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Development of a tool for defining and identifying the dying patient in hospital: Criteria for Screening and Triaging to Appropriate aLternative care (CriSTAL)

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ABSTRACT

Objective To develop a screening tool to identify elderly patients at the end of life and quantify the risk of death in hospital or soon after discharge for to minimise prognostic uncertainty and avoid potentially harmful and futile treatments.

Design Narrative literature review of definitions, tools and measurements that could be combined into a screening tool based on routinely available or obtainable data at the point of care to identify elderly patients who are unavoidably dying at the time of admission or at risk of dying during hospitalisation.

Main measurements Variables and thresholds proposed for the Criteria for Screening and Triaging to Appropriate aLternative care (CriSTAL screening tool) were adopted from existing scales and published research findings showing association with either in-hospital, 30-day or 3-month mortality.

Results Eighteen predictor instruments and their variants were examined. The final items for the new CriSTAL screening tool included: age ≥ 65 ; meeting ≥ 2 deterioration criteria; an index of frailty with ≥ 2 criteria; early warning score >4 ; presence of ≥ 1 selected comorbidities; nursing home placement; evidence of cognitive impairment; prior emergency hospitalisation or intensive care unit readmission in the past year; abnormal ECG; and proteinuria.

Conclusions An unambiguous checklist may assist clinicians in reducing uncertainty patients who are likely to die within the next 3 months and help initiate transparent conversations with families and patients about *end-of-life* care. Retrospective chart review and prospective validation will be undertaken to optimise the number of prognostic items for easy administration and enhanced generalisability. Development of an evidence-based tool for defining and identifying the dying patient in hospital: CriSTAL.

BACKGROUND

The natural progression of chronic disease involves periods of apparent remission interspersed by exacerbations and, in the year leading to death, multiple hospitalisations.¹ Some indicators of poor prognosis can suggest a patient is nearing the *end of life*,² and have been found useful for initiating discussions with families regarding pre-emptive care planning.¹ Yet there is uncertainty of the time, frequency and duration of the next episode of decompensation as well as the ultimate prognosis causing doubts about whether to continue active management. Further, while the majority of people want to die at home, most will die in hospital.^{3–8} Patients nearing the end of life are high-level users of ambulance services,⁹ emergency services,^{2 10} hospital wards¹¹ or intensive care units and many die in hospital.¹² Significant numbers of patients with cancer or other terminal illnesses are suitable for palliative care but often are readmitted to acute hospitals multiple times with lengths of stay of just under a week.^{10 13 14} While there are accepted policies for de-escalating treatment in terminally ill patients,^{2 15–17} there are also inherent and societal pressures on medicine to continue utilising technological advances to prolong life even in plainly futile situations.¹⁵

The implications of a decision to administer or withhold aggressive treatment for terminal patients are enormous for clinicians, patients and their families, for the health system and for society as a whole. It can be difficult to reach a decision that balances the rights of patients to die with dignity^{18 19} and the expectations of families about satisfactory *end-of-life* care,^{20 21}



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while considering the limitations of health resources where opportunity costs cannot be disregarded.^{22–24} Delaying unavoidable death contributes to unsustainable and escalating healthcare costs, despite aggressive and expensive interventions. These interventions may not influence patient outcome; often do not improve the patient's quality of life; may compromise bereavement outcomes for families; and cause frustration for health professionals.^{20 25–29} This highlights the importance of developing more accurate ways of identifying patients near the end of life, involving both the patients and their carers in those discussions and then making more appropriate management plans.

For about two decades many acute hospitals have adopted rapid response systems to identify and manage seriously ill patients.^{25 30–32} They were initially developed to recognise at-risk patients early as a basis for triggering a rapid response to improve patient outcomes. In doing so, the system also identifies patients at the end of life who are predictably deteriorating. Up to one-third of all of rapid response team (RRT) calls have been related to end-of-life issues.^{33 34} This emphasises the failure of current hospital systems to recognise patients at the end of life. Often it is the patient and carers who initiate this conversation.^{25 35}

Clinical decision aids are widely used to involve patients in informed treatment decisions that incorporate their personal preferences and values.³⁶ Sensitive clinical decision rules have been used to discontinue futile resuscitation on patients who experience a cardiac arrest.³⁷ However, we have not found a fit-for-purpose screening checklist or clinical decision tool for objective identification of *end of life* within days, weeks or months to minimise inappropriate treatment at hospital admission.²⁹ There is a need to recognise patients at the end of life while at the same time acknowledging uncertainty around the exact time and circumstances when death will occur.³⁸

The aims of the CrisTAL checklist are to assist clinicians to recognise these patients and to change the culture of the hospital to one where end of life is openly discussed and dealt with more appropriately.³⁹

RATIONALE

Accordingly, there is a need to collate evidence to assist clinicians, carers and families in decision-making about the most sustainable model for appropriate and best quality care in the last few months of life. The specific objectives of this research are to:

1. review literature to obtain definitions for *dying patient* and *end of life*;
2. review existing literature regarding screening tools for the prediction of death in hospitalised patients;
3. propose a checklist for screening of hospitalised patients at-risk of dying in the short to medium term.

Two common and important situations where patients at the end of life can potentially be identified

are on admission to the emergency department (ED); and when a patient deteriorates and becomes the subject of a RRT call. This paper reports on the development of a clinical decision aid for use in both circumstances: CrisTAL (Criteria for Screening and Triaging to Appropriate aLternative care). It summarises the information available in the literature to construct the domains for such a screening instrument based on patient data items routinely available at the point of care.

The tool is intended to offer a starting point to begin discussions with the patient and relatives about priorities and preferences on type and place for *end-of-life* care.^{39 40} It also may identify elderly who will benefit from alternative care pathways instead of hospitalisation.^{5 41} The routine use of such a tool may also change the culture of the organisation to one which is more aware of patients who may be at the end of life and one where different management pathways are considered earlier. The tool is not meant to dictate whether or not a patient receives life sustaining therapy or is the subject of a do-not-resuscitate order. However, it may provide an objective assessment to inform and support that decision, made jointly by patients, their family and the treating team.

METHODS

We undertook a narrative literature search in PubMed, Cochrane Library and Google Scholar for published and unpublished papers about explicit and practical definitions of '*end of life*' and for tools or screening instruments to predict death. The search strategy included the following terms: (End of life, terminal, dying, inappropriate resuscitation, do-not-resuscitate, cardiopulmonary resuscitation order, limitations of treatment, discontinuation of care, futility, advanced directive) and (hospital, acute care facility, palliative care, ED) and (Screening tool, decision aid, algorithm, predictive, predictor of death). This was supplemented with manual searches through the reference lists of eligible papers.

The variables and thresholds explored for the screening tool were adopted from existing scales and published findings that demonstrated their association with either in-hospital or 30-day mortality or survival to 12 weeks.^{42–47} Based on the practicalities of applying the tool as decision-making support at the point of care, we used four criteria to decide whether the existing instrument was helpful for the purpose of objectively diagnosing dying and whether to discard items: ready availability in medical records,^{42 43} need for clinical judgement, use of value judgment and self-sufficiency of indicators. This review was followed by consultation with two doctors and three ICU nurses with intensive care qualifications and experience in end-of-life care, about the feasibility of acquiring or documenting these data items in routine care.

RESULTS

We found 112 relevant articles dealing with the definition of dying, determination of severity of deterioration, prediction of in-hospital death, preferred place of death and options for alternative end-of-life care. Among these, we identified 18 instruments and their variants validated in different settings. Below is a summary of the operational definitions and commonly used or cited tools to predict death in hospital.

Operational definitions

Nine working definitions of end of life were found to assist in limiting the number of items for a screening

tool to a manageable set (table 1). These were mostly impractical in their requirement of clinicians' subjective assessment; or confined to patients imminently dying within hours; and of limited use for elderly patients with chronic disease, nearing end of life within days or weeks.

We defined *inappropriateness of admission to hospital* for patients at the end of life as those 'admissions when the resources of the hospital will not have any significant impact on the clinical prognosis of the elderly patient with multiple life-threatening comorbidities'.

As pragmatic definitions of '*dying patients*' were not prevalent in the literature, we searched for a suitable

Table 1 Definitions of *end of life* and their suitability for routine use in screening

Year	Author/reference	Definitions or potential items to include in a definition	Comments and rationale for inclusion or exclusion
1981	US President's Commission ⁴⁸	When a terminally ill, mentally competent patient refuses resuscitative treatment and/or where treatment would be futile	Does not assist in applying terminology in a screening tool for use in routine care as it would be impractical without operational boundaries or classification of irreversible conditions or futile treatments
1987	Blackhall ⁴⁹	When treatments will not be beneficial and may even be potentially harmful	This concept may be clearer for specialists but not so useful for first-line doctors/nurses at admissions in ED
1989	Stolman ¹⁵	Terminally ill patient, imminently dying (life expectancy ≤6 months) chronic debilitating irreversible condition where life-saving treatment would be futile. Coupled with competent patient with unacceptable quality of life who refuses treatment or whose family requests to not resuscitate	Life expectancy would require a prognostic table and some patients with low quality of life may refuse treatment but they are not imminently dying
1990	Tomlinson and Brody ⁵⁰	When treatment is futile, defined as intervention (such as CPR) on terminal cases that provide no physiological benefit to the patient, that is, restoring spontaneous heart beat or blood pressure	While philosophically sound, it clearly involves clinical and value judgment that could vary from one clinician to another
2005	Paterson, UK. ⁴¹	Patients expected to die within 24 hours are those who were unconscious, self-ventilating, deteriorating and having a diagnosis incompatible with survival	This framework for <i>end-of-life</i> care was introduced to help clinicians in the delivery of care for the acutely dying, that is, who should not be triaged if they are at that advanced stage in the dying process at the time of admission
2006	NHMRC ⁵¹	Patients requiring frequent intervention, being bed-bound, irreversible loss of appetite, profound weakness, trouble swallowing, dry mouth, weight loss, becoming semiconscious, with lapses into unconsciousness, and experiencing day-to-day deterioration that is not reversible	Combination of objective signs and symptoms and subjective considerations to be used in routine practice as indications of an imminent death; suitable for use in nursing homes and may more closely fit the needs at the hospital admission department for identification of patients dying over the next few days but does not cover the profile of those dying over weeks or months
2007	NICE, UK ²¹	Group 1: 'those with advanced, progressive, or incurable conditions who are expected to die within the next 12 months'; and Group 2: 'adults with existing conditions who are at risk of dying from a sudden, acute crisis in their condition'; this group includes those with life-threatening acute conditions caused by sudden catastrophic events	Our manuscript is concerned with the first group, where the prediction of time to death is more feasible, but the definitions above are still not operative due to the uncertainty and dependency on expertise of subjective clinical or value judgements
2007	Jones <i>et al</i> ³⁵	Elderly with multiple-pre-existing comorbidities and mostly designated NFR at the time of death (pre-existing or newly designated) with or without evidence of advanced care planning	This is a minimum standards definition applying to a well-defined patient group that triggers a RRT call; This represents the readily identifiable tip of the iceberg. We are also seeking to target those other patients with undiagnosed organ failures and without a documented NFR orders at the time of presentation to hospital for <i>end-of-life</i> screening so they can be offered <i>end-of-life</i> care out of acute hospitals
2014	Schmidt and Moss ⁵²	Patients suffering from poor quality of life due to clinical deterioration that is subtle and not immediately life-threatening but in whom the burden of treatment substantially outweighs the benefit	Conceptually encapsulates the definition of <i>dying</i> in the short term but it is difficult to measure without a checklist or classification as it involves clinical and value judgements which leave room for interpretation among healthcare professionals

CPR, cardiopulmonary resuscitation; ED, emergency department; NFR, not for resuscitation; RRT, rapid response team.

proxy measure that could be drawn from studies examining predictors of poor survival. These are abundant and cover both subjective and objective parameters anticipating death.

Subjective variables and their utility in predicting short-term to medium-term mortality

Of the instruments developed in the past 30 years for prognostication of death after admission, many still require value judgements and unstructured subjective assessments, which renders them less reassuring and hence less useful as a tool for deciding at the time whether to admit a patient.

Performance Status Scales designed as early as 1949 by Karnofsky^{53 54} and The World Health Organisation (ECOG PS) in 1982 are simple and popular instruments for determining appropriate intensity of care for patients. They have undergone adaptations over time⁵⁵ where completion still involved major value judgements, which makes them impractical and unreliable for a standardised prognosis (table 2).

Various indices have been designed to identify illness severity and risk of death after admission (table 2). Some reliably capture the level of quality of life in terminal patients but do not focus on objective signs;⁵⁴ some use nursing assessment of organic and psychosocial aspects;⁵⁶ others suggest a checklist that combines objective (eg, semiconsciousness) and subjective items (eg, 'irreversible deterioration').⁵¹ Some emphasise application of survival prediction for in hospital-based palliative care services with high prognostic accuracy (85.6%) in estimating death within 3 days of admission to a palliative care facility, but only 54% and 57.6% accuracy in predicting death within 4–30 days and by 6 months.⁵⁷

A global assessment of frailty using a subjective score between 1 (very fit) and 7 (severely frail) had good predictive validity for death within 18 months⁵⁸ but required clinical and value judgements, and did not incorporate the impact of underlying conditions, hence reducing its ease of use for routine care by less experienced personnel. Clinician perception about risk of death has been found to be reasonably accurate in particular for patients with advanced chronic heart failure or chronic obstructive pulmonary disease as an adjuvant in the decision to more efficiently target palliative services and end-of-life care planning.⁵⁹

Finally, the global self-rated question designed to assess patient perception of their own health in comparison with other people their age, not intended as a prognostic tool but since the early 1980s has been associated with predicting long-term mortality in the elderly,⁶⁰ independently of 'objective health status' and across ethnic groups. The self-rated health question is now better understood,^{60–62} and has been validated as a screening tool for vulnerable people at higher risk of death in community.⁶³ Its influence on

imminent risk of death at hospital admission is not known and we will include it in our screening tool.

Objective variables and their utility in predicting short-term mortality

Several factors have been found to have an impact on the risk of death after hospital admission, including age 65 years and above,^{42 63 85 86} multiple comorbidities,¹⁸ multiorgan failure,⁴⁴ physiological data from laboratory test results^{64 76} and type of service and urgency of admission.⁴³

We propose a combined algorithm quantifying the aggregate risk estimation of some previously developed instruments to take us closer to a more accurate definition of *dying*. An historical exploration of 18 of these estimates has shed more light on the influence of these factors.

The diagnosis of advanced cancer has probably attracted the most attention for predicting prognosis and appropriate care. From a review of 24 studies and 18 prognostic indicators, there was general agreement that anorexia and weight loss showed the most significant association with poor survival, followed by cognitive impairment, dyspnoea and dysphagia.⁸³ While several of these studies were conducted in small convenience samples, some with doubtful statistical methods,⁴² clinicians would agree that these are largely symptoms of imminent death. Uncertainty of what constitutes dying in the short term has led to the development of practical prediction tools to assist in treatment decision-making, guide family consultations, and minimise unnecessary expense to the health system (table 2).

Prognostic scales and indices

Performance Status Tools have been well received and modifications tested in various settings.

Table 2 summarises scales found a predicting outcome and time to death/discharge, some of which have been validated in similar or divergent populations and others have led to refinements and developments of further tools.⁷² many are cancer-specific scales, thus have limited value for wider use in ED.⁸² For instance the PaP score is good at reducing the prognostic uncertainty of death within 1 month of admission to palliative care services.⁷⁶ However, it is only validated for patients with cancer and it can yield significant differences between the prediction of registered nurses and doctors.^{76 77 87}

The Charlson Comorbidity Index (CCI), was designed to estimate 1–10-year mortality in longitudinal studies and is not validated as prognostic indicator for short-term outcomes in cancer or other conditions.⁸⁸ The Elixhauser Comorbidity Index is a complex tool⁷⁴ which uses administrative databases to estimate increased risk of in-hospital death or prolonged hospital stay.⁶⁸ but clinicians may not find it user-friendly because it relies on administrative data

Table 2 Existing scales or screening tools to predict risk of death and their domains

Year/Author	Scale name and scoring	Components	CrisTAL Inclusion criteria and comments			
			Readily available	Clinical judgement	Value judgement	Sufficient for prognosis
1949 Clark ⁵³ and modified by Péus ⁵⁵	Karnofsky Performance Score (KPS)	Quality of life across the spectrum of health from 0=normal to 100=terminal	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
			Administered face to face or by phone; involves value judgements; poor inter-rater reliability; does not cater for preadmission functional status			
1981 Addington-Hall ⁵⁴	Spitzer Quality of Life Index	Five dimensions of quality of life: activity, daily living, general health, support of family and friends, and outlook	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
			High clinician's acceptability as it takes 1 min to administer but has not proven accurate in predicting death within 6 months in individuals			
1985 Knaus ⁶⁴ 1992 McMahon ⁶⁵ 1995 DelBualo ⁶⁶ 2006 Zimmerman ⁶⁷ 2013 Sharif ⁴⁷	Acute Physiology and Chronic Health Evaluation APACHE II APACHE III APACHE IV APACHE-L	The point score is calculated from 11 ICU physiological measurements + age: Temperature (rectal), Mean arterial pressure, pH arterial, Heart rate, Respiratory rate, Sodium (serum) Potassium (serum), Creatinine, Haematocrit, White cell count, Glasgow Coma Scale	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
			Used to predict hospital mortality in ICU. Unsuitable for admissions unit			
1987 Charlson ⁶⁸ 1988 Pompei ⁶⁹	Charlson Comorbidity Index (CCI)	Includes 19 categories of comorbidity and each condition is assigned with a severity score of 1, 2, 3 or 6 depending on the risk of dying associated with this condition. Higher scores indicate greater comorbidity (patients with a score >5 have a 100% risk of dying at 1 year)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			Complex calculation. Many adaptations attempted to improve predictive accuracy of 10-year mortality. Some capability for predicting short-term mortality. Does not cater for functional status or immediate risk of death, that is, physiological risk			
1993 Le Gal ⁷⁰	SAPS II	Age, heart rate, Systolic BP, Temp, GCS, CPAP Y/N, PaO ₂ , FIO ₂ , urine Output, BUN, K, Bicarbonate, WCC, Chronic diseases, medical/ surgical admission	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
			Validated in 12 countries and the results were encouraging even in the absence of a primary diagnosis but high reliance on sophisticated testing not routinely conducted outside ICU			
1996 Anderson ⁷¹ 2008 Virik and Glare ⁷²	Palliative Performance Scale (PPS)	Assessment of observed ambulation, activity, evidence of disease, self-care, intake, level of physical activity and level of consciousness. Score 0=death Score 70=bed bound Score 100=full health and ambulation	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
			Validated in Canada and Australia. However, the original intention of developers was not to use PPS for prognostication. ⁷¹ Subjective observations do not contribute to standardisation of assessment Recent validation showed a PPS of 10 was associated with over 90% in-hospital mortality whereas a PPS of 70 was associated with 0% deaths			
1998 Elixhauser ⁷³ 2009 Van Walraven ¹⁸ 2013 Austin ⁷⁴	Elixhauser comorbidity Index	Relies on administrative databases to retrieve diagnostic items for 30 coexisting disease groups and applies weights to severity	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			Data items which are incomplete and not detailed enough to provide a clinically precise time of diagnosis. Complex to calculate, not too accurate on predicting mortality, more useful for researchers than clinicians at predicting length of stay			
2001 Subbe ⁷⁵	MEWS	Scores of 5 or more were associated with increased risk of death	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
			Good predictive ability for risk of death in busy acute services			
2004 Glare ⁷⁶ 2012 Maltoni ⁷⁷	Palliative Prognostic Score (PaP)	Karnofsky Performance Status plus Dyspnoea Anorexia White cell counts Clinician's weighted prediction of survival	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			Validated in Italy, Australia and England. Good association with short-term mortality but predictive value of tool affected by less experienced doctors			
2013 Kuo-H ⁷⁹	Rapid Emergency Medicine Score (REMS)	Blood pressure, respiratory rate, Glasgow Coma Scale, peripheral oxygen saturation,	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			Effective in predicting risk of death in hospital in conjunction with other clinical parameters including surgical treatment within 24 h. However, it has little relevance for elderly patients with chronic disease seeking hospital care			
2005 Rockwood ⁵⁸	CSHA Clinical Frailty Scale	Scores of 1 (very fit) to 7 (severely frail) assigned by physician on the basis of qualitative definitions incorporating physical functioning and presence of comorbidities	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
			Each 1-category increment of the frailty scale increased the risk of mortality. Largely subjective or reliant on clinical and value judgements			
2006 Paterson ⁷⁸	SEWS	Respiratory rate, oxygen saturation, temperature, blood pressure, heart rate and conscious level	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
			Score correlated both with in-hospital mortality and length of stay			

Continued

Table 2 Continued

Year/Author	Scale name and scoring	Components	CrisTAL Inclusion criteria and comments			
			Readily available	Clinical judgement	Value judgement	Sufficient for prognosis
2006 Kellet ⁴⁶ 2012 Kellett ⁸⁰	Simple Clinical Score (SCS)	Weighted cores derived from 16 independent variables: age, pulse, systolic blood pressure, respiratory rate, temperature, oxygen saturation, breathless on presentation, abnormal ECG, diabetes, coma, altered mental status, new stroke, unable to stand unaided, nursing home resident, daytime bed rest prior to current illness	☑	☑	☐	☐
			Most items available and some easily obtainable. Successfully validated for 30-day and 1-year prediction but limited generalisability for many chronic conditions			
2008 Groarke ⁸¹	EWS	Pulse, systolic blood pressure, respiratory rate, oxygen saturation and neurological status. Increases in score indicate risk of complication or death	☑	☑	☐	☑
			Used to identify physiological deterioration in patients on admission. Good predictor of transfer to high dependency care			
2008 Stone ⁸²	Palliative Prognostic Index (PPI)	PPS + Oral intake Oedema Dyspnoea at rest Delirium	☑	☑	☐	☐
			Developed for Japanese patients with advanced cancer in hospices and validated in Ireland in hospitals, hospices and the home. