proxy for the availability of informal support. Education level served as a proxy for income.

Community enabling variables were measured at the state level, and these data were obtained from a variety of sources. When possible, longitudinal data were obtained. State variable selection was based on findings from an extensive literature review. The selection enabled two hypotheses to be studied: that time to NHA would be associated with (a) the availability of NH beds and (b) the availability of HCBS. Availability was operationalized by variables reflecting supply and demand and by spending variables believed to be reflective of a state's policy emphasis (see Figure 1). Because a colder climate had been found to be independently associated with an increased risk for NHA (Scanlon, 1980; Weissert & Cready, 1989), climate as measured by mean heating degree days (National Climatic Data Center, 1992) was also studied. The difference across states in relation to the percent of Medicaid spending on

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**Figure 1.** Variables studied per Anderson’s Behavioral Model of Health Services Utilization—Time to nursing home admission. *Variable values at baseline and follow-up were used. HCBS, home and community-based services; LTC, long-term care.
LTC (per persons aged 65+) has been shown to be significantly affected by a state’s demographic and economic variables (adjusted $R^2$ of 57%; Kane, Kane, Ladd, & Nielsen, 1998). Because of this, it is speculated that the percent of a state’s spending on LTC is useful as a marker of states with different population needs and structures and with different economic resources.

Table 1 lists the data source for each state-level variable and the years for which data were available. For fiscal years 1991 through 1994, state Medicaid budget data were retrieved from published Medicaid statistical reports (Health Care Financing Administration [HCFA], 1993a, 1993b, 1994, 1995). For fiscal years 1988–1990, unpublished Medicaid financial management reports were provided to us by HCFA. To ensure the comparability of the two sources, percentages calculated for fiscal year 1990, using the unpublished management reports, were compared to percentages calculated in 1991 using the published document. Percentages were quite similar between the two years, with changes in the expected direction. Additionally, budget numbers and calculated percentages for fiscal year 1993 were compared with those appearing in an American Association of Retired Persons (AARP) publication (Hardwick, Pack, Donohoe, & Kristen, 1994). The numbers and percentages were identical.

### Illness/Need Level Variables

Perceived illness/need variables were obtained from a CERAD modified Blessed Dementia Rating Scale (Blessed, Tomlinson, & Roth, 1968). For this scale, the informant provided the information based on the participant’s cognitive ability in the preceding 6 months. Variables derived from scale data included: (a) a continuous variable representing the total Blessed Dementia Rating Scale score; (b) a continuous variable representing the memory and instrumental activities of daily living (IADLs) subscore; (c) a continuous variable representing the activities of daily living subscore (ADLs); and (d) three dichotomous variables representing any impairment (vs no impairment) in eating, dressing or toileting. For the eight memory and IADL items, the rating scale was $0$ = no impairment, $.5$ = some impairment, and $1$ = severe impairment. For the ADL subscore, the three ADLs included in the Blessed Dementia Rating Scale were rated from $0$ (no assistance required) to $3$ (total dependence). Information on behavior problems was also obtained from informants, but because of missing data, the influence of behavior problems could not be studied here.

Physical status variables available from clinical evaluation and studied here included diastolic and systolic blood pressure, and the presence (at baseline and at each follow-up) and history (at baseline only) of heart disease, stroke, epilepsy, thyroid problems, Parkinson’s disease, cancer, or other physical conditions. A global physical and neurologi- cal evaluation (i.e., normal or abnormal) was also available at baseline and at follow-up. The presence (at baseline) and history (at follow-up) of depression was also recorded. The dementia stage was represented via a global score.

