Risk Score for Predicting Mortality in People With Dementia: A Nationwide, Population-Based Cohort Study in Taiwan With 11 Years of Follow-Up

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ABSTRACT

Objective: Many researchers and physicians attempt to determine the prognosis and short- and long-term mortality risks of dementia for formulating suitable care plans for patients and their families. However, the published prediction models have been insufficient for this purpose and have worked only in certain specific populations. For medical autonomy and end-of-life decisions, an informative tool to predict 6-month, 1-year, 2-year, 3-year, and 5-year mortality rates for dementia patients merits further investigation.

Methods: Patients aged ≥ 65 years who received *ICD-9-CM* diagnoses of dementia between 2002 and 2009 were identified from Taiwan's National Health Insurance Research Database and followed until the end of 2013. Patient characteristics and comorbidities that were considered potential risk factors for mortality were assessed. Mortality-predicting risk scores were developed using a regression coefficient-based scoring approach. In total, 6,556 patients were identified and then randomly divided into a derivation cohort (n = 4,371) and validation cohort (n = 2,185).

Results: By the end of the study, 1,693 of the 4,371 dementia patients (38.7%) in the derivation cohort were deceased. Mean duration of follow-up was 6.26 years. Eleven acute and chronic factors were identified for building the predictive score model, which produced scores from 0 to 24 points (higher scores indicated higher mortality). The score model exhibited good predictive power for various life expectancies (area under receiver operating characteristic curve: 6-month = 0.852, 1-year = 0.779, 2-year = 0.725, 3-year = 0.721, 5-year = 0.703) and good calibration in the validation cohort (Hosmer-Lemeshow test, $\chi^2 = 4.709$, $P = .788$).

Conclusions: The developed predictive score model may be the first tool that uses the same clinical factors to determine both short- and long-term mortality risks in patients with dementia.

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Dementia, a progressive neurodegenerative disease, is a critical and rapidly growing concern in public health and clinical practice in both developed and developing countries.[1–3] Dementia is a major cause of disability and dependency among older people and incurs heavy psychological and economic burdens on caregivers, family members, and society. Diagnosis of dementia has been documented as a critical predictor of shorter survival.[4–6] For example, a study[4] indicated that individuals who are diagnosed with dementia at the age of 65 years are associated with a median survival of only 10.7 years. Another study[5] has demonstrated that the mortality risk among patients with dementia is 2.63 times greater than that among same-aged individuals without dementia.

Many researchers have attempted to determine the prognosis and mortality of dementia for the purpose of formulating suitable care plans for patients and their families.[4,7–11] Studies[12–15] have demonstrated, even after adjustments of covariates, that dementia patients exhibit a 2-fold risk of acute organ dysfunction and severe sepsis, implying more opportunities and needs to make decisions between palliative care and life-sustaining treatments, ie, hemodialysis, mechanical ventilation, and intensive care. If a patient with dementia formulates his or her own directives regarding end-of-life treatment choices prior to losing their capacity to do so, it might relieve the burden of decision-making that would otherwise be faced by bereaved caregivers when the patient is dying.[16] However, life expectancy is difficult to predict for dementia patients, especially for patients with multiple comorbidities.[17,18] Most of the available prediction models are suitable exclusively for predicting the mortality rate for periods of ≤ 1year, and a few models are suitable for predicting 5-year mortality.[4,7–11] For example, Mitchell and collegues[7] used the Minimum Data Set and developed a 6-month mortality risk score for nursing home residents with advanced dementia. In another study, Claus and collegues[10] constructed a survival index for patients with Alzheimer's disease, which combined demographic, cognitive, electroencephalogram, and computed tomography features. However, the aforementioned models were limited by several methodological concerns, such as limited statistical power due to

Clinical Points

- For medical autonomy and end-of-life issues, an informative tool to predict short-term and long-term mortality rates for dementia patients is scarce.
- This score model predicts both short-term and long-term mortality by using one formula that includes clinical acute and chronic factors.
- Physicians might use this score system to arrange individualized medical or psychosocial services based on different mortality risks.

small sample sizes or selection bias, and they included few or no acute or chronic competing risks for death.[4,10,11] Additionally, some examinations, such as cognitive tests, electroencephalography, computed tomography, and biological parameters, were not easily interpreted nor easily accessible in clinical practice.[10,19] Hence, an adequate and informative tool for predicting longer-term mortality in dementia patients is required to enable discussion of end-of-life concerns among patients with early-stage dementia and their caregivers and physicians.

