CURRENT REVIEWS

A Systematic Review of Prognostic Tools for Estimating Survival Time in Palliative Care

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INTRODUCTION

Terminally ill patients often ask, "How long do I have to live?" This issue is an important one from at least three perspectives: a) patients may desire more accurate prognostic information for their plans and decisions at the end of life; b) clinicians want to improve their prognostic skills and give better care to those who are terminally ill; and c) program managers want accurate information in order to support the resource needs and associated costs for patients at the end of life (1–4). Yet studies on survival prediction in terminally ill patients have shown that clinicians are often inaccurate when estimating survival times (5,6). To illustrate this point, a meta-analysis by Glare et al. (7), using 1,563 pooled dyads of clinician survival prediction (CSP) and actual survival (AS) from eight published studies, revealed CSP overestimated AS of terminally ill cancer patients by at least four weeks in 27% of cases, and was correct to within one week in 25% of cases. The study by Christakis and Lamont (5) found that just 20% of predictions were correct, with clinicians overestimating survival by a factor of up to 5.3. Even though estimates tend to be inaccurate and overly optimistic, Chow et al. (8) found that clinicians can improve their prediction accuracy with repeated measurements over time, and with the integration and application of appropriate prognostic tools and indicators in the prediction process.

Four systematic reviews on survival prediction in terminally ill patients have identified a set of prognostic factors that are found to be predictive of survival time. Three of these studies are based on cancer patients (8–10) with the fourth featuring noncancer patients (11). Performance status is consistently found to be a strong predictor associated with survival time in different studies. Clinical symptoms—including anorexia, weight loss, dysphagia, dyspnea, cognitive failure, and confusion—commonly found in far advanced illness are also associated with a shorter life span. Furthermore, the review by Chow et al. (8) on terminally ill cancer patients, identified specific prognostic tools used by clinicians to estimate survival, including the Karnofsky performance status (KPS), Spitzer quality of life index, and palliative prognostic score (PaP). Similarly, the review by Coventry et al. (11) identified prognostic models for chronic obstructive pulmonary disease (COPD) and dementia patients. In the third edition of The Oxford Textbook of Palliative Medicine, Glare and Christakis (12) provide an overview of different prognostic scores and models described in the literature that include such prognostic tools as the SUPPORT model, Japan simple indicator, good-bad-uncertain (GBU) index, and PaP that may hold promise in hospice palliative care[1].

In spite of recent research to better understand survival prediction in terminally ill patients, there are still insufficient resources and guides for use by clinicians to improve their survival estimates. As well, most published studies on survival prediction of the terminally ill have focused on end-stage cancer, with less attention paid to noncancer but equally life-threatening illnesses such as organ failure (e.g., COPD) and frailty (e.g., Alzheimer's disease). Even though prognostic tools have been shown to improve survival prediction accuracy, to date only a handful have undergone independent validation and still fewer are specific for hospice palliative care. This paper systematically reviews the ability of a range of non-disease-specific and disease-specific prognostic tools to estimate survival time

[1]The term "hospice palliative care" has been adopted by the Canadian Hospice Palliative Care Association to refer to hospice, palliative care, and other related forms of supportive care provided to terminally ill patients across settings.

Journal of Palliative Care 23:2/2007; 93–112

for terminally ill hospice palliative care patients. Specifically, the paper offers practical guidance on how these prognostic tools can be used in practice; compares the overall strengths, limitations and value of such tools; and discusses key issues and implications for future research.

METHODS

Research Questions

The research questions for this review were:

1. Which prognostic tools are currently used by clinicians in hospice palliative care settings to predict survival of terminally ill patients?
2. How accurate are these prognostic tools in estimating survival time of these patients?
3. How can clinicians use these prognostic tools to improve their survival estimates?
4. What are the key issues associated with the use of these tools that require further research?

In this paper, the term "prognostic tools" will be used in its broadest sense to include models, instruments, and tools.

Search Strategy

We were interested in studies that involved the validation or use of specific prognostic tools in estimating survival time of hospice palliative care patients. As such, the search strategy was constructed to include various combinations of terms related to three constructs—terminally ill, prognostic tool, and survival estimate. For "terminally ill" we included the terms hospice, palliative care, end-of-life, end-stage, advanced stage, and noncurable. For "prognostic tool" we included the terms instrument, tool, model, and assessment. For "survival estimate" we included prognosis, prognostication, trajectory, and survival prediction. These terms were combined into specific facets for the subsequent library database and hand searches. Additional details of the search process can be obtained from the authors upon request.

An initial search was conducted in the fall of 2004 with MEDLINE, ISI Web of Science, PsycINFO, and CINAHL covering the years from 1989 to 2004. We also did a hand search of key hospice palliative care-related journals, conference proceedings, and government reports using the same search terms. With the relevant articles selected for the review, we conducted a second round of "forward/backward" citation searches[2] in which we scanned for additional studies cited in the reference section of each relevant article (backward search), as well as studies that cited the relevant article itself (forward search). In the third round, the names of specific prognostic tools mentioned in the reviewed articles or known to our palliative care physicians on the research team were searched for additional publications on those tools. To ensure being current with the most recent literature, we conducted a final round of library database searches using the same key terms for the timeframe up until the end of 2005.

Inclusion/Exclusion Criteria

Only articles published in English that described primary studies on survival prediction involving terminally ill hospice palliative care patients with the use of some type of prognostic tool were included. We considered studies from a broad range of hospice palliative care settings including nursing homes and hospitals where palliative care services are (or can be) offered, but excluding critical care units where invasive/aggressive interventions are provided. Articles were excluded if they involved the development of a tool or pilot studies without validation. Also excluded were studies that were part of a clinical trial, those with survival time greater than one year, as well as theoretical, conceptual, and commentary articles. A one-year survival time cut off was delineated to include studies on prognostic tools for individuals living with noncancer life-limiting illnesses, such as advanced dementia, whose survival trajectories are more erratic and often difficult to predict. The four systematic review articles (8–11) that described the use of prognostic tools were included to identify additional articles that should be reviewed. The initial search results were screened independently by two researchers using these inclusion and exclusion criteria to ensure that a satisfactory inter-rater reliability rating could be achieved.

Quality Assessment Criteria

A set of quality assessment (QA) criteria were developed for this review based on existing criteria and guidelines used to assess observational cohort studies (14) and those on prognosis (15). We used five QA criteria that focused on: patient selection, study design, prognostic variables, follow up, and analysis. For patient selection, we examined whether the study included a representative and well-defined sample of patients at a similar point in the course of the disease, and the proportion of patients enrolled in the study. For study design we distinguished between prospective and retrospective cohort studies with control groups, as well as case series without controls.

[2]The term "forward/backward search" is used by Webster (13) in their article on writing a literature review.

For prognostic variables we examined whether the outcome measure was clearly defined, and considered whether assessment data was collected by unbiased assessors. For follow up, we looked at whether the duration of patient follow up in the study was adequate with dropouts reported. Statistical methods were checked including whether confounding factors were identified and adjusted. A score of 0 to 2 was assigned to each of the five criteria, depending on whether the study met the conditions in full, partially, or not at all, respectively, giving a possible score range of 0.0 to 10.0. For the final ranking, articles with a weighted score between 8.0 and 10.0 were considered "adequate" studies, those between 5.0 and <8.0 were rated "somewhat adequate", and studies with scores <5.0 were deemed "inadequate" in overall quality. Five researchers took part in the QA process as members of the review team. First, the researchers reviewed each article independently, then met as a group to reach consensus on the overall quality rating. All screening and review of articles was recorded and tracked using a Web-based review tool called EGOR® from the commercial software development firm ShirWin Knowledge and Learning Systems, in Edmonton, Alberta, Canada.

Data Extraction and Synthesis

For each article, we extracted pertinent data to provide a synopsis of the study in terms of its research design, the type of patients and care settings involved, the number of patients enrolled in the study, the median survival time (or mortality, if available), and our overall quality rating. For data synthesis, two decision trees were used to divide the prognostic tools described in these studies into two broad categories of non-disease-specific or disease-specific tools. The latter category was further divided into cancer or noncancer specific groups. For each tool featured we described the variables involved, the patient population(s), care setting involved, and the survival prediction results, as well as the overall strengths, limitations, and value of all the tools reviewed. As part of the final synthesis, we identified key issues associated with the use of these prognostic tools that require further research.

RESULTS

Characteristics of Reviewed Studies

The initial library database search returned 93 citations, with another 21 from a hand search of journals, proceedings, and Web sites. Of these 114 citations screened independently by two of the researchers according to the inclusion/exclusion criteria, 36 were considered relevant and the full articles were retrieved for review. The forward/backward citation search from these 36 articles returned another 805 distinct citations, of which 10 were considered relevant and were retrieved for review. The final search for specific prognostic tools and articles published in 2005 returned 56 citations, of which 12 were considered relevant for retrieval. In this review, we focused on studies that were based on clinician observations and physiologic parameters. As such, studies were separated out if they used patient-reported quality-of-life instruments to estimate survival. These are considered in a subsequent review to be published later. In total, 29 of the retrieved articles (2–4,16–41) out of 975 citations met the inclusion criteria as primary studies to be reviewed. Two of these articles (31,32) were based on the same study and hence were treated as one article in the review, bringing the final count to 28 studies for the final synthesis.

A synopsis of the 29 articles is shown in Table 1, including the type of patient cohort, disease, setting, sample size, survival time, and quality rating. Based on the QA criteria noted above, 15 studies were considered adequate, with ratings of 8.0 or higher; 12 were considered somewhat adequate; one was designated inadequate. Since the intent of this review was to provide clinicians with acceptable quality, validated, and/or tested prognostic tools that could be used in hospice palliative care settings, we focused on the 15 studies with "adequate" ratings from this assessment (shown in descending QA rating sequence in Table 1). Many of these studies had small sample sizes, hence caution is needed when interpreting their results due to possible over-fitting of the prognostic models/tools that included many variables. Given the diversity across these studies in terms of the patient populations, types of analysis, and reported findings, we elected to conduct a narrative synthesis to summarize the findings, rather than a meta-analysis to quantify and compare the relative accuracy of these prognostic tools.