### Table 1. Data Sources for State Variables and Years of Available Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data Source</th>
<th>Years Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH beds per 1,000 persons 85+</td>
<td>Institute for Health and Aging, University of California at San Francisco</td>
<td>1986, 1990, 1992</td>
</tr>
<tr>
<td></td>
<td>(DuNah, Harrington, &amp; Bedney, 1993)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Raetzman, 1991; Raetzman &amp; Jensen, 1992; Raetzman, Jensen, &amp; Wright, 1993)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Swan, Keo de Wit, Pickard, &amp; Clark, 1993)</td>
<td></td>
</tr>
<tr>
<td>Home health agencies per 100,000 persons 65+</td>
<td>Public Policy Institute, American Association of Retired Persons</td>
<td>1989, 1991</td>
</tr>
<tr>
<td></td>
<td>(Raetzman, 1991; Raetzman &amp; Jensen, 1992)</td>
<td></td>
</tr>
<tr>
<td>Adult day centers per 100,000 persons 65+</td>
<td>Health Resources Publishing (1992)</td>
<td>1992</td>
</tr>
<tr>
<td>Number of licensed residential care beds per 1,000 persons 65+</td>
<td>Institute for Health and Aging, University of California at San Francisco</td>
<td>1989, 1990, 1991, 1992</td>
</tr>
<tr>
<td></td>
<td>(Harrington, DuNah, &amp; Bedney, 1993)</td>
<td></td>
</tr>
<tr>
<td>Mean heating degree days</td>
<td>National Climatic Data Center, National Oceanic and Atmospheric Administration, U.S. Department of Commerce (1992)</td>
<td>61-year average of the yearly population-weighted values for each state in study</td>
</tr>
</tbody>
</table>

Notes: HCBS, home and community-based services; NH, nursing home; LTC, long-term care.
using the Clinical Dementia Rating Scale (CDR; Morris, 1993). The CDR stage was based on a clinician's rating of the categories of memory, orientation, judgment and problem solving, community affairs, home and hobbies, and personal care. Stages range from 0 (no dementia) to 5 (terminal dementia). To study the influence of and to control for cognitive impairment, a revised Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) was used. A battery of neuropsychologic tests was also available for analysis but, because of multicollinearity concerns arising from previous factor analysis conducted by CERAD investigators (Morris et al., 1989), these tests were not included in the same models as the MMSE. Other analyses and multivariate models (not reported here) included tests from the CERAD Neuropsychologic Assessment Battery rather than the MMSE. These methods yielded the same findings in regard to the hypothesis tested.

The Dependent Variable

The dependent variable is time to NHA. Survival time was counted from the date of entry into the CERAD study to NHA. As discussed by Aneshensel et al. (1993), determination of survival time is relevant to the type of study conducted: patient-centered, health care system-centered, or caregiver-centered. Because this study was health care system-centered, entry into the CERAD study served as a surrogate for entry into the health care system for AD evaluation. Given that individuals studied here were in early stages of AD and were referred to the CERAD study from Alzheimer's Disease Research Centers and other university projects in the United States, it is likely that entry into the health care system for evaluation of dementia was quite proximal to entry into the study. Another consideration in choosing study entry as the time origin (rather than the approximate date of onset) was that patient variable information was unavailable prior to study entry. Without variable measurement from the date of onset of the global disorder of AD, interpretation of analyses using date of onset would be ambiguous.

Based on strong evidence in the literature that NHAs for persons with cognitive impairment are permanent (Liu, McBride, & Coughlin, 1994; Greene & Ondrich, 1990; Kelman & Thomas, 1990), the study endpoint was reached when a subject entered an NH for the first time. Right censoring occurred when a patient died or was lost to follow-up. For this study, a participant was considered lost to follow-up when there was no follow-up evaluation, no reported death, and no reported NHA for a 24-month period following date of study entry or last yearly follow-up.

Data Analysis

Using baseline values, descriptive univariate analyses were conducted. Also using baseline values, survival and hazard distribution curves and probabilities were generated for all cases as a whole and by subgroups by variable categories. The SAS LIFETEST procedure (SAS Institute, Inc., Evanston, IL) was used for this. Specifically, the method of Kaplan and Meier (1958) was used. With the method of Kaplan and Meier, estimated survival probabilities are computed using a product limit formula.

The Cox Proportional Hazards Model with time-varying covariates was used for multivariate analyses. Using this method, the effect of the \( k \)th variable on the survival probability at time \( t \) depends on the value of the \( k \)th variable at time \( t \) (Kleinbaum, 1996). The estimation of regression coefficients generated as a result of this modeling, therefore, represents the effect of baseline values and of subsequent values (Altman & De Stavola, 1994). Unlike a model that uses only baseline values to predict a future event, modeling with updated values identifies the influence of predictor values most proximal to the actual event.

To accomplish the updated modeling, participants were assigned the baseline value upon study entry, and they were assigned the annual follow-up value for each subsequent year they remained in the community and were still being followed. For the state variables, assignment was more complex because participants entered the study between 1987 and 1995. For these variables, the baseline value was the state variable value for the year the subject entered the study, and the follow-up values were the state values for the years subsequent to the year of the subject's study entry.