By using a large, population-based sample from the Taiwan National Health Insurance Research Database (NHIRD), we developed an accessible and practical prognostic risk score to predict 6-month, 1-year, 2-year, 3-year, and 5-year survival after evaluation for dementia.

METHODS

To create the risk score system, we performed an extensive review of the literature to identify potential predictors of mortality in dementia patients.[7–9,18–32] We then held a consensus meeting of clinical experts to discuss and decide the relevant variables for our model. Finally, multivariable Cox proportional hazards (PH) regression analysis was conducted to select the most relevant factors in our prediction model, and then a regression coefficient-based scoring approach was used to create the final model for predicting mortality.[33–36]

Derivation and Validation Cohort

Taiwan's National Health Insurance (NHI) program was established in 1995. The NHI provides compulsory health insurance to nearly all residents of Taiwan. Its coverage rate was approximately 99.6% (23 million residents) at the end of 2010. During the study period, the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) was used for diagnoses in Taiwan, although *ICD-10* and *ICD-11* were already in use in other countries. The NHIRD has been widely used in epidemiologic studies in Taiwan.[37–39] The protocol for the present study was reviewed by the local institutional review board. Informed consent was waived because the NHI database consists of secondary data with all patient-identifying information removed.

Patients who were aged 65 years or older and had received diagnoses of dementia at least twice (*ICD-9-CM* codes 290.0–290.4, 331.0–331.2, and 294.1) from board-certified neurologists or psychiatrists between January 1, 2002, and December 31, 2009, were included as the study cohort. We followed the study cohort until the end of the study (December 31, 2013, or death, whichever occurred first). In Taiwan, neurologists or psychiatrists usually perform serum evaluations (including a complete blood count and biochemistries, iron, thyroid hormone, vitamin B_{12}, folate, and syphilis), psychological examinations, and brain imaging (computed tomography or magnetic resonance imaging) to confirm the diagnosis of dementia. In this study, mortality was identified from the claims data or registry of catastrophic illness.[40] After identifying the study cohort, we randomly grouped two-thirds of our subjects into a derivation cohort, with the remaining one-third grouped into a validation sample.

Variable Selection

Demographic information included age, sex, and level of urbanization (level 1 to level 5: level 1, most urbanized region; level 5, least urbanized region).[41] The literature was reviewed to identify potentially predictive variables of mortality for our prediction models.[7–9,18–32] Variables identified in the NHIRD were selected for further consideration of comorbid conditions.

The variables represented the status of conditions or diseases that patients exhibited upon clinic visits or hospitalization at the time of new diagnosis of dementia or during follow-up for dementia. A consensus meeting with a team of neurologists and psychiatrists who were well experienced in dementia care was convened to confirm that the most relevant variables had been included in our model. The following diagnoses were included in the analyses: hypertension,[18] diabetes mellitus,[9,18,21] femoral neck fracture,[18,27] cerebrovascular disease,[18,21] coronary artery disease,[18,20,21] dysrhythmia,[18,26] peripheral vascular disease (PVD),[18] chronic kidney disease (CKD),[18] chronic obstructive pulmonary disease (COPD),[9,18] chronic heart failure (CHF),[7,9,18,26,28] cancer,[7,9,18,21,26,28] and myocardial infarction (MI).[26] Acute clinical conditions (existing within 3 months before recruitment) were also identified and analyzed. These included recent weight loss (ie, abnormal loss of weight and underweight, cachexia, and malnutrition),[7,8,18,28] recent lung infection (ie, pneumonia, lung abscess, and empyema),[18,20,22,23] recent urinary tract infection (UTI),[18,22] recent upper gastrointestinal bleeding,[22] and recent nasogastric tube procedures.[7,8,18,22,24,28] Additionally, recent prescriptions of antibiotics, benzodiazepines,[31] antidepressants,[29,30] and antipsychotics[29,32] were evaluated based on billing codes in the claims data (see Table 1).