Findings From Reviewed Studies

A synthesis of the 15 reviewed studies is shown in Tables 2a to 2d. For each study, the research design and follow-up method, the patients and care settings, the prognostic tools and variables, as well as the key findings are provided. Eleven prognostic tools have been described in the 15 studies. Four are considered non-disease-specific tools, as they were developed and/or

validated for heterogeneous patient populations (2,21,23,25,29,35,41). Four other tools are cancer-specific, as they were developed and validated for terminally ill cancer patients (4,17,18,31), with one (4) for lung cancer patients. The remaining three tools were developed and/or validated specifically in noncancer diseases—dementia (37), heart failure (26), and organ failure (COPD, end-stage liver disease, and heart failure) (20). Of the 11 tools

Table 1 / SYNOPSIS OF THE 28† STUDIES INCLUDED IN THE REVIEW

Ref	Study	Cohort Type	Disease	Setting	n	Median Survival or Percent Mortality (Dispersion)*	QA Rating
20	Fox (1999)	Prospective	Lung, heart, liver	Hospice	2607	804 days (IQR 181-NA)	10.0
41	Walter (2001)	Prospective	>70 yrs heterogenous	Community hospital	1495; 1427	1 yr mortality: gp-A 4% (CI 2-6); gp-B 19% (CI 15-23); gp-C 34% (CI 29-39); gp-D 64% (CI 58-70)	10.0
25	Harrold (2005)	Prospective	Heterogeneous	Community hospice	466	NA	9.5
2	Flacker (2003)	Retrospective	Heterogeneous	Nursing home	60341; 40328	34% died ≤1-yr	9.0
23	Glare (2004)	Prospective	Cancer	Oncology ward	98	12 weeks (IQR: 7 to 25 weeks)	9.0
26	Lee (2003)	Retrospective	Heart failure	Multiple hospitals	2624; 1407	10.4% died ≤30 days; 30.5% ≤1-yr	9.0
32	Morita (1999b)	Prospective	Cancer	Inpatient hospice	150;95	26 days for deceased (range 1-217)	9.0
18	Chuang (2004)	Prospective	Cancer	Palliative care unit	356;184	15 days	8.5
17	Bozcuk (2004)	Prospective	Cancer	Palliative care unit	334;131	8 days	8.0
22	Glare (2001)	Prospective	Heterogeneous	Palliative consult	100	30 days (CI 24-40)	8.0
3	Head (2005)	Retrospective	Heterogeneous	Home-based hospice	396	28 days (SD: 71.8)	8.0
29	Maltoni (1999)	Prospective	Cancer	Inpatient hospice	451	gp-A 76 days (CI 67-87); gp-B 32 days (CI 28-39); gp-C 14 days (CI 11-18)**	8.0
31	Morita (1999a)	Prospective	Cancer	Inpatient hospice	150;95	26 days for deceased (range 1-217)	8.0
35	Olajide (2004)	Prospective	Heterogeneous	Palliative consult	255	9 days (IQR 3-41)	8.0
4	Schonwetter (1994)	Prospective	Lung cancer	Community hospice	310;78	27 days	8.0
37	Schonwetter (2003)	Retrospective	Dementia	Community hospice	245;80	Died <180 days: 22.5 days (range 0-178); died >180 days: 271.5 days (range 185-797)**	8.0
21	Glare (2003)	Prospective	Non-cancer	Palliative consult	65	gp-A 266 days (CI 88-...); gp-B 18.5 days (CI 9-48); gp-C 5 days (CI 3-6)**	7.5
27	Luchins (1997)	Prospective	Dementia	Hospices	47	4 months	7.5
19	Evans (1985)	Prospective	Cancer	Terminal care consult	42	NA	7.0
30	Mitchell (2004)	Retrospective	Dementia	Nursing home	6799; 4631	35.1% died ≤6 months	7.0
33	Morita (1999c)	Prospective	Cancer	Inpatient hospice	245	PPS 10-20%: 6 days (CI 4.6-7.4); 30-50%: 41 days (CI 35-47); >60% 108 days (CI 85-131)**	7.0
34	Morita (2001)	Prospective	Cancer	Inpatient hospice	150;108	Died: 23 days (range 2-212); survived: 300 days**	7.0
24	Hanrahan (1999)	Prospective	Dementia	Community hospice	45	2.1 months	6.0
28	Maltoni (1994)	Prospective	Cancer	Hom care services	100	KPS 20-30: 2 wks; KPS 40-50: 5 wks; KPS >50: 6.5 wks**	6.0
38	Thorogood (1992)	Prospective	Lung cancer	Cancer clinic	176	25% died <3 months	6.0
39	Virik (2002)	Prospective	Heterogeneous	Palliative care unit	139	13 days (CI 26.9-31.3)	6.0
40	Volicer (1993)	Prospective	Dementia	Intermediate care	68;71	NA	6.0
16	Bennett (2000)	Retrospective	Cancer	Inpatient hospice	93;104	27 days (range 3-349)	5.5
36	Schonwetter (1998)	Retrospective	Non-cancer	Community hospice	104	14 days	4.0

†There are 29 citations; 31 and 32 are based on the same study, so are considered together; Ref=reference number for the study; n=cohort size, where two numbers are shown, the left is the initial cohort for tool development with the right for validation; QA=quality assessment; NA=not available; *dispersion is presented in confidence interval (CI), range, standard deviation (SD) or interquartile range (IQR); **median survival times of individual risk groups given, but not overall value

Table 2 / SUMMARY OF REVIEWED STUDY FINDINGS

Authors	Design and Follow up	Patients and Setting	Prognostic Tool and Variables	Key Findings
Bozcuk et al. 2004 [Ref 17] **Turkey**	Retrospective and prospective cohort study; retrospective cohort with survivors in a control group as initial data sets over 48 months to develop the tool; then prospective cohort over 4 months to validate tool; follow up until hospital discharge or death	All cancer patients except for hematological malignancies admitted to internal medicine department of a teaching hospital; 334 patients with 199 who died and 135 survivors in initial data set, and 131 in test data set	*Tool:* Intrahospital cancer mortality risk model (ICMRM) *Assessments:* Patient characteristics and clinical data collected from medical records and department database upon admission; variables used to develop/validate tool included gender, province, cancer type and stage, ECOG performance status, admission reason, previous cancer treatment , comorbidities, Hgb, WBC, serum calcium, creatinine, ALT, LDH, albumin, duration of disease in days from initial diagnosis to hospitalization date; survival time from admission to death/discharge	Median hospital stay (intrahospital death) was 8 days. Model had predictive accuracy of 0.88 in ROC curve from retrospective cohort and 0.82 from prospective cohort. Patients with ECOG performance status of 4, short duration of disease, emergency admission, low Hgb count, and high LDH at time of admission more likely to die in hospital.
Chuang et al. 2004 [Ref 18] **Taiwan**	Prospective cohort study to develop and validate tool with initial and test data sets, and follow up to death or end of study	Terminal cancer patients admitted to PCU with 356 consecutive patients in initial data set over 20 months and 184 patients in test set over 8 months	*Tool:* Cancer prognostic scale (CPS) *Assessments:* Variables used to develop/validate tool were ECOG and symptoms/signs recorded daily by physicians and senior nurses; other variables were age, gender, referral place, cancer site, metastasis, weight loss, prior treatment/herb medication; survival time from admission date to death or end of study	Overall median survival was 13 days for initial set and 15 days for test set. Dying process could be classified by stages according to symptoms and signs. Survival <2 weeks when CPS >3.5 (accuracy 0.72 in initial set and 0.61 in test set); survival <1 week when CPS >6.0 (0.72 accuracy in initial set and 0.66 in test set)
Flacker et al. 2003 [Ref 2] **USA**	Retrospective cohort study to develop and validate tool, using an initial data set and a test set collected over 42 months; follow up of mortality status not known for 13.2% of initial data set and 13.8% of test set	Newly admitted and long-stay nursing home residents ≥65 yrs in 643 Medicare and Medicaid certified nursing homes in New York State; initial data set had 60,341 new admissions and test set had 40,328 admissions	*Tool:* Mortality risk index score (MRIS) *Assessments:* Variables to develop/validate tool were minimum data set instrument for 1st assessment within 2 weeks of admission matched with NDI; 62 variables in total including age, race, gender, diagnosis, functional status, symptoms/signs, comorbidities; ≤1 year mortality as outcome variable for new admissions; survival time computed from NDI	11,811 or 34% of newly admitted patients died within 1 year. Important factors for 1-year mortality for newly admitted residents were shortness of breath, unstable conditions, male gender, 25% food uneaten, CHF, low functional ability, BMI<23 kg/m², cancer, bedfast, pressure ulcer, swallowing problem, and bowel incontinence
Fox et al. 1999 [Ref 20] **USA**	Prospective cohort study to validate tool using one data set from SUPPORT phase-1 and phase-2 studies with a 6-month follow up	Advanced lung, heart or liver disease; consecutive 2607 patients from 5 US medical centres over 36 months who survived to hospital discharge; excluded those discharged in 48 hours, did not speak English, with trauma, pregnancy, or AIDS	*Tool:* Combination prognostic criteria (CPC) *Assessments:* Variables used to validate tool included 3 sets of combination criteria (broad, intermediate, narrow inclusion) aimed at low, medium, and high thresholds used for hospice eligibility based on NHO guidelines with 5 general clinical criteria (home care, readmission, ADL, weight loss, albumin) and 2 disease-specific criteria for COPD (cor pulmonale, PO_2), CHF (ejection fraction, arrhythmia), ESLD (cachexia, creatinine); other variables were age, gender, race; survival time computed from NDI	Estimated median survival time for study population was 804 days, with 665 (25%) out of 2607 patients dead within 6 months of discharge. Broad inclusion criteria identified 923 patients eligible for hospice of whom 70% survived >6 months; intermediate criteria identified 200 patients of whom 65% survived >6 months; narrow criteria identified 19 patients of whom 53% survived >6 months. Sensitivities and specificities were 41.7% and 66.7% for broad inclusion, 16.2% and 90.1% for intermediate, and 1.4% and 99.5% for narrow criteria. Current NHO guidelines are not effective in identifying those patients with survival prognosis of ≤6 months
Glare et al. 2001 [Ref 22] **Australia**	Prospective cohort study to validate tool using one data set with follow up to death or to 249 days after end of study	100 terminally ill heterogeneous patients consecutively referred to a palliative medicine consult service in a university hospital over 4 months	*Tool:* Palliative prognostic score (PaP) *Assessments:* Researcher recorded PaP* on day of first palliative consultation with patients during admission; other variables were, age, gender, diagnosis, length of stay, length of time before/after PaP score; survival time from admission to death/discharge/end of study	Median survival 60 days (95%CI 41–89), 34 days (25–40), and 8 days (2–11) for 3 groups. Survival % at 30 days were 66%, 54%, and 5% for the 3 groups in study. Overall 30-day survival probability for group A >70%, group B 30%–70%, group C <30%. 9% were noncancer patients in study with distinct groups A and C survival patterns
Glare et al. 2004 [Ref 23]	Prospective cohort study to validate tool, using a data set collected over	Consecutive cancer patients in oncology ward of university hospital; 100 of	*Tool:* Palliative prognostic score (PaP) *Assessments:* PaP recorded at first consult by palliative care physician	Overall median survival was 12 weeks with 83% alive at 1 month and 26% alive at 6 months. Estimated median survival of 3 groups

Table 2 / SUMMARY OF REVIEWED STUDY FINDINGS (cont'd)

Authors	Design and Follow up	Patients and Setting	Prognostic Tool and Variables	Key Findings
Australia	16 weeks and followed up of censored survival to 180 days	120 eligible patients (83.2%) ≥18 yrs including those on antineoplastic therapy but not with hematologic malignancies	with WBC and lymph count from most recent 2 weeks and survival censored at date of last contact and <365 days; other variables were age, gender, tumour sites and metastasis, current treatment, previous treatment, reasons for admission; survival time from admission to death/discharge/end of study	were A 17 weeks, B 7 weeks, and C <1 week; Survival at 1 month for 3 groups were A 98%, B 61%, and C 25%
Harrold et al. 2005 [Ref 25] **USA**	Prospective cohort study to validate tool using one data set with follow up to death or end of study	Heterogeneous hospice population; consecutive admissions for 466 patients at a community hospice over 12 months	*Tool:* Palliative performance scale (PPS) *Assessments:* PPS** recorded upon enrolment by intake nurse, patients followed until death or discharge; other variables from patient chart were site of care, diagnosis, marital status, ethnicity, gender, age; survival time from admission to death/discharge	6-month mortality rates for 3 PPS groups: 96% for PPS 10%–20%; 89% for PPS 30%–40%; 81% for PPS ≥50%. Strong association between PPS and mortality in nursing home residents and non-cancer patients with greater prediction accuracy than community and cancer patients. PPS may be useful in confirming hospice eligibility for reimbursement purposes
Head et al. 2005 [Ref 3] **USA**	Retrospective cohort study to validate tool using one data set from chart audit	Heterogeneous home-based hospice population; included 396 of 502 patients admitted to a community hospice program over 3 months, excluding length of stay <5 days (enrolment 79%)	*Tool:* Palliative performance scale (PPS) *Assessments:* PPS recorded upon enrolment and discharge by primary nurse; other variables were age, gender, comorbidities, race, marital status, diagnosis; survival time from enrolment to death or discharge	Overall median survival of 28 days. PPS and diagnosis were significantly associated with survival. Overall, 100% of those with PPS 10%–20%, 96.4% of PPS 30%, 97.3% of PPS 40%, 87.9% of PPS 50%, 83.3% of PPS 60%–70% survived <6 months. PPS not highly discriminating between 30%–40% or 50%–70%, negative-change scores predictive of decline toward death, stable PPS over time resulted in discharge
Lee et al. 2003 [Ref 26] **Canada**	Retrospective cohort study to develop and validate tool, using an initial data set and a test set; deaths up to 1-year after admission identified through linkage to Registered Persons Database	Community based patients newly admitted with heart failure over 24 months with 2624 patients from 34 hospitals as initial data set, and another 24 months with 1407 patients from 14 hospitals as test set	*Tool:* Heart failure risk scoring system (HFRSS) *Assessments:* Variables to develop/validate tool were chart data within 24 hours of admission collected by cardiology nurse abstractors; demographic variables were age, gender; clinical/lab data were vital signs, Hgb, WBC, Na, K, creatinine, BUN, glucose, ejection fraction; comorbid conditions; outcomes as 30-day and 1-year mortality from admission	Data from initial hours of hospital presentation could predict mortality at 30 days and 1 year. Both models included acute physiologic parameters and chronic disease comorbidities. Variables are hyponatremia, respiratory rate, blood pressure, dementia, cirrhosis, cancer, abnormal BUN and Hgb. Risk score stratified risk of death at time of initial hospital presentation into very low (≤60 points), low (61–90 points), high (121–150 points and very high (>150 points), and an intermediate risk group (91–120 points) at average risk. Predictive accuracy for initial data set was 0.8 for 30-day mortality and 0.77 for 1-year mortality, whereas the test data set was 0.79 for 30-day mortality and 0.76 for 1-year mortality.
Maltoni et al. 1999 [Ref 29] **Italy**	Prospective cohort study to validate tool using one data set, follow up 2 months after end of enrolment	Terminal cancer patients with advanced solid tumour excluding renal cancer, multiple myeloma, and lymphatic pathologies; 451 consecutive patients in 14 PCUs over 8 months	*Tool:* Palliative prognostic score (PaP) *Assessments:* PaP* on enrolment; other variables were age, gender, primary site of neoplasia, metastastic sites, treatment, hospitalization, transfusion; survival time from enrolment to death/discharge/end of study	Overall median survival of 33 days. 3 risk groups with distinct survival profiles: group A with median survival 76 days and 30-day survival probability at 86.6%; group B with median survival 32 days and 30-day survival at 51.6%; group C with median survival of 14 days and 30-day survival at 16.9%
Morita et al. 1999 x2 publications on same study [Ref 31] **Japan**	Prospective cohort study to develop and test tool using an initial data set and a test set, with follow up to 6 months after final assessments	Terminally ill cancer patients; consecutive PCU admissions; 150 patients with 355 assessments over 12 months as initial data set, and 95 patients with 233 assessments over 7 months as test set	*Tool:* Palliative prognostic index (PPI) *Assessments:* PPI** recorded by physicians upon admission and every 3 weeks until death or end of study; other variables were age, gender, tumour sites; survival time from admission to death/end of study	Survival profiles of test set: group A with PPI ≤2.0 and mean survival 134±11 days (95% SE 113–155 days), group B with 2.0<PPI≤4.0 and mean survival 89±7.0 days (95% SE 76–103 days), group C with PPI >4.0 and mean survival 23±2.9 days (95% SE 17–29 days). Prediction of test set for 3-week survival with PPI >6 had sensitivity 83%, specificity 85%,

Table 2 / SUMMARY OF REVIEWED STUDY FINDINGS (cont'd)