As recommended by Altman and De Stavola (1994), missing follow-up values were replaced. All CERAD variables included in the time-dependent models were examined over follow-up time to determine if there were strong, consistent linear increases or decreases in variable values. When this was the case, and when there were values present for the years prior to and after the missing value, the missing value was imputed using the average of the prior and subsequent years' values. Only three variables fell into this category—memory and IADLs, ADLs, and MMSE. Wald chi-square statistics were found to be only slightly higher when averages versus the last known variable values were used, and statistical significance in univariate models was unchanged. For variables without a strong, consistent linear trend, and for categorical variables, missing follow-up values were replaced by entering the last variable value. For health care system variables, when there were no values for a specific year, the value for the prior year was used or, when there were no prior year values, the value from the most proximal subsequent year was entered.

An essential assumption of the Cox model is that the conditional relative risk associated with a given level of a variable does not change with time—it is proportionate (Tibshirani, 1982). Examination of log (–log) estimated survival curves, as well as tests for significance of interactions with survival times, were used to test this proportionality assumption. Many variables were found to be nonproportional over time; the conditional relative risks appeared to change at around 3–4 years. To present the data more accurately and clearly, this nonproportionality was addressed by fitting two multivariate models: one for the time interval from study entry to 3 years' follow-up and one for the interval of 3 to 9 years' follow-up (for those still at risk of NHA at 3 years). Within these two time intervals, risk ratios were proportional over time.

The continuous variables were assessed for linearity. This was performed by comparing (via the likelihood ratio test with a chi-square distribution with 2–5 degrees of freedom) a model containing the continuous variable to a
model representing 4–6 levels of the continuous variable and with 3–5 dummy variables (Collett, 1994).

Without the availability of a random effects model for use with the Cox model, standard errors for state variables would be underestimated because state variables are treated statistically as independent, when, in effect, they were the same for participants residing in the same state and entering the study in the same year. As mentioned earlier, to control for regional heterogeneity—and thus to correct for a portion of the understimation of the state variable standard errors—eight of the nine U.S. census regions were entered into the near final multivariate models as fixed effects. The addition of regions as fixed effects did result in higher standard errors for the state variables and thus reduced the statistical significance of all state variables included in near final models.

RESULTS

Descriptive Findings

Descriptive statistics for sociodemographic characteristics and physical and cognitive functioning are shown in Table 2. The majority of the participants were female and married, and they had an average of 12.8 years of education (SD = 3.6). As reflected by the MMSE and the memory and IADL and ADL scores, CERAD participants were not highly impaired at baseline.

During the follow-up, 379 participants (59%) were institutionalized. Other outcomes are shown on Table 3. Of those lost to follow-up, 56 (8.7% of total sample) did not have follow-up data for at least three years, and only 22 (3.4% of total sample) did not have follow-up data for at least two years. Participants lost to follow-up were more often female, unmarried and incontinent, and had higher diastolic sitting blood pressures at study entry. Those who died were more often male and needed more assistance to dress and eat. Other CERAD baseline variable values were least two years. Participants lost to follow-up were more often male and needed more assistance to

dress and eat. Other CERAD baseline variable values were
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dress and eat. Other CERAD baseline variable values were

Twenty-five percent of the subjects were admitted to a nursing home by 1.77 years (95% CI 1.57, 2.05). The median time to NHA was 3.44 years (95% CI 3.04, 3.75).

Cox Proportional Hazards Regression Models

Variables found to be associated with a shorter time to NHA in univariate analysis, but not in multivariate analysis, included the percent of Medicaid spending on LTC and mean heating days (a colder climate). No physical status measures were statistically significantly associated with time to NHA in univariate analysis.

Table 4 and Table 5 display the results of multivariate analyses using the Cox Proportional Hazards Model with updated covariate values. During the modeling process, a statistically significant interaction was detected between marital status and the percent of state Medicaid LTC spending on HCBS (p = .003). Subsequent analyses also detected interactions between marital status and the ratio of NH beds (p = .061), NH percentage of occupancy (p = .021), age (p = .026), and gender (p = .11). Because of these findings, we decided to stratify the multivariate analysis by marital status (married vs unmarried).

As previously discussed, because of nonproportionality of the conditional relative risks over time for many of the variables studied, multivariate models for two time intervals are shown. For unmarried persons, covariate effects for years 3–9 could not be estimated reliably because of the small sample size remaining at Year 3.

Figure 2 shows the estimated adjusted survival curves for those married and unmarried individuals. As seen, the curves are significantly different, with the difference greatest in the earlier time period (p < .001 per Wilcoxon test). The median time to NHA for unmarried participants was 2.37 years; it was 3.61 years for married participants.

Predisposing Variables

For unmarried persons in the first 3 study years (see Table 4), no predisposing variables were significantly associated with time to NHA. For married persons in the first 3 study years (see Table 5), being older was independently associated with a shorter time to NHA, with each additional year of age resulting in a 4% increased risk of NHA.

Enabling Variables

For unmarried persons (see Table 4), a higher percentage of state Medicaid LTC spending on HCBS was significantly associated with a shorter time to NHA. Other enabling variables for those married and unmarried individuals. As seen, the curves are significantly different, with the difference greatest in the earlier time period (p < .001 per Wilcoxon test). The median time to NHA for unmarried participants was 2.37 years; it was 3.61 years for married participants.

Table 3. Participants With and Without Nursing Home (NH) Admission as Outcome (N = 639)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admitted to NH</td>
<td>379 (59%)</td>
</tr>
<tr>
<td>Not Admitted to NH</td>
<td>260 (41%)</td>
</tr>
<tr>
<td>Died</td>
<td>70 (11%)</td>
</tr>
<tr>
<td>Survived in community</td>
<td>98 (15%)</td>
</tr>
<tr>
<td>Lost to follow-up *</td>
<td>92 (14%)</td>
</tr>
<tr>
<td>after Year 1</td>
<td>22 (3.4%)</td>
</tr>
<tr>
<td>after Year 2</td>
<td>34 (5.3%)</td>
</tr>
<tr>
<td>after Year 3</td>
<td>14 (2.2%)</td>
</tr>
<tr>
<td>after Year 4</td>
<td>14 (2.2%)</td>
</tr>
<tr>
<td>after Year 5</td>
<td>3 (0.47%)</td>
</tr>
<tr>
<td>after Year 6</td>
<td>4 (0.63%)</td>
</tr>
<tr>
<td>after Year 7</td>
<td>1 (0.16%)</td>
</tr>
</tbody>
</table>

\*Percent of total participants followed.

\*Due to rounding, total does not equal 100%.

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Table 2. Characteristics at Study Entry (N = 639)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number (%) or Mean SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at Study Entry (years)</td>
<td>71.4 7.9</td>
</tr>
<tr>
<td>Gender (female)</td>
<td>343 (54%)</td>
</tr>
<tr>
<td>Married</td>
<td>476 (74%)</td>
</tr>
<tr>
<td>Education (years)</td>
<td>12.8 3.6</td>
</tr>
<tr>
<td>Memory and IADL Impairment</td>
<td>3.76 1.62</td>
</tr>
<tr>
<td>ADL Impairment</td>
<td>.65 1.09</td>
</tr>
<tr>
<td>Clinical Dementia Rating</td>
<td></td>
</tr>
<tr>
<td>1 = Mild</td>
<td>372 (58%)</td>
</tr>
<tr>
<td>2 = Moderate</td>
<td>267 (42%)</td>
</tr>
<tr>
<td>MMSE</td>
<td>18.0 5.1</td>
</tr>
</tbody>
</table>

\*Impairment per Blessed Dementia Rating Scale.
also in the first 3 study years, for married persons in the first 3 study years, a higher number of NH beds per 1,000 persons aged 85+ resulted in a longer time to NHA at Years 3–9 (for those still at risk at Year 3), but these associations were not statistically significant (see Table 5). None of the other state variables were independently associated with time to NHA in the multivariate models. It was felt that the percent of state Medicaid spending on LTC spending on HCBS was independently associated with a shorter time to NHA being almost three times faster for unmarried persons in the first 3 study years (see Table 4). A rating of profound to terminal dementia (as compared to mild to moderate) was significantly associated with NHA being almost 12 times faster for unmarried persons in the first 3 study years. For unmarried persons, none of the other illness/need level variables had statistically significant associations with time to NHA.

In both time intervals for married persons, impairment in memory and IADLs was associated with a shorter time to NHA, but the association was only marginally significant in Years 3–9 (see Table 5). The risk ratios for ADL impairment were significantly different in the two time intervals, with ADL impairment being independently associated with a shorter time to NHA in the first 3 study years and with a slightly longer time to NHA in Years 3–9 (see Table 5).

For married persons, a CDR rating of severe was independently associated with a shorter time to NHA in the time interval of 3–9 years after baseline (see Table 5). The risk ratios for the CDR rating of profound or terminal were significantly different in the two time intervals, with the rating in the first time interval associated with a shorter time to NHA, and in the second interval, a longer time. Neither association, however, was statistically significant. A higher MMSE score (less impairment) was independently associated with a longer time to NHA (in the first 3 study years, see Table 5).

Findings Related to State Health Care System Variables

The findings reported here support the present study’s hypotheses relating to (a) the availability of HCBS and (b) the availability of NH beds. For unmarried persons in the first 3 study years, a higher percentage of LTC Medicaid spending on HCBS was independently associated with a longer time to NHA. This finding is in agreement with the work of Bianchetti and colleagues (1995) and is also consistent with the findings of Greene and colleagues (1995, 1998), Jette and colleagues (1995), and Pezzin and colleagues (1996). At study entry, unmarried persons were frailer than their married counterparts (data not shown). Unmarried persons were also more likely than married persons to have characteristics associated with poverty (U.S. Bureau of the Census, 1996) and thus to be Medicaid eligible; they were older (p = .001), primarily female (87% vs 42% for married persons; p = .001), and had 2 fewer years associated with a longer time to NHA (in the first 3 study years), the conditional relative risk being .90 (CI .85, .96) for each percentage point of additional spending. For married persons (see Table 5), a higher number of HHAs per 100,000 persons aged 65 and older resulted in a longer time to NHA (in the first 3 study years). Also in the first 3 study years, for married persons a higher number of NH beds per 1,000 persons aged 85 and older and a higher NH percent-
Table 5. Proportional Hazards Multiple Regression Models—Married Persons With Alzheimer’s Disease* (n = 476)

<table>
<thead>
<tr>
<th>Risk Set at Beginning of Interval</th>
<th>Number of NHAs During Interval</th>
<th>Time Interval</th>
<th>Difference Between Risk Ratios for Time Intervals—p Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Entry to 5 Years</td>
<td>476</td>
<td>277</td>
<td>107</td>
</tr>
<tr>
<td>3–9 Years</td>
<td>179</td>
<td>107</td>
<td></td>
</tr>
</tbody>
</table>

**Estimates of Conditional Relative Risk of NHA (95% CI)**

<table>
<thead>
<tr>
<th>Predisposing Variables</th>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Risk Set at Beginning of Interval</strong></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td><strong>Number of NHAs During Interval</strong></td>
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<tr>
<td><strong>Estimates of Conditional Relative Risk of NHA (95% CI)</strong></td>
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<tr>
<td><strong>Predisposing Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Age (older)</strong></td>
<td>1.04***</td>
<td>1.00</td>
<td>.134</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.02, 1.06)</td>
<td>(1.00, 1.03)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gender (male)</strong></td>
<td>1.11</td>
<td>1.14</td>
<td>.708</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.81, 1.53)</td>
<td>(.76, 1.71)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Education (more)</strong></td>
<td>1.02</td>
<td>1.00</td>
<td>.741</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.97, 1.06)</td>
<td>(.92, 1.04)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Enabling Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NH beds per 1,000 persons 85+</strong></td>
<td>1.006*</td>
<td>1.01**</td>
<td>.750</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.0, 1.01)</td>
<td>(1.0, 1.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NH occupancy rates</strong></td>
<td>1.18*</td>
<td>1.23</td>
<td>.714</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.02, 1.36)</td>
<td>(1.03, 1.65)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>% of Medicaid LTC spending on HCBS</strong></td>
<td>1.01</td>
<td>1.03</td>
<td>.572</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.97, 1.05)</td>
<td>(.96, 1.06)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Home health agencies per 100,000 persons 65+</strong></td>
<td>.77*</td>
<td>.86</td>
<td>.433</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.61, .97)</td>
<td>(.57, 1.31)</td>
<td></td>
<td></td>
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<tr>
<td><strong>Mean heating degree days (colder)</strong></td>
<td>1.03</td>
<td>1.07</td>
<td>.439</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.99, 1.08)</td>
<td>(.79, 1.18)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>% of Medicaid spending on LTC</strong></td>
<td>.98</td>
<td>1.01</td>
<td>.323</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.95, 1.02)</td>
<td>(.96, 1.06)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Illness/Need Level Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Blessed Memory and IADL subscore (more impairment)</strong></td>
<td>1.21**</td>
<td>1.21**</td>
<td>.424</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.07, 1.37)</td>
<td>(1.09, 1.48)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Blessed ADL subscore (more impairment)</strong></td>
<td>1.15**</td>
<td>.99</td>
<td>.014</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>(1.05, 1.26)</td>
<td>(.89, 1.11)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>CDR of Severe</strong></td>
<td>.89</td>
<td>2.05**</td>
<td>.171</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.56, 1.42)</td>
<td>(1.23, 3.42)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CDR of Profound or Terminal</strong></td>
<td>1.78</td>
<td>.88</td>
<td>.039</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.60, 5.3)</td>
<td>(.33, 2.35)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>MMSE (higher score)</strong></td>
<td>.96**</td>
<td>1.0</td>
<td>.161</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.93, .98)</td>
<td>(.96, 1.03)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Model x2 (degrees of freedom)</strong></td>
<td>107.40 (22)**</td>
<td>48.34 (22)**</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Controlling for 8 geographic regions.
*Years after admission to study.
*Effect of one unit increase.
*Effect of one percentage point increase.
*Effect of an increase of 100.
*Reference group is mild to moderate dementia per CDR scale.
*p ≤ .05; **p ≤ .01; ***p ≤ .001.

