Survival prediction in nursing home residents using the Minimum Data Set subscales: ADL Self-Performance Hierarchy, Cognitive Performance and the Changes in Health, End-stage disease and Symptoms and Signs scales

Jenny S. W. Lee1, Patsy P. H. Chau2, Elsie Hui1, Felix Chan3, Jean Woo1

Background: With the intention to aid planning for elderly focused public health and residential care needs in rapidly aging societies, a simple model using only age, gender and three Minimum Data Set (MDS) subscales (MDS-ADL Self-Performance Hierarchy, MDS-Cognitive Performance and the MDS-Changes in Health, End-stage disease and Symptoms and Signs scales) was used to estimate long-term survival of older people moving into nursing homes. Methods: A total of 1820 nursing home residents were assessed by the MDS 2.0 and their mortality status 5 years later was used to develop a survival prediction model. Result: In December 2006, 54.2% of subjects were dead. Older age at nursing home admission (HR = 1.036 per 1-year increment, 95% CI 1.028–1.045), men (HR = 1.895, 95% CI 1.651–2.175), higher impairment level according to the MDS-ADL (HR = 1.135 per 1-unit increment, 95% CI 1.099–1.173) and MDS-CPS (HR = 1.077 per 1-unit increment, 95% CI 1.033–1.123), and more frail on the MDS-CHESS (HR = 1.150 per 1-unit increment, 95% CI 1.042–1.268), were all independent predictors of shorter survival after nursing home admission in multivariate analysis. Survival function was derived from the fitted Cox regression model. Survival time of nursing home residents with different combinations of risk factors were estimated through the survival function. Conclusion: The MDS-ADL, MDS-CPS and MDS-CHESS scales, in addition to age and gender, provide prognostic information in terms of survival time after institutionalization. The model may be useful for health care and residential care planning in an ageing community.

Keywords: elderly, nursing home, mortality prediction, survival, function, cognition.

Introduction

To accurately estimate future long-term care needs in an aging community, it is useful to be able to predict how long nursing home residents will stay in long-term care. As the most common means of leaving these facilities is by death, it is therefore important to estimate the duration of survival after admission to the facility. However, estimation is complex. Though many mortality predictors have been identified for nursing home residents, their strength may vary according to gender or even to whether the resident was newly admitted or not. These include older age, being male, functional impairment, weight loss, low body mass index and having diseases such as diabetes, congestive heart failure, respiratory diseases, pressure ulcers and poor nutrition. A variety of prediction models incorporating different combinations of these factors have also been published. Predictors for short- and long-term mortality also differ. Individual chronic diseases such as diabetes, heart failure, chronic lung diseases and renal failure are significant predictors for 1-year mortality prediction, but such is not the case for 5-year mortality, where cognitive and physical impairment are more relevant than the presence of specific diseases.

The Minimum Data Set 2.0 (MDS 2.0) currently used in North America and also internationally provides a comprehensive measurement of the physical, cognitive and functional status of individual nursing home residents. Subscales have been developed based on MDS items for describing functional (the MDS-ADL Self Performance Scale) and cognitive status (the MDS-Cognitive Performance Scale). In addition, the MDS-Changes in Health, End-stage disease and Symptoms and Signs (MDS-CHESS) scale provides prediction of mortality and clinical instability. Using the MDS-Cognitive Performance Scale (MDS-CPS), the MDS-ADL Self Performance Scale (MDS-ADL), and combining the scores with age, presence of cancer, renal and heart failure, and several symptoms, the Minimum Data Set Mortality Risk Index (MMRI) predicts those at the end of life, with ~6 months’ survival. Longer survival prediction models based on this widely available tool however, have not yet been developed. Such a tool may be useful in estimation of life expectancy, if incorporated as part of the documentation in the care setting.

Subsidized nursing homes are in high demand in many aging societies including Hong Kong, where the waiting time is typically in terms of years. The number of older persons in institutions has doubled from 5.5% to 10% in the past decade. With one-quarter of the seven million population expected to be over the age of 65 by the year 2036, and a life expectancy of 83–88 years depending on the gender, well-planned elderly focused public health and residential care policies are
called for. With this aim in mind, we attempt to use the MDS subscales to provide a quick estimate of the long-term survival of those moving into these facilities.

**Methods**

Among the 533 private nursing homes and 130 subsidized nursing homes in Hong Kong, 10 private and 4 subsidized homes with at least 100 residents were randomly selected using a sampling ratio of 2.5 private to 1 subvented homes. The ratio was chosen to reflect the excess of private homes. Of the 1914 residents in these residential facilities, 1820 of them were successfully assessed using the Minimum Dataset—Residential Assessment Instrument version 2.0 (MDS-RAI 2.0) translated into Chinese in December 2001 to August 2002, with a response rate of 95%.

The MDS-RAI had been translated into Chinese and validated, demonstrating adequate psychometric properties in terms of inter-rater reliability, test–retest reliability, context validity, criterion validity and clinical validity. The 22 sections of the MDS include (1) Identification Information; (2) Demographic Information; (3) Customary Routine; (4) Face Sheet Signatures; (5) Identification and Background Information; (6) Cognitive Patterns; (7) Communication/Hearing Patterns; (8) Vision Patterns; (9) Mood and Behavior Pattern; (10) Psychological Well-Being; (11) Physical Functioning and Structural Problems; (12) Continence in last 14 days; (13) Disease diagnoses; (14) Health Condition; (15) Oral/Nutritional Status; (16) Oral/Dental Status; (17) Skin Condition; (18) Activity Pursuit; (19) Medications; (20) Special Treatments and Procedures; (21) Discharge Potential and Overall Status; and (22) Assessment Information.

Data were collected by two research assistants who were trained in the use of the instrument. Medical and social information was collected from the residents or from a proxy if the former deemed too frail to be interviewed. Proxies included personal care workers, other front-line nursing staff, family members or close friends. The participant’s file at the facilities was also consulted for background social and medical history. Participants’ daily routines were confirmed with home staff to ensure reliability and validity of the information gathered.

Among the 1820 residents interviewed, 583 resided in subvented homes while 1237 were from private homes. Reasons for unsuccessful assessments included hospitalization, moved to other facilities, home leave and death.

**Activities of daily living, cognitive impairment and physical frailty**

The MDS ADL Self-Performance Hierarchy (MDS-ADL) scale was used to describe the actual performance level of each resident across a spectrum of activities of daily living (ADL). Multiple MDS items concerning ADL and dependency levels in performing those activities were used to formulate a score that ranged from 0 (independent) to 6 (total dependence) according to the methods described by Morris et al. The MDS Cognitive Performance Scale (MDS-CPS) was used to provide a functional view of cognitive performance for each participant. Multiple cognitive items in the MDS were used to generate a score which ranged from 0 (intact cognition) to 6 (very severe impairment), using the rules as described by Morris et al.

The MDS-Changes in Health, End-stage disease and Symptoms and Signs (MDS-CHESS) scale provides prediction of mortality and clinical instability. It captures many of the symptoms and signs of poor health indicative of limited survival (such as vomiting, dehydration, poor appetite, weight loss and shortness of breath), changing health and decline in health status over the previous 90 days, and end-stage disease diagnoses. The score was derived from individual MDS items in symptoms and signs of ill health and frailty, and ranges from 0 (no instability in health) to 5 (highly unstable health).

**Determination of mortality status**

A search of the mortality status of all subjects as on 31 December 2006 was made in the Hong Kong Department of Health mortality database, by their Hong Kong identification card number, which is unique for all Hong Kong residents. The database covers all deaths that take place in Hong Kong.

**Statistical analysis**

To compare subjects who were dead and those who were still alive as on 31 December 2006, the t-test and χ²-test were used to detect any differences in continuous and categorical variables respectively. *P* < 0.05 was considered statistically significant.

Survival time was defined as the time from nursing home admission to death. Multivariate analysis using Cox regression model was performed to determine the relationship between the three scales: MDS-ADL, MDS-CPS and MDS-CHESS, and mortality, controlling for age, gender and time of the assessment. Backward elimination was used to remove insignificant factors, if any. Hazard Ratios (HR), describing the hazard of death associated with the various factors, were obtained by exponentiating the fitted coefficients of the Cox regression model. Survival function was derived from the fitted Cox regression model. Survival time of nursing home residents with different combinations of risk factors were estimated through the survival function. Statistical analyses were performed using SPSS for Windows Version 14.0 (SPSS Inc., Chicago, IL).