Authors	Design and Follow up	Patients and Setting	Prognostic Tool and Variables	Key Findings
				positive predictive value 80%, negative predictive value 87%, and overall accuracy 84%; for 6-week survival when PPI >4 had sensitivity 79%, specificity of 77%, positive predictive value 83%, negative predictive value 71%, and overall accuracy 78%
Olajide et al. 2004 [Ref 35] **USA**	Retrospective cohort study to validate tool using one data set with follow up to death or discharge from hospital (231/255 or 92.4% patients)	Heterogeneous population referred to inpatient palliative care consultation program of a teaching hospital; 255 patients over 31 months	*Tool:* Palliative performance scale (PPS) *Assessments:* PPS*** by attending physician and nurse at consult; other variables were age, gender, diagnosis, dyspnea, pain, fatigue, consciousness, and delirium; survival time from PPS assessment to death/discharge	Overall median survival of 8 days. PPS found to be strongly associated with survival; all 5 symptoms were associated with PPS, with shortness of breath as the only symptom with an independent effect on survival when adjusted for PPS
Schonwetter et al. 1994 [Ref 4] **USA**	Prospective cohort study to develop and validate tool, using an initial data set and a test set, with follow up until death or end of data collection	Terminal lung cancer from community-based home hospice service; 310 of 323 consecutive patients in initial data set over 16 months (enrolment rate 96%), and 78 patients in test data set	*Tool:* Lung cancer prognostic model (LCPM) *Assessments:* Variables to develop/validate tool were gender, age, race, religion, marital status, caregiver relation, tumour type, metastasis, living will, BP, KPS, ADL; Likert scales for appetite, nourishment, mobility, pain; disorientation symptoms, dry mouth, dysphagia, dyspnea, weight loss; survival time from admission to death/discharge/end of study	Overall median survival of 27 days. Variables in multivariate model for survival prediction included pulse, toileting, feeding, living will, tissue type, dry mouth, liver metastasis, and pain. Patients with shorter survival when they had: no living will on admission, tissue types other than adenocarcinoma or squamous-cell lung cancer, liver metastasis, high pulses, required assistance or dependent on toileting and feeding, dry mouths, severe or incapacitating pain
Schonwetter et al. 2003 [Ref 37] **USA**	Retrospective cohort study to develop and validate tool, using an initial data set and a test set	Dementia patients admitted to community based hospice; 165 of 214 patients over 24 months in initial data set (enrolment rate 77%), and 80 patients over 12 months in test data set	*Tool:* Dementia prognostic model (DPM) *Assessments:* Variables to develop/validate tool were chart audit data from by two nurses; variables were age, gender, religion, marital status, education, caregiver relation, care location, diagnosis, comorbid conditions, complications, weight, feeding tube, serum albumin, cholesterol, KPS, FAST, Charlson comorbidity index, symptoms, advance directives, composite score for sum of complications, Medicare guidelines met/not-met; survival from admission until death or end of study	Median survival 22.5 days for those who died in 6 months and 271.5 days after 6 months. Hospice Medicare guidelines shown not valid in predicting 6-month survival. Variables predictive of 6-month survival were age, marital status, anorexia, KPS and interaction between KPS and anorexia. KPS was more useful survival predictor than FAST. Nutrition and performance important when estimating prognosis, increased age was associated with increased mortality, married dementia patients had shorter survival times in initial but not test data set
Walter et al. 2001 [Ref 41] **USA**	Prospective cohort study to develop and validate tool using an initial data set and a test set, with follow-up of 1 year	Heterogeneous population ≥70 years discharged from hospitals over 60 months; excluded ICU, LOS<2 days, elective subspecialty admission; 1495 patients from tertiary care hospital as initial data set and 1427 patients from community hospital as test set	*Tool:* Prognostic index for 1-year mortality in older adults (PIMOA) *Assessments:* Trained abstractors collected data from medical chart to develop/validate tool, including demographics, lab data, length of stay, comorbid conditions, admission reason, discharge locations, ADL; demographics included age, gender, race, marital status; lab data included creatinine, albumin; researchers interviewed patients/surrogates for mental status questionnaire and modified Katz index of ADL; survival time as death within 1 year after hospital discharge, compared with NDI	1-year mortality by risk scores for derivation cohort was: 13% in lowest-risk group with 0–1 point, 20% in group with 2–3 points, 37% in group with 4–6 points, and 68% in highest-risk group with >6 points; for validation cohort was: 4% in lowest-risk group, 19% in group with 2–3 points, 34% in group with 4–6 points, and 64% in highest-risk group. ROC curve for prediction accuracy in derivation cohort was 0.75 vs. 0.79 in validation cohort

*PaP covers anorexia, dyspnea, KPS, CPS, WBC, lymph%
**PPI covers PPS, oral intake, edema, dyspnea, delirium
***PPS covers ambulation, activity/evidence of disease, self-care, oral intake, consciousness
ADL=activities of daily living
ALT=alanine transaminase
BMI=body mass index
BUN=blood urea nitrogen
CHF=congestive heart failure
COPD=chronic obstructive pulmonary disease
ECOG=European Cooperative Oncology Group
ESLD=end-stage liver disease
FAST=functional assessment staging test
Hgb=hemoglobin
K=potassium
KPS=Karnofsky performance scale

LDH=lactose dehydrogenase
LOS=length of stay
Na=sodium
NDI=National Death Index
NHO=National Hospice Organization
PCU=-palliative care unit
ROC=receiver operating characteristics
SE=standard error
SUPPORT=Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments
WBC=white blood count

examined, only the palliative performance scale (PPS) (3,25,35) and PaP (21,23,29) have been validated in two or more independent studies with different authors, patient populations, and/or care settings. Seven (2,4,17,18,26,37,41) of these tools are based on single studies that combined the development and validation steps into one study by dividing their patient populations into two cohorts for development and testing purposes.

Of the remaining two tools, the palliative prognostic index (PPI) by Morita et al. (31,32) had a follow-up study (34) in 2001 that was identified in our review but not included in the final synthesis. The combined prognostic criteria (CPC) by Fox et al. (20) for organ failure compared a modified subset of the existing National Hospice Organization (NHO) guidelines against the SUPPORT model for prediction accuracy, but is otherwise not independently validated. Because Fox concluded that the CPC were not effective in predicting 6-month survival, we have excluded that tool from our synthesis. The 10 prognostic tools are described in detail in the appendices. Appendices 1a to 1d are for the four non-disease-specific tools; Appendices 2a to 2d are for the four cancer disease-specific tools; Appendices 3a to 3b are for the two noncancer disease-specific tools.

DISCUSSION

Use of Prognostic Tools in Hospice Palliative Care

Ten prognostic tools that may be useful in hospice palliative care settings have been identified through this systematic review. These tools have been grouped as non-disease-specific (i.e., reflecting heterogeneous populations) or disease-specific, with the latter divided into cancer- or noncancer-specific. Two decision trees have been included to help clinicians decide when to use a particular tool in situations when they want to estimate survival time of an individual patient under their care (Figures 1a and 1b). The selection of prognostic tools based on disease type, patient population, and care setting as outlined in the decision trees is discussed below. (Tables 1–3 and Appendices 1–3 provide specific details of the tools.)

Non-Disease-Specific Prognostic Tools. Four tools are included in this category: palliative performance scale (PPS) (3,25,35), palliative prognostic score (PaP) (21,23,29), prognostic index for one-year mortality in older adults (PIMOA) (41), and mortality risk index score (MRIS) (2). Clinicians using these tools to estimate survival time for an individual patient should consider several features. PPS is a simple assessment tool for functional status and has been used in different settings to predict survival times that range from less than one week to six months. Lower PPS levels are associated with lower survival probability and shorter duration. Similarly, PaP can be used to predict 30-day survival probability and has been tested in different settings, but requires the inclusion of selected symptoms and blood cell counts (i.e., WBC, lymphocyte %). For adults 70 years of age or older discharged from hospital following an acute medical illness and for whom hospice palliative care may be appropriate, PIMOA, which is based on ADL scores, co-morbid conditions, and selected lab tests, could be used to predict one-year mortality rates. For newly admitted nursing home residents, MRIS, which is based on a subset of the minimum data set (MDS) variables, can be used to predict one-year mortality rates.

Disease-Specific Prognostic Tools in Cancer. Four tools for cancer patients are included in this category; these being the intrahospital cancer mortality risk model (ICMRM) (17), cancer prognostic scale (CPS) (18), palliative prognostic index (PPI) (31,32), and lung cancer prognostic model (LCPM) (36). Clinicians using them to estimate survival of a cancer patient should consider each tool's specific characteristics. For terminally ill cancer patients (excluding those with hematological malignancies), ICMRM estimates the probability of surviving a short-term hospital stay (median: 8 days) based on ECOG, emergency admission, and selected lab tests. Similarly, CPS is based on tumour sites, functions, and symptoms, and can estimate short-term survival of up to two weeks for cancer patients staying in an inpatient palliative care unit. PPI estimates survival of up to six weeks in different palliative care settings, and is based on PPS plus four symptoms. For community-based home hospice patients with end-stage lung cancer, LCPM could be used to estimate survival times ranging from <3 days to >1 year based on the number of ADL factors, tumour sites, and symptoms present.

Figure 1a / DECISION TREE FOR NON-DISEASE-SPECIFIC PROGNOSTIC TOOLS FOR HETEROGENEOUS PATIENT POPULATIONS

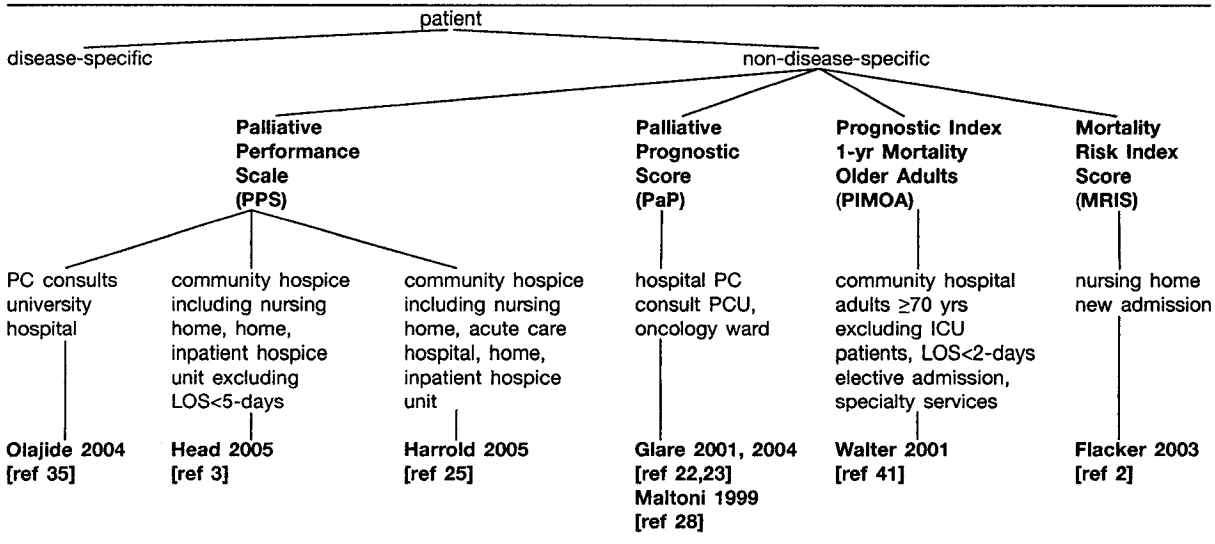
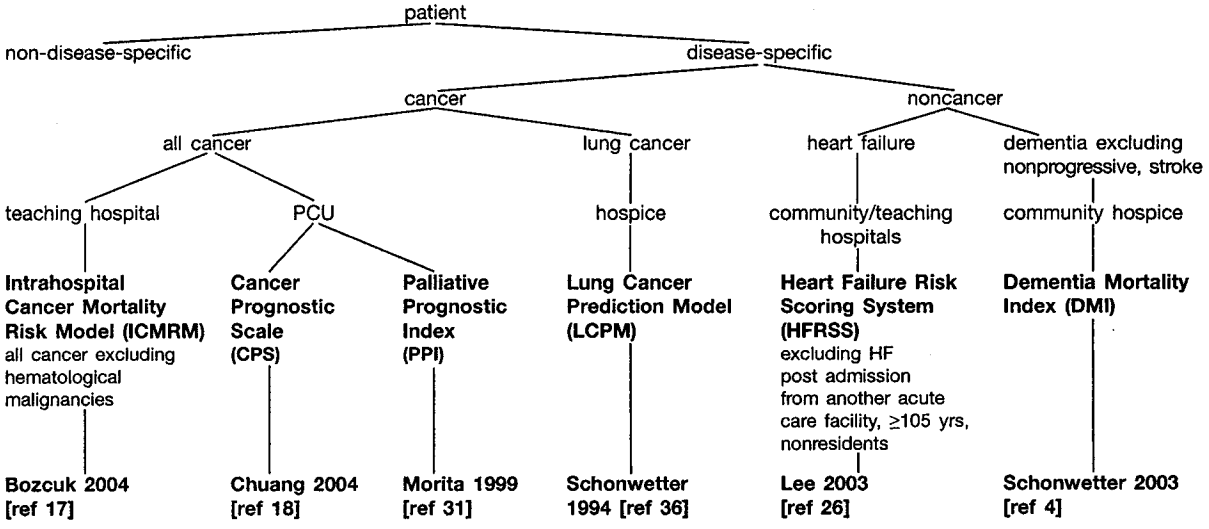


Figure 1b / DECISION TREE FOR DISEASE-SPECIFIC PROGNOSTIC TOOLS FOR PATIENT POPULATIONS WITH SPECIFIC DISEASES



Disease-Specific Prognostic Tools in Noncancer. Two prognostic tools are included in this category. The heart failure risk scoring system (HFRSS) (26) calculates 30-day and one-year mortality rates of patients hospitalized for heart failure with the aim of facilitating planning for end-of-life care. It uses a composite scoring method that is based on 10 physiologic variables for the 30-day mortality prediction model, with hemoglobin (Hgb) added as the 11th variable for the one-year model. The dementia prognostic index (DPI) (4) determines the probability of six-month mortality in dementia (excluding nonprogressive type and stroke) patients newly admitted into hospice. It includes age, nutritional and functional status, and Karnofsky performance scale in the model, but is more qualitative in its assessment and reporting (e.g., older adults at greater risk of less than six-month survival).

Strengths, Limitations and Value of These Tools

While this review has shown there are different prognostic tools that can be used to predict survival time in hospice palliative care, clinicians need to be aware of the conditions under which these tools have been tested, and ways to make meaningful interpretations of the results. To assist in this, a comparison of their overall strengths, limitations, and value based on our synthesis of the 15 studies is described below. This comparison is also summarized in Table 3a for the four non-disease-specific tools with heterogeneous populations, and in Table 3b for the six disease-specific tools for several types of cancer and noncancer patients.

Non-Disease-Specific Prognostic Tools. The overall strengths of PPS and PaP, as shown in Table 3a, are that they have been used in both

cancer and noncancer patients, and in different settings. Both tools are highly predictive, with lower PPS levels being associated with shorter survival time ranging from less than one week to less than six months, depending on the study; whereas, for PaP, three risk groups with different 30-day survival probabilities are used consistently. The limitations of PPS in the studies included in this review may be its questionable grouping into three bands that are not highly discriminating. A more recent study by Lau et al. (42), however, reported significant separation at each PPS level from PPS 10% through PPS 70%. The limitations for PaP are the need to include a lab test, its use of questionable clinician survival prediction ranges, and having predictions of survival time constrained to 30 days only. PIMOA and MRIS can be used for both cancer and noncancer patients. PIMOA is limited in providing only a one-year survival prediction and the further stipulation of being a discharged hospital patient who is 70 years or older. Similarly, MRIS is restricted to one-year survival prediction of newly admitted nursing home patients and uses the MDS that is mandatory in some jurisdictions. Also, some assessment tools within MDS are not commonly used in palliative care nor validated. In terms of overall value, PPS and PaP are considered simple and useful prognostic tools with high degrees of predictive accuracy. PIMOA can be used only for one-year survival prediction on older adults, while the use of MRIS in hospice palliative care is uncertain due to its reliance on MDS. A more general limitation with all of these tools, especially PIMOA and MRIS, is that they require further validation with larger heterogeneous populations in different settings.

Disease-Specific Prognostic Tools. The overall strength of the four tools for cancer patients, as shown in Table 3b, is that they are predictive of short-term survival in different settings (1–2 weeks to <6 weeks). The limitations include the need for Hgb and lactate dehydrogenase (LDH) in ICMRM, subjective symptom measures in CPS, overly broad nondiscriminating PPS bands in PPI, and ambiguity with the "living will" in LCPM. Another consideration with the CPS and PPI is that the validation studies were conducted in Asian countries where cancer prevalence and treatment may differ from those

Table 3a / COMPARISON OF THE FOUR NON-DISEASE-SPECIFIC PROGNOSTIC TOOLS FOR HOSPICE PALLIATIVE CARE

Tool	Population/ Setting	Strengths	Limitations	Overall Value
Palliative Performance Scale (PPS) [ref 3,25,35]	Heterogeneous; home/community hospice, palliative care units, nursing homes, hospital consult services	Used in different settings for cancer and noncancer patients; low PPS highly predictive of survival rates from <1 week to <6 months; lower PPS is associated with higher level of dyspnea	Studies with single programs only, unclear on how results apply to other sites; ambiguity at PPS 40%–60% range; existence of 3 PPS bands questionable; further validation needed on distress scale used to relate PPS and symptoms	PPS is a useful communication tool; it is a strong predictor of survival in cancer and noncancer patients across different settings; caution is needed in discriminating mid-range PPS levels
Palliative Prognostic Score (PaP) [ref 22,23,29]	Heterogeneous; palliative care units, oncology ward, hospital consult services	Used in different settings for cancer and noncancer patients; PaP highly predictive of 30-day survival; combines performance status with clinician estimates, symptoms, and lab tests known as predictors	Requires lab test for WBC and lymphocyte%; clinician survival estimate ranges seem arbitrary; KPS groupings questionable; prediction up to 30 days only; originally designed for cancer, then used in heterogeneous patients, so needs further validation	PaP is a simple-to-use instrument for survival prediction in cancer and noncancer patients across different settings; further validation needed
Prognostic Index 1-yr Mortality Older Adults (PIMOA) [ref 41]	Heterogeneous ≥70 yrs old; community hospital	Used for cancer and noncancer patients; combines ADL with selected diseases and lab tests leading to 4 distinct risk groups	Only ≥70 yrs old discharged from hospital where palliative care may be appropriate; ADL data from interviews is subjective and ADL groupings questionable; prediction at 1 year survival only	PIMOA could supplement clinician's prognosis for older patients after hospital discharge to discuss advance directives; further validation needed
Mortality Risk Index Score (MRIS) [ref 2]	Heterogeneous; nursing home new admission	Tool seems robust as it is based on >10,000 cases from 643 nursing homes; MDS data should be readily available since all new admissions are assessed using MDS	MDS data is time consuming to collect, with its own scales not used elsewhere; limited to new admissions to nursing homes; prediction at 1-year survival only	MRIS could be a useful planning tool for patients entering nursing homes but its use in palliative care is uncertain; further validation needed

WBC=white blood count; KPS=Karnofsky performance status; ADL=activities of daily living; MDS=minimum data set

Table 3b / COMPARISON OF THE SIX DISEASE-SPECIFIC PROGNOSTIC TOOLS FOR HOSPICE PALLIATIVE CARE

Tool	Population/ Setting	Strengths	Limitations	Overall Value
Intrahospital Cancer Mortality Risk Model (ICMRM) [ref 17]	Cancer; teaching hospital	Used for all hospitalized cancer patients excluding hematologic malignancies; high predictive accuracy with validation cohort; model uses ECOG performance scale well known by clinicians	Single study in teaching hospital setting; requires lab test for Hgb and LDH; curable cancers under-represented; short term prediction only; complex formula to compute survival probability may deter use	ICMRM could be a useful tool for clinicians to predict survival upon hospital admission for care planning; further validation needed
Cancer Prognostic Scale (CPS) [ref 18]	Cancer; palliative care units	Used in all types of cancer; able to predict short-term survival of 1–2 weeks; uses tumour staging, symptoms, ECOG that are easy to obtain and known predictors	Single study in an Asian hospital with different cancer prevalence; symptoms such as tiredness and weight loss can be subjective; short-term prediction of 1–2 weeks	CPS is a simple-to-use tool for cancer patients in their final stage of dying; further validation needed especially in non-Asian settings
Palliative Prognostic Index (PPI) [ref 31]	Cancer; palliative care units	Used for all types of cancer in a palliative care unit; includes PPS and selected symptoms known as predictors; high predictive accuracy with cut-off scores for <3 and <6 week survival	Studies in one Asian setting with different cancer prevalence; symptoms can be subjective; use of PPS bands questionable; significance of near-cut-off scores unclear; prediction up to 6 weeks	PPI is a simple-to-use tool for predicting up to 6 week survival in cancer patients; further validation needed especially in non-Asian settings
Lung Cancer Prediction Model (LCPM) [ref 36]	Lung cancer; hospice	Specific to lung cancer with multiple variables for function, tumour type, pain, and living will; prediction ranges from 3 to 443 days based on variables present	Single study in one hospice setting for lung cancer; type of living will can be subjective; 65% male subjects not reflective of changing prevalence; model difficult to use	LCPM may be useful since lung cancer is common in hospice palliative care; further validation needed
Heart Failure Risk Scoring System (HFRSS) [ref 26]	Heart failure; community and teaching hospitals	Specific to heart failure in different hospital settings; uses information routinely available to clinicians; high predictive accuracy for 30-day and 1-year survival;	Single study for new heart failure patients only but from multiple hospital sites; needs lab test for BUN, Na, and Hgb; complex formula for scoring may defer use	HFRSS could be a useful tool as heart failure cases are increasingly seen by palliative care services; 30-day and 1-year survival probabilities are useful in care planning; caution until further validation is needed
Dementia Mortality Index (DMI) [ref 4]	Dementia; community hospice	Specific to dementia in community hospice setting; few variables that are easy to obtain; predictive for 6-month survival	Single study in one community hospice setting only; use of data imputation to maintain sample size in study questionable; insufficient detail on model and its actual application	DMI may be a useful tool for 6-month survival prediction of dementia patients in hospice settings; further validation needed as it is based on a single study

ECOG=Eastern Cooperative Oncology Group; Hgb=hemoglobin; LDH=lactose dehydrogenase; Na=sodium; BUN=blood urea nitroge

in North America and Europe. The strengths of HFRSS and DMI (for heart failure and dementia patients, respectively) lie in the use of routinely available clinical data, which enable them to predict 30-day and one-year survival in heart failure, and six-month survival in dementia. The overall value of these six tools is their potential usefulness in predicting survival time of hospice palliative care patients with many types of cancer, heart failure, and dementia. A major limitation is that most of these tools have been tested in single studies conducted at single sites. Exceptions are the PPI, which has been reported in more than one study (same authors and setting); and HFRSS, which is based on multiple hospital sites. Considered together, all of these tools require further independent validation to determine whether they can be generalized for routine use in hospice palliative care.

Implications for Research

From this systematic review, we have identified three key issues around the validation, reporting, and refinement of these 10 prognostic tools for hospice palliative care that require further research.

Need for Further Validation. A major limitation of the 10 prognostic tools featured in this review is the lack of independent validation with different patient populations, care settings, and research/clinician teams. Even the more established tools such as PPS, PPI, and PaP would benefit from further validation efforts to

assess their predictive accuracy when used with different patient populations and care settings. Additionally, it is important to note that many of these tools are based on studies involving relatively small sample sizes from single sites. For instance, the Glare (23) PaP validation study was based on 98 cancer patients from an oncology ward of a teaching hospital. Also, some tools were developed/validated from retrospective cohort studies, which are less robust in design. Thus, we recommend that more prospective studies with larger samples in multiple settings be undertaken to further examine the validity and reliability of these tools for predicting survival.

Consistent Reporting of Prognosis. Another challenge for clinicians is being able to make sense of the survival prediction scores that arise from use of the tools. For instance, the results for these 10 tools vary dramatically across the 15 studies. There are few instructions to guide clinicians on how to interpret the scores/results in ways that are applicable to their own settings and patients. As an example, PaP (22,23,29) uses a fixed, 30-day survival time with three ranges of survival probabilities based on the patient score, whereas PPS (3,25,35) has different survival times that range from seven days to six months, depending on the PPS level. Both CPS (18) and PPI (31) use cut-off scores with distinct survival time intervals (e.g., <3 weeks if PPI >6). Some of the single studies for such tools as PIMOA (41) and MRIS (2) included results from both derivation and validation cohorts, but offered no guidance on how they should be interpreted. The dementia study (4) contains no information on how one can compute and use the DPI score.

It is clear that much research is still needed to reach consensus about which survival prediction scores/results to report and describe to make it easier for clinicians to compare the tools and use in discussion with patients and families. The following survival intervals are proposed as indicators: 1 day, 3 days, 1 week, 2 weeks, 1 month, 2 months, 3 months, 6 months, 1 year, 3 years, and 5 years. When death is near, short intervals recognize that rapid changes are common. For the patient, such clarity may provide time for "last words"; for family, practical concerns of when to travel are crucial if they desire to be present before death, or of the likely remaining burden in providing care; and, for clinicians, more helpful discussions can occur regarding the above, as well as considering workload needs or feasibility in location of death. Using wider intervals at higher levels of functioning recognizes such variability in survival as well as the time required to assess maximum effects of some treatments. These intervals were drawn from the varying survival scales cited in the 15 studies. As such, they require consensus from frontline clinicians and validation from further studies.

Refinement of the Prognostic Tools. Survival prediction in hospice palliative care is inherently complex, as seen in this review, with the range of prognostic tools available and the large number of variables involved. While many of these variables are known predictors based on an earlier review by Viganò (9), it is not clear if their inclusion in these tools is optimal, or whether the addition or reduction of other variables can further improve predictive accuracy. For instance: Should PPS be grouped into three risk categories as reported by Harrold (25) and used accordingly in PPI (31), when Lau (42) showed significant separations at each PPS level? Combined with the knowledge that certain symptoms are associated with decreased survival, it is important to ask how much more accuracy in survival prediction can be achieved through the use of tools such as the PPS. For tools that include symptoms, should they be specific sets of symptoms or can one simply count the number of symptoms present, as with LCPM (36)? Can KPS be replaced with PPS in the PaP tool, since PPS extends beyond hospitalization with its ambulation dimension? How important is it to include the lab test in PaP versus PPI or PPS?

Currently, survival prediction begins with an initial set of factors when the patient is first seen by the clinician. Therefore, another question that can be asked is whether the predictive accuracy can be improved through repeated measures. And if so, how often should these be repeated? Further, would it be meaningful to consider the amount of change or rate of change to improve prediction accuracy? These are just some examples of the types of research questions that should be considered to help refine the composition, use, and value of the prognostic tools in hospice palliative care.

Enhancing the Quality of Publications. Only 15 of the 28 studies reviewed were considered to be of sufficient quality for inclusion in our final synthesis. Further suggestions for enhancing the quality of prognostic tool studies are to use a representative and well-defined patient cohort, a prospective study design, an unbiased data collection method with sufficient follow up and minimal dropouts, and appropriate statistical techniques that include strategies for dealing

with confounding variables. Last and equally important, researchers and clinicians should continue to work together to provide sufficient instructions to guide how best to develop and use the tools and results.

Limitations of This Review

Despite our best effort to conduct a thorough synthesis of the current state of knowledge on prognostic tools in hospice palliative care, the review has a number of limitations. First, the process used to search the literature and select the articles for review may have excluded important studies that would be considered relevant. For example, we focused on English articles only, so studies published in other languages would have been missed. Also, since we insisted on using only those prognostic tools that have been validated, some well known assessment tools such as ECOG and KPS had to be excluded, as we could not find appropriate validation studies using them within hospice palliative care settings.

Second, we took a more traditional view of the terminally ill and assumed they would reside at home, in residential hospices, palliative care units, or receive hospital-based palliative consult services. As such, we avoided dealing with the expanding concept of the end-of-life care continuum and excluded studies with such tools as SUPPORT, which have originated in critical care settings (43,44). Third, none of our clinical research team have used any of the prognostic tools reviewed except for PPS; therefore, our understanding of these tools may be limited. Finally, this review excluded prognostic tools that are based on quality-of-life instruments, which are to be the topic of a future systematic review by the authors.

CONCLUSIONS

Prognostication in hospice palliative care is a complex task for clinicians because of the wide range of factors that must be taken into account, including variations that exist between individuals, diseases, care settings, and the environment. At the same time, clinicians need simple validated prognostic tools to assist with survival prediction for their patients. In this review, the 10 prognostic tools featured were grouped into two categories—non-disease-specific and disease-specific. Under the disease-specific tools are those that have been created for cancer and noncancer populations. Two decision trees were constructed to guide clinicians on the use of these tools based on disease, patient population, and care setting. This is a key contribution of this systematic review, along with the consideration of the conditions under which the tools should be used, their strengths, limitations, and value in survival prognosis. Overall, this review aims to promote better understanding and uptake of these tools by clinicians wanting to use them in practice. For this reason, the information from the systematic review has been captured in a series of tables for comparative and educational purposes. Some of these tools, including the most studied PPS, PaP, and PPI, hold promise for improving clinicians' survival estimates. Ultimately, much more research is needed, including further validation of the 10 tools in different patient populations and settings, more consistent reporting of prognostic scores/results, and ongoing refinement of these tools as new research and data come to light.

A tool and its predicted result are only a number that acts as a guide. It is important to keep in mind that every patient is unique, with a host of characteristics and attributes that affect when he or she might die. Even with the aid of prognostic tools, at the bedside there is also caution and mystery at hand, such that one can only observe and not determine the final journey.

Date received, November 24, 2006; date accepted, April 3, 2007.

ACKNOWLEDGEMENTS

Funding support for this review has been provided through the Canadian Institutes of Health Research New Emerging Teams in Palliative and End-of-Life Care grant, the Telus Strategic Alliance Grant, and the Victoria Hospice Society's Strengthening the Base initiative.

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Appendix 1a: Palliative Performance Scale (PPS)

Publication Source: Head [ref 3], Harrold 2005 [ref 25] and Olajide 2004 [ref 35]
Disease Type: Non-disease-specific
Patient Population: Cancer and noncancer patients; Head 2005 study excluded patients with length of stay (LOS) <5 days [ref 3]
Care Setting: Palliative care consults, acute care hospital, palliative care unit, community hospice including nursing home, home
Survival Prediction: Median survival in days; 6 months mortality; mortality rate at each PPS level; mortality rate at 7, 30, 90, and 180 days
Variables: Ambulation, activity, and evidence of disease; self-care; intake; conscious level
Data Collection: Assessment conducted within 24 hours of admission/consult/enrolment
Score Range: 11 categories from 0% to 100% in increments of 10%
Reporting: PPS scores are associated with length of survival, decreased scores are predictive of decline toward death, while stable PPS over time result in discharge considerations [Head, ref 3]; 3 PPS categories at PPS 10%–20%, 30%–40% and ≥50% with different 6-month mortality rates, and stronger association between PPS and mortality, nursing home residents, and noncancer diagnoses [Harrold, ref 26]; lower PPS significantly associated with higher levels of dyspnea [Olajide, ref 35]

(a) PPS variables and levels

PPS Level	Ambulation	Activity & Evidence of Disease	Self-care	Intake	Conscious Level
100%	full	normal activity & work no evidence of disease	full	normal	full
90%	full	normal activity & work some evidence of disease	full	normal	full
80%	full	normal activity with effort some evidence of disease	full	normal or reduced	full
70%	reduced	unable normal job/work significant disease	full	normal or reduced	full
60%	reduced	unable hobby/housework significant disease	occasional assistance necessary	normal or reduced	full or confusion
50%	mainly sit/lie	unable to do any work extensive disease	considerable assistance required	normal or reduced	full or confusion
40%	mainly in bed	unable to do most activity extensive disease	mainly assistance	normal or reduced	full or drowsy +/- confusion
30%	totally bed bound	unable to do any activity extensive disease	total care	normal or reduced	full or drowsy +/- confusion
20%	totally bed bound	unable to do any activity extensive disease	total care	minimal to sips	full or drowsy +/- confusion
10%	totally bed bound	unable to do any activity extensive disease	total care	mouth care only	drowsy or coma +/- confusion
0%	death	-	-	-	-

(b) Reporting of PPS survival estimates from Harrold study (25, p. 506)

		PPS 10%–20%			
	Death on or before	7 days	30 days	90 days	180 days
	Mortality (all patients)	72%	91%	96%	96%
Site of care	nursing home	79%	92%	95%	95%
	community	64%	90%	97%	100%
Diagnosis	cancer	50%	62%	100%	100%
	non-cancer	74%	94%	96%	97%

		PPS 30%–40%			
	Death on or before	7 days	30 days	90 days	180 days
	Mortality (all patients)	22%	58%	80%	89%
Site of care	nursing home	17%	57%	77%	88%
	community	24%	58%	82%	90%
Diagnosis	cancer	20%	60%	88%	95%
	non-cancer	23%	57%	76%	85%

		PPS 50%–70%			
	Death on or before	7 days	30 days	90 days	180 days
	Mortality (all patients)	6%	33%	69%	81%
Site of care	nursing home	6%	35%	71%	76%
	community	7%	24%	59%	82%
Diagnosis	cancer	5%	36%	75%	84%
	non-cancer	9%	27%	56%	75%

Appendix 1b: Palliative Prognostic Score (PaP)

Publication Source: Glare 2001 [ref 22], Glare 2004 [ref 23] and Maltoni 1999 [ref 29]
Disease Type: Non-disease-specific
Patient Population: Cancer and noncancer patients
Care Setting: Hospital palliative care consults, palliative care unit, oncology ward
Survival Prediction: 30-day survival probability
Variables: Dyspnea, anorexia, Karnofsky performance status, clinical prediction of survival in weeks), total white blood count, and lymphocyte%
Data Collection: Data collected upon enrolment
Score Range: From 0 to 17.5 with 3 risk groups A, B, and C based on score range
Reporting: Three risk groups with different chances of surviving 30 days; group A with >70% chance, group B with 30%–70% chance, and group C with <30% chance [Glare 2004, ref 23]

(a) PaP variables, values and partial scores

Variable	Value	Partial Score
Dyspnea	no	0
	yes	1
Anorexia	no	0
	yes	1.5
Karnofsky performance status (KPS)	≥30	0
	≤20	2.5
Clinical prediction of survival (weeks)	>12	0
	11–12	2
	9–10	2.5
	7–8	2.5
	5–6	4.5
	3–4	6
	1–2	8.5
Total white blood count (WBC)	normal (4.8–8.4)	0
	high (8.5–11)	0.5
	very high (>11)	1.5
Lymphocyte%	normal (20–40)	0
	low (12–19.9)	1.0
	very low (<11.9)	2.5
	Total	0–17.5

Risk Group 30-day Survival Probability	Score
A >70%	0–5.5
B 30%–70%	5.6–11.0
C <30%	11.1–17.5

(b) Karnofsky Performance Scale

100	Normal no complaints; no evidence of disease
90	Able to carry on normal activity; minor signs or symptoms of disease
80	Normal activity with effort; some signs or symptoms of disease
70	Cares for self; unable to carry on normal activity or to do active work
60	Requires occasional assistance, but is able to care for most personal needs
50	Requires considerable assistance and frequent medical care
40	Disabled; requires special care and assistance
30	Severely disabled; hospital admission is indicated although death not imminent
20	Very sick; hospital admission necessary; active supportive treatment necessary
10	Moribund; fatal processes progressing rapidly
0	Dead

Reference source: http://www.hospicepatients.org/karnofsky.html

Appendix 1c: Prognostic Index 1-yr Mortality Older Adults (PIMOA)

Publication Source: Walter 2001 [ref 41]
Disease Type: Non-disease-specific
Patient Population: Adults ≥70 yrs excluding ICU patients, LOS <2 days, elective admission
Care Setting: Community hospital, specialty services
Survival Prediction: 1-year mortality rate
Variables: Male, ADL dependency at discharge, comorbid conditions, creatinine and albumin on admission
Data Collection: Standardized interviews with patients and surrogates at admission and discharge, and from medical record
Score Range: 4 categories from 0 to >6 based on points for risk factors present
Reporting: 1-year mortality rate in percentage based on PIMOA score, derived from development/validation cohort mortality rates in [ref 41, page 2992]

(a) PIMOA risk factors and points

Risk Factor	Points
Male	1
ADL dependencies at discharge	
dependent in 1–4 ADLs	2
dependent in all ADLs	5
Comorbid conditions	
congestive heart failure	2

cancer	
solitary cancer	3
metastatic cancer	8
Laboratory values on admission	
creatinine, mg/dL*	
>3.0	2
albumin, g/dL	
3.0–3.4	1
<3.0	2

ADL=activities of daily living; *to convert to μmol/L, multiply by 88.4

(b) Reporting of 1-year mortality risk (also called bedside risk scoring system)

	Derivation Cohort		Validation Cohort	
Risk group, points	No. who died/No. at risk	95% CI	No. who died/No. at risk	95% CI
0–1	46/356	13 (10–16)	14/364	4 (2–6)
2–3	77/382	20 (16–24)	74/391	19 (15–23)
4–6	176/475	37 (33–41)	137/399	34 (29–39)
>6	193/282	68 (63–73)	173/273	64 (58–70)

CI=confidence interval

Appendix 1d: Mortality Risk Index Score (MRIS)

Publication Source: Flacker 2003 [ref 2]
Disease Type: Non-disease-specific
Patient Population: Newly admitted residents
Care Setting: Nursing home
Survival Prediction: 1-year mortality risk
Variables: Presence of cancer, shortness of breath, CHF, bedfast, male, unstable conditions, >25% food uneaten, low functional ability score, swallowing problem, bowel incontinence, BMI <23 kg/m²
Data Collection: Complete MDS assessment within 2 weeks of new admission
Score Range: 10 categories from 0 to 19, sum of hazard ratio for variables present
Reporting: 1-year mortality rate in percentage based on MRIS score, derived from development/validation cohort mortality rates in [ref 2, p. 218]

(a) MRIS partial scores for 1-year mortality risk

Variable	Development Cohort Hazard Ratio (95% CI)	Validation Cohort Hazard Ratio (95% CI)
Presence of cancer	2.48 (2.34–2.63)	2.43 (2.28–2.60)
Shortness of breath	2.24 (2.09–2.40)	2.15 (2.00–2.32)
Congestive heart failure	1.65 (1.60–1.71)	1.66 (1.60–1.73)
Bedfast	1.92 (1.72–2.10)	1.99 (1.90–2.20)
Male	1.52 (1.47–1.57)	1.42 (1.37–1.48)
Unstable conditions	1.87 (1.76–1.98)	1.59 (1.50–1.69)
>25% of food uneaten	1.80 (1.71–1.89)	1.75 (1.65–1.85)
Low functional ability score	1.76 (1.66–1.87)	1.77 (1.65–1.90)
Swallowing problem	1.53 (1.43–1.64)	1.41 (1.31–1.52)
Bowel incontinence	1.39 (1.32–1.48)	1.44 (1.35–1.54)
Body mass index <23 kg/m²	1.29 (1.25–1.34)	1.36 (1.31–1.41)

CI=confidence interval

(b) Reporting of 1-year mortality rate by MRIS in percent

Score	Development Cohort (mortality rate in %)	Validation Cohort (mortality rate in %)
0–1	11.8	11.4
2–3	20.7	20.2
4–5	31.3	32.3
6–7	43.4	44.5
8–9	56/6	55.9
10–11	70.6	69.0
12–13	80.6	81.7
14–15	92.7	87.6
16–17	95.4	95.4
18–19	100.0	100.0

Appendix 2a: Intrahospital Cancer Mortality Risk Model (ICMRM)

Publication Source: Bozcuk 2004 [ref 17]
Disease Type: Disease-specific, all cancers except hematological malignancies
Patient Population: Cancer patients
Care Setting: Internal medicine ward in teaching hospital
Survival Prediction: Probability of intrahospital death at time of hospitalization
Variables: Performance status, ECOG, duration of disease, duration in days, type of admission, hemoglobin (Hgb), lactose dehydrogenase (LDH)
Data Collection: Data from medical records and department database at time of admission
Score Range: Sum of hazard ratio for each variable present in resident

Reporting: Likely to die in hospital with ECOG grade 4, short disease duration, emergency admission, low Hgb and high LDH at time of admission

(a) The Intrahospital Cancer Mortality Risk Model Equation

ICMRM = log [probability of death / (1 – probability of death)]
= [5.53 + 4.89 x performance status (1 if ECOG = 4, 0 if otherwise)]
– [log duration of disease (log transformation of duration in days)]
– [1.91 x type of admission (1 if elective, 0 if emergency)]
– [0.18 x Hgb (g/dl) + 2.27 x LDH (1 if >378 μ/ml, 0 if otherwise)]

(b) ECOG Performance Status (ECOG-PS), from Oken et al. [ref 45]

Grade	Description
0	Fully active, able to carry on all pre-disease performance without restriction
1	Restricted in physically strenuous activity, but ambulatory and able to carry out work of a light or sedentary nature, e.g., light house work, office
2	Ambulatory and capable of all self care but unable to carry out any work activities. Up and about more than 50% of waking hours
3	Capable of only limited self-care, confined to bed or chair more than 50% of waking hours
4	Completely disabled. Cannot carry on any self-care. Totally confined to bed or chair
5	Dead

Appendix 2b: Cancer Prognostic Scale (CPS)

Publication Source: Chuang 2004 [ref 18]
Disease Type: Disease-specific, all cancers
Patient Population: Cancer patients
Care Setting: Palliative care unit
Survival Prediction: 1-week and 2-week survival based on CPS score
Variables: Sum of partial scores for (lung metastasis + liver metastasis + tiredness + ascites + edema + cognitive impairment + weight loss + ECOG)
Data Collection: Not specified
Score Range: 0 to 8.5, sum of partial score based on each variable present
Reporting: 2-week predicted survival when CPS scores were <3.5 and 1-week predicted survival when CPS scores were <6.0

(a) CPS score=0.0 (no altered variables) to 8.5 (maximal alteration for all variables)

Variable	Severity	Partial Score
Lung metastasis	Yes	0.5
Liver metastasis	Yes	0.5
Tiredness	3	1
Ascites	2, 3	1
Edema	1, 2, 3	1
Cognitive impairment	1, 2, 3	0.5
Weight loss	1	0.2
	2	0.7
	3	1
ECOG	2	1.5
	3	2
	4	3

(b) Accuracy of CPS in survival prediction for training and test data sets

Predicted Survival	Training Set Accuracy	Test Set Accuracy
Survival <2 weeks (cutoff score ≥3.5)	0.72	0.61
Survival <1 week (cutoff score ≥6.0)	0.72	0.66

Appendix 2c: Palliative Prognostic Index (PPI)

Publication Source: Morita 1999 [ref 31]
Disease Type: Disease-specific, all cancers
Patient Population: Cancer patients
Care Setting: Palliative care unit
Survival Prediction: Predicted survival of <3 weeks and <6 weeks based on PPI score
Variables: PPS, oral intake, edema, dyspnea at rest, and delirium
Data Collection: Data collected upon admission
Score Range: 3 risk groups, from 0 to 15 based on sum of partial score values
Reporting: Three risk groups: A (PPI≤2.0), B (2.0<PPI≤4.0), and C (PPI>4.0) identified, where group B expected to survive significantly longer than group C, and group A to survive significantly longer than either group. Also <3-week survival is expected when PPI >6.0 cutoff is used, with <6-week survival is expected when PPI >4.0 cutoff is used [ref 32]

CPS variables, values, and partial scores

Variable	Value	Partial	Max
Palliative performance scale	10–20	4.0	4.0
	30–50	2.5	
	>60	0	

Oral intake	severely reduced (<mouthfuls)	2.5	2.5
	moderately reduced (>mouthfuls)	1.0	
	normal	0	
Edema	present	1.0	1.0
	absent	0	
Dyspnea at rest	present	3.5	3.5
	absent	0	
Delirium	present	4.0	4.0
	absent	0	
			15.0
Risk groups: A (PPI≤2.0), B (2.0<PPI≤4.0), and C (PPI>4.0)			
Expected survival using cutoff points:		PPI>6.0	<3 weeks
		PPI>4.0	<6 weeks

Appendix 2d: Lung Cancer Prediction Model (LCPM)

Publication Source: Schonwetter 1994 [ref 36]
Disease Type: Disease-specific, lung cancer
Patient Population: Lung cancer patients
Care Setting: Hospice
Survival Prediction: 50% and 90% mortality in days after admission to hospice
Variables: Pulse, toileting, feeding, living will, tissue type, dry mouth, liver metastasis, and pain
Data Collection: Data collected upon admission with evaluation form
Score Range: 0 to 8, based on the number of variables present
Reporting: Shorter survival is independently associated with those who had no living will on admission to hospice, had tissue types other than squamous cell or adenocarcinoma, had liver metastases, were tachycardic, required assistance or were dependent in toileting and feeding, had dry mouths, and had severe or incapacitating pain [ref 36, pp. 368–369]

(a) LCPM Variables and Descriptors

Variable	Descriptor Associated With Shorter Survival Time
Pulse	Tachycardic
Toileting	Needs assistance or dependent
Feeding	Needs assistance or dependent
Living will	Absence
Tissue type	Other than adenocarcinoma or squamous cell
Dry mouth	Present
Liver metastasis	Present
Pain	Severe or incapacitating

(b) LCPM Composite Scores and Survival Times

Score (no. of variables)	n	50% Dead (days)	90% Dead (days)
1	4	83	443
2	26	71	346
3	42	46	184
4	78	37	121
5	65	19	67
6	58	9	65
7	26	9	34
8	6	3	10

Appendix 3a: Heart Failure Risk Scoring System (HFRSS)

Publication Source: Lee 2003 [ref 26]
Disease Type: Disease-specific, non-cancer, heart failure (HF)
Patient Population: HF patients excluding HF post-admission, from another acute care facility, >105 years old and nonresi dents
Care Setting: Community and teaching hospitals
Survival Prediction: 30-day and 1-year mortality risks
Variables: Age, vital signs (respiratory rate RR, systolic blood pressure SBP), serum concentration (sodium Na, hemoglobin Hgb, blood urea nitrogen BUN), comorbid condition (cerebrovascular disease [CVD], dementia, chronic obstructive pulmonary disease [COPD], hepatic cirrhosis, cancer)
Data Collection: Presenting features and clinical data within first 24 hours of admission
Score Range: 5 categories, ≤60 to >150 points based on partial scores from variables present for 30-day score and 1-year score
30-day score = age + RR + SBP + Na + BUN + CVD + dementia + COPD + cirrhosis + cancer
1-year score = age + RR + SBP + Na + BUN + CVD + dementia + COPD + cirrhosis + cancer + Hgb
Reporting: In the Lee study, patients with very low-risk scores (≤60) had a mortality rate of 0.4% at 30 days and 7.8% at 1 year. Patients with very high-risk scores (>150) had a mortality rate of 59.0% at 30 days and 78.8% at 1 year. Patients with higher 1-year risk scores had reduced survival at all times up to 1 year [ref 26, pp. 2581,2585]

(a) HFRSS variables and partial scores for 30-day and 1-year mortality

Variable	30-day score	1-year score
Age (years)	+age (in years)	+age (in years)
Respiratory rate, min (min 20; max 45)	+rate (in breaths/min)	+rate (in breaths/min)
Systolic blood pressure, mm Hg		
≥180	-60	-50
160–179	-55	-45
140–159	-50	-40
120–139	-45	-35
100–119	-40	-30
90-99	-35	-25
<90	-30	-20
Urea nitrogen (max 60 mg/dL)	+level (in mg/dL)	+level (in mg/dL)
Sodium concentration <136 mEq/L	+10	+10
Cerebrovascular disease	+10	+10
Dementia	+20	+15
Chronic obstructive pulmonary disease	+10	+10
Hepatic cirrhosis	+25	+35
Cancer	+15	+15
Hemoglobin <10.0 g/dL (<100 g/L)	NA	+10

(b) Mortality rates stratified by 30-day risk scores

		30-day mortality rate	
Risk category	Score	Derivation cohort	Validation cohort
Very low	≤60	0.4	0.6
Low	61–90	3.4	4.2
Intermediate	91–120	12.2	13.7
High	121–150	32.7	26.0
Very high	>150	59.0	50.0

(c) Mortality rates stratified by 1-year risk scores

		1-year Mortality Rate	
Risk Category	Score	Derivation cohort	Validation cohort
Very low	≤60	7.8	2.7
Low	61–90	12.9	14.4
Intermediate	91–120	32.5	30.2
High	121–150	59.3	55.5
Very high	>150	78.8	74.7

Appendix 3b: Dementia Mortality Index (DMI)

Publication Source: Schonwetter 2003 [ref 4]
Disease Type: Disease-specific, noncancer, dementia excluding nonprogressive dementia and stroke
Patient Population: All dementia patients except those secondary to trauma or substance abuse, and those with stroke
Care Setting: Community-based hospice
Survival Prediction: Predicted mortality at 6 months
Variables: Age, marital status, anorexia, KPS, anorexia/KPS interaction
Data Collection: Data from medical records, admission history, and physical collected
Score Range: Not defined in original article
Reporting: Hospice patients who are older, more anorexic, and have a poorer functional status on admission to hospice likely to have shorter survival times in hospice, with the combination of a low KPS and anorexia being an additional significant predictor [ref 4, p. 110]

DMO Variables and 6-month survival times of original and validation cohorts

		<6-Month Survival	
Variable	Value	Original cohort	Validation cohort
Age	in years	older adults	older adults
Marital status	married/unmarried	married	NA
Anorexia	present	present	present
Karnofsky performance scale*	0% to 100%	poor function	poor function
Anorexia-KPS interaction**	present and 0% to 100%	anorexia with low KPS score	anorexia with low KPS score

NA=variable not applicable in model; *KPS is only marginally significant in the model; **presence of anorexia and poor functional status has highest risk of dying before six months

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