of education (p = .001; data not shown). Unmarried persons’ lower levels of informal support, together with their greater likelihood to be Medicaid eligible, possibly accounts for the differential effect by marital status of the Medicaid HCBS spending variable.

It is speculated that a state’s Medicaid spending on HCBS reflects a state’s receptiveness to home and community-based care and, thus, a greater policy emphasis on such service use as well as a possibly greater availability of such services to Medicaid and non-Medicaid eligible elderly adults. This thinking is congruent with the work by Ladd, Kane, Kane, and Nielsen (1995), who used a similar LTC variable in conjunction with a variable measuring a state’s HCBS expenditures per person aged 65+, as a proxy for a state’s commitment to HCBS.

For married persons, we found that a higher ratio of home health agencies to 100,000 persons aged 65+ in a state was associated with a longer time to NHA. It may be that for unmarried persons, it is the more supportive services provided through state Medicaid programs that can delay NHAs, whereas for married persons, it is the more medically related services provided through Medicare-
certified home health agencies. Alternatively, the results presented here may be the effect of differential availability of Medicaid HCBS.

In addition to paying for HCBS, states actualize an HCBS policy emphasis by avoiding unnecessary NHAs via required preadmission screening. In fact, this screening often accompanies increased state spending on HCBS. The independent effect of preadmission screening on time to NHA was not studied here, but we suggest that this variable be included in future, related studies.

For married persons, a higher ratio of NH beds was also significantly associated with an increased risk of NHA (association was of marginal statistical significance in Years 3–9). This finding is consistent with previous research predicting permanent and long-stay NHAs (Coughlin, McBride, & Liu, 1990; Liu et al., 1994) and with the finding by Liu and colleagues (1994) that NH bed supply was highly significant for private patients but less so for Medicaid eligible persons. The finding that higher NH occupancy rates in a state are associated with increased risk of NHA for married persons (statistically significant in the first 3 study years) seems counterintuitive. Higher occupancy rates (fewer unfilled NH beds) may indicate excess demand for NH beds; in such environments, differential NH access is given to private-pay residents (Nyman, 1993; Scanlon, 1980), more likely the married persons in this study. Alternatively, high NH occupancy rates can also be indicative of a less competitive LTC market (Banaszak-Holl, Zinn, Brannon, Castle, & Mor, 1997), perhaps with less availability of alternative services.

Figure 2. Estimated time to nursing home admission for CERAD participants by marital status. Adjusted to baseline means for education, age, MMSE, percentage Medicaid LTC spending on home and community-based services (10%), nursing home beds per 1,000 persons 85+ (531), nursing home occupancy rate (95%), and to memory and IADLs = 4; ADLs = 0, and clinical dementia rating = 1.
The influence of the percentage of a state’s Medicaid spending on LTC has not been studied previously in relation to the risk of institutionalization. Although this variable was statistically significant in the univariate model, it did not maintain this significance in multivariate models. Because this variable has been shown to be associated with a state’s demography and economic resources (Kane, Kane, Ladd, & Nielsen, 1998), we felt the inclusion of this variable in the final multivariate models controlled for some of a state’s heterogeneity.