**Results**

Of the 1820 nursing home residents assessed, 985 (54.2%) were dead as on 31 December 2006. One subject was excluded due to conflicting data on the date of nursing home admission and death. The mean age was 79.5 years, and 67.7% were women. The five most common diagnoses in our sample were hypertension (52.9%), stroke (33.5%), Alzheimer’s disease and other dementia (30.3%), diabetes (22.6%) and congestive heart failure (10.5%). Cancer was reported in 4.5%.

Subjects who were dead by 31 December 2006 were significantly older (80.7 vs. 78.2 years), more likely to be men (37.0% vs. 26.7%), and were more impaired in ADL and cognitive function. They were also more unstable medically as measured by the MDS-CHESS score (table 1).

Older age at nursing home admission (HR = 1.036 per 1-year increment, 95% CI 1.028–1.045, *P* < 0.001), men (HR = 1.895 as compared to women, 95% CI 1.651–2.175, *P* < 0.001), higher impairment level according to the MDS-ADL (HR = 1.135 per 1-unit increment, 95% CI 1.099–1.173, *P* < 0.001) and MDS-CPS (HR = 1.077 per 1-unit increment, 95% CI 1.033–1.123, *P* = 0.001), and more frail on the MDS-CHESS (HR = 1.150 per 1-unit increment, 95% CI 1.042–1.268, *P* = 0.005), were all independently associated with shorter survival after nursing home admission in multivariate analysis.

Table 2 shows a sample of survival predictions using age, gender and the three MDS-derived subscales as assessed on the admission date. For instance, a man aged 70 years, scoring 3 on the MDS-ADL, 2 on the MDS-CPS and 1 on the MDS-CHESS, would have a 50% chance of surviving for 4.13 years after
Table 1 Characteristics of subjects, by mortality status as at 31 December 2006 (n = 1819)

<table>
<thead>
<tr>
<th>Status as at admission Predicted survival (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alive as at 31 December 2006 (n = 834)</td>
</tr>
<tr>
<td>Age at admission to nursing home, mean ± SD*</td>
</tr>
<tr>
<td>Female, n (%)*</td>
</tr>
<tr>
<td>Number of days between nursing home admission and assessment, mean ± SD</td>
</tr>
<tr>
<td>MDS ADL Self Performance Hierarchy Scale, mean ± SD*</td>
</tr>
<tr>
<td>MDS-Cognitive Performance Scale, mean ± SD*</td>
</tr>
<tr>
<td>MDS-CHESS score, mean ± SD*</td>
</tr>
<tr>
<td>Number of days since nursing home admission (up to 31 December 2006), mean ± SD*</td>
</tr>
</tbody>
</table>

*p < 0.05

Table 2 Predictions of survival time in nursing home-based on Cox regression, assuming assessment was done immediately after admission.

<table>
<thead>
<tr>
<th>Status as at admission</th>
<th>Predicted survival (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>MDS- ADL</td>
</tr>
<tr>
<td>Male</td>
<td>P25</td>
</tr>
<tr>
<td>65</td>
<td>0</td>
</tr>
<tr>
<td>65</td>
<td>3</td>
</tr>
<tr>
<td>65</td>
<td>6</td>
</tr>
<tr>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>70</td>
<td>3</td>
</tr>
<tr>
<td>70</td>
<td>6</td>
</tr>
<tr>
<td>75</td>
<td>0</td>
</tr>
<tr>
<td>75</td>
<td>3</td>
</tr>
<tr>
<td>75</td>
<td>6</td>
</tr>
<tr>
<td>80</td>
<td>0</td>
</tr>
<tr>
<td>80</td>
<td>3</td>
</tr>
<tr>
<td>80</td>
<td>6</td>
</tr>
<tr>
<td>85</td>
<td>0</td>
</tr>
<tr>
<td>85</td>
<td>3</td>
</tr>
<tr>
<td>85</td>
<td>6</td>
</tr>
</tbody>
</table>

admitting to a nursing home. There is a 25% chance each for his surviving either shorter than 2.65 years or longer than 5.71 years. Based on Kaplan–Meier estimator, the log-rank test among females and males is significant (χ² = 38.569, P-value <0.001). Figures 1a to c show the estimated survival functions of the nursing home residents under selected scenarios.

Discussion

All the three MDS subscales reflecting ADL performance, cognitive function and medical frailty predict the survival of older persons admitted to nursing homes in Hong Kong, with adjustment to age and gender. This is the first study using these subscales for mortality prediction among Asian populations. The importance of these three factors, i.e. functional disabilities, cognitive impairment and physical frailty in older nursing home residents in mortality prediction correlates with that of studies in other populations.10,19

We found that both cognitive impairment by the CPS scale and ADL dependence are independently related to mortality. Other studies, however, have found that cognition has been a less consistent mortality predictor compared with functional impairment.2,4,13,19,20 A difference in case-mix might have increased the importance of cognitive impairment in our model. Our model might be more suitable for nursing home populations with a large proportion of dementia patients, and be less applicable to medically unstable populations, e.g. cancer patients.

The survival prediction in this study was derived using a simplistic approach based on the three MDS subscales only. Many diseases well known to be mortality predictors, and measurements of comorbidity, such as the Charlson Index,21 have been left out of the model. Cancer and malnutrition, for example, were strong predictors of death among nursing home residents in Hong Kong and elsewhere.6,10,22 Older people with certain parameters of poor nutrition and frailty such as anaemia, low albumin and low high-density cholesterol were known to have higher mortality risk.23,24 These indicators have been left out of our models because we feel that the ultimate outcomes of frailty and comorbidities would have been well captured by the scopes of the MDS subscales. Survival estimation using data available from documentation as part of the care process may have an advantage over other methods requiring collection of special data as an independent exercise. Furthermore, for easier interpretation of hazard ratios, time-dependent covariates were not included though they might improve the goodness-of-fit of the model.

Our model can be useful in long-term care planning. In Hong Kong, there is a long waiting list for subsidized nursing home places. Given the predicted survival of nursing home residents, policy makers and administrators could then review the current situation of the occupancy and waiting times for residential care, and in addition, predict future long-term care needs with better accuracy.

Furthermore, our model can also be useful in identifying needs for advance care planning and end-of-life care in the
planning in both the public and medical sectors. Education in end-of-life issues, and encourage advance care help to draw the attention of policy makers in advocating more while the actual needs would come much earlier. Our results of life care, based only on the life tables, might be delayed, physical frailty. As a result, health policies in promoting end-

additional input of measures of cognition, function and longer life span than that in our model, which includes tables according to only gender and age estimate a much

reasons for institutionalization also vary. In institutions where facilities in other regions, as case-mix differ, and cultures and home population, may not be extrapolated to long-term care

Our sample, though representative of the Hong Kong nursing home. It has been found that the odds of death increased with institutionalization. The Hong Kong life tables according to only gender and age estimate a much longer life span than that in our model, which includes additional input of measures of cognition, function and physical frailty. As a result, health policies in promoting end-of-life care, based only on the life tables, might be delayed, while the actual needs would come much earlier. Our results help to draw the attention of policy makers in advocating more education in end-of-life issues, and encourage advance care planning in both the public and medical sectors.

Limitations
Our sample, though representative of the Hong Kong nursing home population, may not be extrapolated to long-term care facilities in other regions, as case-mix differ, and cultures and reasons for institutionalization also vary. In institutions where particular types of residents, for example, the demented or those with cancer, are segregated, the model may not apply.

Conclusion
The MDS-ADL, MDS-CPS and MDS-CHESS scales, in addition to age and gender, provide prognostic information in terms of survival time after institutionalization. The model may be useful for health care and residential care planning in an ageing community.

Acknowledgement
The authors would like to thank Professor Iris Chi for overseeing the initial survey.

Funding
SK Yee Memorial Fund.

Conflicts of interest: None declared.

Key points
- The three MDS subscales predict the survival of older persons admitted to nursing homes with adjustment to age and gender.
- Survival estimation using MDS data available from documentation as part of the care process may have an advantage over other methods requiring collection of special data as an independent exercise.
- This simple survival prediction model may help policy makers to review the current occupancy and waiting times for long-term care, and also to predict future long-term care needs with better accuracy.
- The model includes additional functional, physical and cognitive information of nursing home residents, hence may be more useful than life tables in estimating end-of-life care needs in this population.

References

Received 29 September 2008, accepted 9 January 2009