Statistical Methods

Descriptive analyses were conducted using independent *t* testing and Pearson's χ^2 testing in the derivation cohort and for comparing the derivation and validation cohorts. Mortality was the dependent variable for all analyses. Patients who did not die within the target periods (ie, 6 month, 1-year, 2-year,

Table 1. Demographic and Clinical Characteristics of the Derivation Cohorts at Enrollment[a]

Characteristic	Total (N = 4,371), n (%)	Not Deceased (n = 2,678), n (%)	Deceased (n = 1,693), n (%)	*P* Value
Sex, male	2,068 (47.31)	1,140 (42.57)	928 (54.81)	**< .001**
Enrollment age, y				**< .001**
65 to < 70	429 (9.81)	328 (12.25)	101 (5.97)	
70 to < 75	745 (17.04)	513 (19.16)	232 (13.70)	
75 to < 80	1,128 (25.82)	693 (25.87)	435 (25.69)	
80 to < 85	1,126 (25.76)	626 (23.38)	500 (29.54)	
85 to < 90	661 (15.12)	371 (13.85)	290 (17.13)	
≥ 90	282 (6.45)	147 (5.49)	135 (7.97)	
Enrollment age, y, mean (SD)	79.01 (6.91)	78.27 (6.99)	80.17 (6.62)	**< .001**
Follow-up period, y, mean (SD)	6.26 (3.15)	7.79 (2.42)	3.83 (2.58)	**< .001**
Level of urbanization				.349
1 (most urbanized)	1,128 (25.81)	689 (25.73)	439 (25.93)	
2	1,133 (25.92)	682 (25.47)	451 (26.64)	
3	700 (16.01)	417 (15.57)	283 (16.72)	
4	721 (16.50)	446 (16.65)	275 (16.24)	
5 (least urbanized)	689 (15.76)	444 (16.58)	245 (14.47)	
Chronic comorbidities				
Hypertension	3,728 (85.29)	2,246 (83.87)	1,482 (87.54)	**.001**
Diabetes	2,157 (49.35)	1,264 (47.20)	893 (52.75)	**< .001**
Femoral neck fracture	472 (10.80)	264 (9.86)	208 (12.29)	**.012**
CKD	478 (10.94)	238 (8.89)	240 (14.18)	**< .001**
Stroke	2,856 (65.34)	1,686 (62.96)	1,170 (69.11)	**< .001**
COPD	2,165 (49.53)	1,241 (46.34)	924 (54.58)	**< .001**
CHF	1,052 (24.07)	570 (21.28)	482 (28.47)	**< .001**
Cancer	912 (20.86)	455 (16.99)	457 (26.99)	**< .001**
Myocardial infarction	183 (4.19)	90 (3.36)	93 (5.49)	**.001**
CAD	2,480 (56.74)	1,479 (55.23)	1,001 (59.13)	**.012**
Dysrhythmia	1,466 (33.54)	858 (32.04)	608 (35.91)	**.009**
PVD	331 (7.57)	204 (7.62)	127 (7.50)	.907
Acute/recent clinical conditions within 3 mo before recruitment				
Weight loss	69 (1.58)	35 (1.31)	34 (2.01)	.081
Upper GI bleeding	196 (4.48)	99 (3.70)	97 (5.73)	**.002**
LRI	401 (9.17)	178 (6.65)	223 (13.17)	**< .001**
UTI	814 (18.62)	419 (15.65)	395 (23.33)	**< .001**
NG tube insertion	558 (12.77)	247 (9.22)	311 (18.37)	**< .001**
Recent prescription within 3 mo before recruitment				
Antibiotic	629 (14.39)	322 (12.02)	307 (18.13)	**< .001**
Benzodiazepine	1,810 (41.41)	1,060 (39.58)	750 (44.30)	**.002**
Antidepressant	1,134 (25.94)	689 (25.73)	445 (26.28)	.697
Antipsychotic	1,750 (40.04)	1,007 (37.60)	743 (43.89)	**< .001**

[a]Values are mean (SD) unless otherwise noted. Boldface type indicates significance.
Abbreviations: CAD = coronary artery disease, CHF = congestive heart failure, CKD = chronic kidney disease, COPD = chronic obstructive pulmonary disease, GI = gastrointestinal, LRI = lower respiratory infection, NG = nasogastric, PVD = peripheral vascular disease, UTI = urinary tract infection.

3-year, and 5-year) after enrollment were considered to be censored observations. Age, as a continuous variable, was represented in 5-year intervals, which served as categorical variables to facilitate application of the calculated clinical risk score.[18]

The full model, a multiple Cox PH regression model with all of the covariates listed in Table 1, was used to assess the predictors of mortality. To establish a simpler model that would still be powerful for mortality prediction, several risk factors with $P < .05$ in the full model were selected using forward likelihood ratio (LR) methods, and these factors were used to establish another Cox PH regression model, as the reduced model. Hazard ratios and 95% CIs were presented in both the full and reduced models. Using a regression coefficient-based scoring approach,[33–36] a points system was formulated; points for each predictor were summed to determine 6-month, 1-year, 2-year, 3-year, and 5-year risk of mortality in patients with dementia. To construct the table, we calculated the sum of the predictors' scores for each patient in the derivation cohort and then estimated the mortality curves for various life expectancies.

Variance inflation factor (VIF) was used to measure collinearity among risk factors; specifically, VIF values of > 10 indicated collinearities among predictor variables. Areas under the receiver operating characteristic curve (AUROCs) were used to evaluate the performance of the risk models. To examine whether the reduced model was as powerful as the full model, area under the curve (AUC) with a 95% CI, sensitivity, and specificity were calculated, and an AUC test was conducted to compare AUCs in the 2 models. C-statistic

Table 2. Multiple-Variable Analysis of Mortality in the Derivation Cohort (N = 4,371)

Variable and Category	Model 1: Full Model HR (95% CI)	*P*	Model 2: Reduced Model[a] HR (95% CI)	*P*
Enrollment age, y		<.001		<.001
65 to <70	1.00 (ref group)	…		…
70 to <75	1.29 (1.02–1.63)	.035	1.29 (1.02–1.63)	.031
75 to <80	1.60 (1.28–1.98)	<.001	1.61 (1.29–2.00)	<.001
80 to <85	1.94 (1.56–2.41)	<.001	1.97 (1.59–2.44)	<.001
85 to <90	1.98 (1.57–2.49)	<.001	2.00 (1.60–2.52)	<.001
≥90	2.24 (1.72–2.92)	<.001	2.26 (1.74–2.93)	<.001
Sex (male/female)	1.46 (1.32–1.62)	<.001	1.46 (1.32–1.61)	<.001
Level of urbanization		.316		
1 (most urbanized)	1.00 (ref group)	…		
2	0.99 (0.86–1.13)	.836		
3	1.01 (0.87–1.18)	.874		
4	0.93 (0.80–1.09)	.399		
5 (least urbanized)	0.85 (0.72–1.01)	.064		
Chronic comorbidities (yes/no)				
Hypertension	1.09 (0.94–1.27)	.267		
Diabetes	1.20 (1.09–1.32)	<.001	1.20 (1.09–1.33)	<.001
Femoral neck fracture	1.08 (0.93–1.26)	.311		
CKD	1.34 (1.16–1.54)	<.001	1.34 (1.17–1.54)	<.001
Stroke	1.02 (0.92–1.14)	.694		
COPD	1.13 (1.02–1.25)	.021	1.13 (1.02–1.25)	.017
CHF	1.20 (1.06–1.34)	.003	1.20 (1.08–1.34)	.001
Cancer	1.48 (1.33–1.65)	<.001	1.50 (1.35–1.67)	<.001
Myocardial infarction	1.26 (1.02–1.56)	.036	1.26 (1.02–1.56)	.030
CAD	0.97 (0.87–1.08)	.583		
Dysrhythmia	0.99 (0.88–1.10)	.797		
PVD	0.97 (0.80–1.16)	.705		
Acute/recent clinical conditions (yes/no)				
Weight loss	1.26 (0.90–1.78)	.183		
Upper GI bleeding	1.11 (0.90–1.37)	.334		
LRI[b]	1.20 (1.02–1.42)	.029	1.22 (1.04–1.44)	.016
UTI[b]	1.25 (1.11–1.42)	<.001	1.29 (1.14–1.45)	<.001
NG tube insertion[b]	1.47 (1.26–1.70)	<.001	1.52 (1.31–1.75)	<.001
Recent prescription (yes/no)				
Antibiotic	1.05 (0.91–1.21)	.482		
Benzodiazepine	0.98 (0.88–1.10)	.774		
Antidepressant	1.04 (0.92–1.16)	.547		
Antipsychotic	1.09 (0.98–1.22)	.101		
AUC (95% CI)[c]	0.789 (0.76–0.82)	<.001	0.779 (0.75–0.81)	<.001
Sensitivity	0.706		0.625	
Specificity	0.760		0.820	
Test to compare 2 AUCs	$\chi^2 = 0.209$, $P = .647$			

[a]Variables were selected by forward likelihood ratio test.
[b]Recent clinical condition within 3 mo before recruitment.
[c]1-year survival estimated by logistic regression was used to calculated AUC.
Abbreviations: AUC = area under the curve, CAD = coronary artery disease, CHF = congestive heart failure, CI = confidence interval, CKD = chronic kidney disease, COPD = chronic obstructive pulmonary disease, GI = gastrointestinal, HR = hazard ratio, LRI = lower respiratory infection, NG = nasogastric, PVD = peripheral vascular disease, UTI = urinary tract infection.

was evaluated to determine the ability of the prediction models to discriminate between patients who died and those who remained alive for a specified period of life expectancy. Calibration was performed using the Hosmer-Lemeshow test. Analyses were conducted using SAS version 9.2 (SAS Institute Inc, Cary, North Carolina), and *P* values less than .05 were considered statistically significant.

RESULTS

Demographic Information of the Derivation and Validation Cohorts

From the initial sample, 6,556 patients with dementia were identified for the study cohort, and the prevalence of dementia at different age groups (≥65 years) was as follows: 12.20% at age 65 to <70, 18.04% at age 70 to <75, 23.81% at age 75 to <80, 26.32% at age 80 to <85, 27.44% at age 85 to <90, and 22.05% at age 90 and above. These patients were then randomly divided into the derivation cohort (4,371 patients) and the validation cohort (2,185 patients). In the derivation cohort, 1,693 (38.7%) patients died during follow-up. The mean duration of follow-up period was 6.26 years, and follow-up periods ranged from 0.03 to 12 years (SD = 5.5 and median = 6.11). Mean age at enrollment was 79.01 years, and 2,068 of the patients were men (47.31%).

In the derivation cohort, the deceased group had older age at enrollment; shorter follow-up period; more comorbidities, with the exception of PVD; and undergone more procedures within 3 months before recruitment. They also exhibited higher rates of antibiotic, benzodiazepine, and antipsychotic prescriptions (Table 1). Multivariable analysis in model 1 demonstrated that older age at enrollment, male sex, presence of comorbidities (CKD, COPD, CHF, cancer, diabetes, or MI), recent urinary tract or lung infections, and recent nasogastric tube placement were significantly associated with higher risk of mortality at 1 year. In model 2, the reduced model, the factors with $P < .05$ in model 1 still exhibited statistical significance after assessment using forward LR methods. Sensitivity and specificity were, respectively, 0.706 and 0.760 in model 1 and 0.625 and 0.820 in model 2. The AUC test revealed no significant difference ($P = .647$) in the AUC, 95% CI, between model 1 (0.789, 0.76–0.82) and model 2 (0.779, 0.75–0.81), indicating that the predictive power of the reduced model was comparable to that of the full model (Table 2). Furthermore, for the PH assumption, no violation was evident for the 11 variables in the reduced model.

Risk Score for Mortality

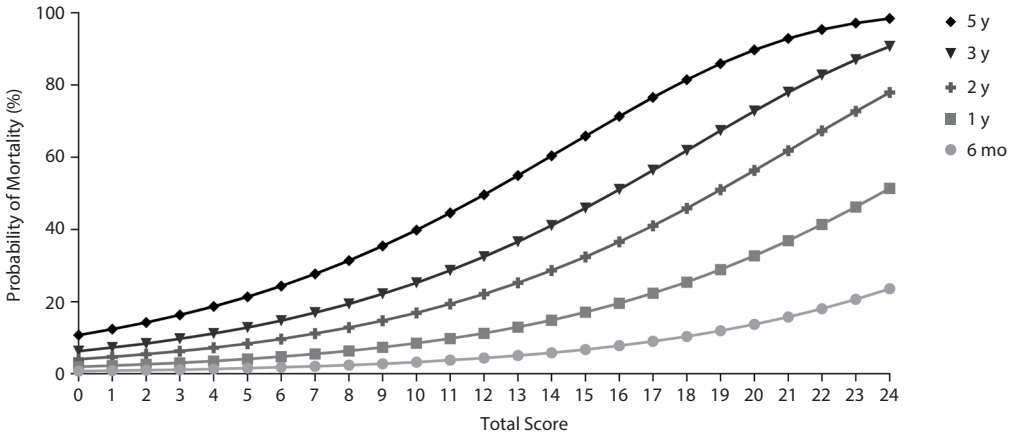
Using the reduced model, multivariable risk scores for 6-month, 1-year, 2-year, 3-year, and 5-year mortality were derived (Table 3). In our scoring system, the ages from 65 to <70 years were assigned a score of 0, and 1 point was added for every 5-year interval. One point was added for individuals with COPD, CHF, diabetes, or recent lung infection; 2 points were added for CKD, MI, or recent UTI; and 3 points were added for male patients, patients with cancer, and patients who had recently received nasogastric tube placement. Figure 1 displays a graded increase in estimated mortality risk along with increases in total score for all the studied

Table 3. Dementia Mortality Risk Score Model

	Points for ALL Subjects					
Variable	0	+1	+2	+3	+4	+5
Enrollment age, y	65 to <70	70 to <75	75 to <80	80 to <85	85 to <90	≥90
Sex	female			male		
COPD	no	yes				
CHF	no	yes				
Diabetes	no	yes				
LRI[a]	no	yes				
UTI[a]	no		yes			
CKD	no		yes			
Myocardial Infarction	no		yes			
Cancer	no			yes		
NG tube insertion[a]	no			yes		

[a]Recent clinical condition within 3 mo before recruitment.
Abbreviations: CHF = congestive heart failure, CKD = chronic kidney disease, COPD = chronic obstructive pulmonary disease, LRI = lower respiratory infection, NG = nasogastric, UTI = urinary tract infection.

Figure 1. Risk Score Model and Estimated Mortality[a]



[a]This figure shows a graded increase in risk of estimated mortality along with an elevating total score for all life expectancies. For example, if a patient was scored 19 points on the mortality risk score model, the patient would be told that his or her estimated mortality risk within 2 years was above 50%.

life expectancies. The total scores for approximate 50% probability of mortality were 24 for 1-year life expectancy (51.4%), 19 for 2-year (51.0%), 16 for 3-year (51.0%), and 12 for 5-year (49.6%).