**Methodology**

In contrast to related research on NHA for persons with AD or related disorders, this study found that for numerous variables, the conditional relative risks were not proportionate over time. Of all the AD-related studies using the Cox Proportional Hazard Model we reviewed, none reported nonproportionality. This lack of similar findings regarding nonproportionality in related studies is puzzling, especially because such nonproportionality is somewhat common in other survival-analysis research (Altman & De Stavola, 1994; Harris & Albert, 1991). Explanations for the difference seen here may be the improved statistical power to detect significant time interactions afforded by this study and the greater length of time we had to observe proportionality. Also, proportionality in some studies appeared to be evaluated only by assessing the plots of the hazard stratified by covariates of interest. Using this assessment technique alone tends to be subjective and is only arbitrary when assessing nonproportionality for classifications of continuous variables or when plots using baseline variable values are assessed but updated variable values are being studied (i.e., plots incorporating updated values are difficult to produce with existing statistical software).

The discrepancy between the nonproportionality findings of this study and other related research raises questions regarding the stability over time of some previous risk estimates and concerns that the proportional hazards regression model may not be appropriate for analyzing institutionalization for persons with AD or, at least, for analyzing institutionalization for periods of time exceeding 3 to 4 years.

**Predisposing Variables**

Older age for married persons with AD was significantly associated with shorter time to NHA (in the first 3 study years). Although few NH utilization studies for persons with AD or related disorders have found age to be a significant predictor (Haupt & Kurz, 1993; Heyman, Peterson, Fillenbaum, & Pieper, 1997), this finding is consistent with the more general NH utilization studies (Branch & Jette, 1982; Murtaugh, Kemper, & Spillman, 1990; Vincente, Wiley, & Carrington, 1979).

Being unmarried was significantly associated with a shorter time to NHA. Of seven identified studies that assessed the effect of marital status on NHA for persons with AD or related disorders, only two found marital status to be significantly associated with the risk of NHA (Heyman et al., 1997; Severson et al., 1994). Our finding here, however, is consistent with the bulk of the more general NH utilization research.

Although education was not an independent risk factor for NHA for either married or unmarried persons, the risk of NHA was greater with more years of education (in the first 3 study years). Because education is closely associated to lifetime economic status and thus the poverty status of elderly individuals (U.S. Bureau of the Census, 1996), higher education levels may translate into a greater ability to pay for NH care as well as to differential NH access for the private-pay population.

**Illness/Need Level Variables**

Findings reported here for the illness/need level variables are in agreement with related research on the risk of NHA for persons with AD or related disorders; as in the literature, these variables were strong predictors of NHA for persons with AD. As in other AD studies (Heyman et al., 1997; Mittelman et al., 1996; Severson et al., 1994), we found that more advanced dementia (per a global dementia rating—here the CDR) was an independent predictor for NHA. Severe to terminal dementia ratings had stronger and more statistically significant associations with the risk of NHA for unmarried persons; however, an interaction term between dementia state and marital status was not statistically significant (data not shown).

**Study Limitations**

Several limitations to this study are noted. First, generalization of study findings is most likely affected by referral bias, and based on previous work (Kokmen, Özsarfati, Beard, O’Brien, & Rocca, 1996), participants in this study may be less frequently women, more likely to be married and not to live alone, more likely to be white-collar workers and highly educated, and less frequently institutionalized than AD incident individuals. Also, because of CERAD screening criteria, participants at study entry had no serious physical illness and a low level of cognitive impairment/dementia, and they each had an informant available. Because of all these factors, the individuals studied here are not considered representative of the general population of non-Latino White persons with AD residing in the community. It is of note, however, that the CERAD registry data do represent some of the best data available on persons with probable or possible AD.

Data on African American or on Latino CERAD subjects were not studied here. Because of differential loss to follow-up between non-Latino African Americans and Whites, a comparative analysis was not performed. Separate analyses on African Americans will be presented elsewhere, but due to a much smaller sample size, these analyses do not evaluate the effect of health care system variables on time to NHA. There were too few Latino CERAD participants to do any meaningful analyses.

Because of missing data, caregiver predisposing and enabling variables could not be controlled for, nor could their association with time to NHA be assessed. Based on findings from the studies identified and reviewed earlier, however, this is not considered a serious omission. Conversely, with omission of behavior problems (because of missing data), we may not have controlled adequately for confound-
were available for study years 1988 through 1994. Data on state Medicaid spending on HCBS and on LTC of NHA. Additionally, we had robust data. In particular, the influence of predictor values most proximal to the event believed to have controlled for some state heterogeneity.

Although these procedures did result in the adjustment de-
erestimation of standard errors may still have occurred. The variable reflecting spending on HCBS in a state does not include state spending on HCBS from other funding streams. In some states this other spending is considerable. Still, we feel the variable used in this study does reflect the effect of increased HCBS spending. Individuals entered the CERAD study in different years and the baseline and subsequent HCBS variable values corresponded to the year of study entry. The effect of an increase of HCBS Medicaid spending, therefore, considered not only state differences but differences over time. To test the effect of increases in HCBS over time within a state, we entered all states (minus one) as fixed effects in our model. In this analysis, a higher percent of Medicaid HCBS spending was still significantly associated with a longer time to NHA (data not shown). We also conducted multivariate analysis substituting a state variable reflecting 1992 total HCBS expenditures per person aged 65 and older. Findings from this analysis validated our results as unmarried persons had a 1.4% reduced risk of NHA for every additional $10 per capita spent on HCBS (p = .02). For married persons, there was no reduction in risk associated with increased spending.

Because this study merged ecologic-level variables (i.e., state variables) with individual-level variables (i.e., patient variables) the most correct multivariate modeling technique is a random effects model. No such model was available for use with Cox Proportional Hazard modeling, so we attempted to correct for this underestimate, and thus to control for underlying geographic variation, by entering eight of the nine geographic census regions as fixed effects into final models. Additionally, inclusion of the variable representing a state’s percent of Medicaid spending on LTC is believed to have controlled for some state heterogeneity. Although these procedures did result in the adjustment desired in the standard errors of the state variables, some underestimation of standard errors may still have occurred.

Last, differential lost to follow-up may have influenced the results seen here. These losses (as described previously) may have resulted in a lower cumulative rate of NHA than would have been observed otherwise.

Even considering such limitations, our study findings appear valid in that they are largely in agreement or consistent with previous related research. We had a large sample size, used a powerful statistical technique measuring time to NHA, and updated variable values allowing us to examine the influence of predictor values most proximal to the event of NHA. Additionally, we had robust data. In particular, data on state Medicaid spending on HCBS and on LTC were available for study years 1988 through 1994.

Implications and Future Directions

The most important policy implication from the findings here emanates from the association seen between a higher percentage of state spending on HCBS and a longer time to NHA for unmarried persons with AD (in the first 3 study years). This finding suggests that, even for persons with as disabling a disease as AD, living in a state which is more receptive to the provision of HCBS (and perhaps also has more restrictive access to NH beds) can delay the time to NHA for unmarried persons in the first 3 years after seeking diagnosis/treatment. State spending on HCBS is thought to be politically driven, and less a result of state demographic profiles and/or economic resources (Kane et al., 1998). There is differential access across states to community alternatives to NH care, and as discussed by Kane and colleagues (1998), these differences are expected to increase with devolution of LTC responsibility to states. Still, for all states, the cost of expanding the provision of HCBS is a legitimate concern, especially when services are provided to high-need patients such as those with AD. Yet, 3 states receptive to such expansion have experienced cost savings (Alexin, Lutzky, Corea, & Coleman, 1996). The alternatives offered in these states are based on a person’s level of need, which includes an assessment of the level of informal support available, and alternatives range from homemaker support to placement in assisted living residences/board and care homes (Alexin et al., 1996). As dementia stages advance, assisted living residences/board and care homes may be the most viable alternative to NH placement for those unmarried persons who have such a greater risk of a shorter time to NHA.

The differential variable effects on time to NHA for unmarried and married persons with AD, as shown in this article, demonstrates the sophistication needed in targeting those at risk for NHA as well as the policy and individual interventions effective in delaying institutionalization. Our findings for Whites with AD, for example, will not likely be wholly compatible with findings for older adults without AD, or for persons with different racial or ethnic backgrounds. Clearly, effective targeting requires sophisticated systems derived from extensive research and conceivably, as suggested by Greene and colleagues (1998), computerized. Work on development of such systems, as well as the underlying research on subgroups of older adults, is recommended.

For future research on AD and related disorders and time to NHA, researchers are advised to assess thoroughly the possibility of nonproportionality of conditional relative risks and to address such possibilities by appropriate analytic techniques and/or presentation. In relation to this, we recommend future research to evaluate when, during the time trajectory, caregiver illness/need variables emerge as important predictors of time to NHA.

Acknowledgments

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