AUROCs (95% CI) for the derivation cohort were computed and presented for 6-month (0.852, 0.810–0.895, $P < .001$), 1-year (0.779, 0.749–0.810, $P < .001$), 2-year (0.725, 0.701–0.748, $P < .001$), 3-year (0.721, 0.701–0.741, $P < .001$), and 5-year (0.703, 0.686–0.721, $P < .001$) mortality. The suitable sensitivity and specificity results for various life expectancies were denoted in Table 4.

Model Validation

The demographics and clinical comorbidities of the validation sample exhibited no significant difference with the derivation cohort (data not shown). In total, 850 (38.9%) subjects died during the follow-up period. The mean follow-up period was 6.21 years, and follow-up periods ranged from 0.03 to 12 years (SD = 3.02 and median = 6.41). Mean age at enrollment was 78.96 years, and 1,018 of the patients were men (46.59 %). The Hosmer-Lemeshow test was performed for calibration, and the results indicated good fit ($\chi^2 = 4.709$, $P = .788$).

DISCUSSION

Using a population-based retrospective cohort with a comprehensive and longer follow-up period, we derived and validated a risk score model to predict mortality for dementia patients across various life expectancies. The ability to assess again for the mortality risk when patients' conditions or diseases were altered during the follow-up period was considerably suitable for clinical application. The current score model was derived from the patients in all clinical settings and not limited to community dwellers, residents of nursing homes, patients in hospitalization, or long-stay residents only. The mean age at enrollment among the studied patients was 79.01 years, which was similar to the age reported in a previous study.[28] We identified the following 11 easily obtainable acute and chronic variables to

Table 4. AUROC for Mortality Rates at 6 Months and 1, 2, 3, and 5 Years[a]

Time	AUROC	95% CI	*P* Value	Sensitivity	Specificity
6-month	0.852	0.810–0.895	<.001	0.766	0.843
1-year	0.779	0.749–0.810	<.001	0.625	0.820
2-year	0.725	0.701–0.748	<.001	0.636	0.711
3-year	0.721	0.701–0.741	<.001	0.708	0.627
5-year	0.703	0.686–0.721	<.001	0.628	0.683

[a]Cut points of estimated positive for mortality at 6 months, 1 year, 2 years, 3 years, and 5 years were 0.02, 0.06, 0.11, 0.15, and 0.27.
Abbreviations: AUROC = areas under receiver operating characteristic curve, CI = confidence interval.

construct the predictive model: age, sex, COPD, CHF, CKD, diabetes, MI, cancer, recent lung infection, recent UTI, and recent nasogastric tube placement. For the validation cohort, the score model exhibited both predictive capability for different life expectancies and good calibration.

As described in the Introduction, dementia patients are associated with relatively short survival times, and several models have been proposed to provide precise data relevant to this concern.[7–9,11,18,19] Stern and colleagues[11] used the data of 236 patients to derive the first algorithms for predicting death in individuals with Alzheimer disease. However, the authors mentioned that the model may be most accurate only for individuals with no life-threatening illness or history of stroke and who are in relatively good health (only 6% of the studied patients were taking >1 medication, and only 28% had abnormal findings on medical evaluations). Similar characteristics of relatively good health identified in 2 cohorts of community-dwelling individuals may also limit the clinical application of Delva's 5-year[19] and Newcomer's 12-month[9] mortality prediction models. To predict 6-month survival of nursing home residents with advanced dementia, Mitchell and colleagues[7] performed a series of investigations of prediction models with moderate accuracy. However, because this model was created for patients with advanced dementia, it may not be helpful for contributing to patient autonomy in decision-making regarding treatment. Overall, using a population-based sample enabled us to formulate an instrument with greater generalizability and applicability; the proposed model was not restricted to patients living in nursing homes or relatively healthy patients with dementia. Additionally, the discrimination power for both short-term (6 months, 1 year) and long-term (5 years) survival was comparable or slightly superior to that of previously reported models.[7,9,18,19] Use of the proposed prediction model may increase patients' chances to arrange their own wills and medical autonomy, and family members may gain time for insight and acceptance of the trajectory toward the death of a dementia patient.

All individuals have a right to make their own treatment decisions in the face of death. However, surrogate decision-makers rarely discuss related directives with patients with dementia when the patients still exhibit the capacity to confirm their preferences.[16] A study indicated that patient-designated and next-of-kin surrogates did not predict patients' end-of-life treatment preferences with complete accuracy.[42] Surrogates were more likely to choose invasive care if they did not expect that the patient would pass away within 1 year.[43] Cultural difference and greater religiosity among physicians are also associated with suggestions for relatively aggressive life-sustaining treatments.[44,45] Overall, such differences in decision-making are associated with multifaceted societal factors, such as lack of an established ethical and legal consensus to guide physicians and family members, economic considerations, and views in some Asian countries that provision of artificial nutrition is a manifestation of filial piety.[44,46] Proactive discussions about the end of life before patients lose their decision-making capacities are critical for the positive effects on patients' life outcomes and reducing the decision-related burdens of caregivers at the end of patients' lives as well as the disparity in the treatment plans of patients and caregivers.[16,47–50] Our model offered physicians an opportunity to initiate conversations about advance directives with patients at earlier stages of dementia. These measures also enabled physicians to initiate discussions in patients' family meetings and make referrals for professional palliative counseling.

Due to the complete national coverage of health insurance in Taiwan, almost every usage of medical services is recorded in the claims database, which thus offers comprehensive data for comorbidities. In line with previous research,[9,18,20–25] our study confirmed the critical roles of several physical illnesses for predicting mortality in patients with dementia. A prospective cohort study[22] indicated that infections and eating difficulties were likely to occur in the terminal stage of dementia and that these factors increased mortality. We used diagnosis of UTI and pneumonia within 3 months prior to recruitment to represent the aforementioned clinical conditions, and the predictive values of these factors were compatible with previous findings.[22,23] Unexpectedly, weight loss did not exhibit a significant influence on mortality, which may have been because this condition was seldom diagnosed by physicians. Nasogastric tube placement within 3 months was significant, and this factor may have been associated with eating difficulties and nutrition conditions, such as dysphagia, decreased swallowing function, reduced oral intake, weight loss, cachexia, and dehydration.[51,52]

Limitations encountered in the present study should be addressed. First, the NHIRD does not provide information regarding smoking status, physical activity, cognitive ability, disease severity, family history, educational level, activities of daily living (ADL), instrumental ADL (IADL), genetic factors (ie, apolipoprotein E genotype), or environmental factors. Consequently, we could not evaluate the influences of these factors.

ADL or IADL dependency is a common predictor of mortality among people with dementia, which was also included in the previous dementia models.[7–9,18,19] From the literature, it is still complicated and inconsistent how the baseline cognitive ability, educational level, functional ability, or type of dementia affects mortality, especially after

considering participants' age and length of follow-up.[17,25,26,53,4] Meanwhile, when adjusting for comorbidity variables (ie, the competing risks of mortality), it is required to clarify if those factors still impacted significantly as independent predictors on the prediction model.[25,53–55] Second, the possibility of diagnosis misclassification could not be fully excluded; however, the diagnoses of dementia were made by board-certified neurologists or psychiatrists at least twice, thus increasing the diagnostic validity. Third, the present score model may be not generalizable to patients with early-onset dementia. Finally, we calculated internal validity for the prediction model to assess the model's accuracy. Studies for external validation and replication of findings in prospective cohorts of other populations may be conducted to further strengthen the validity of the model.

CONCLUSIONS

The proposed predictive score model may be the first to use the same accessible clinical factors to determine both short- and long-term risk of mortality in patients with dementia. Use of this model may enable physicians, specialists, other health-care providers, patients with dementia, and patients' families to acquire early prognostic information and thereby make decisions regarding further intervention. Moreover, medical staff and policy-makers may use this model to arrange individualized medical or psychosocial services for patients with dementia according to their mortality risk and to evaluate the efficacy of clinical trials or interventions for patients with dementia who are at higher risk of mortality.

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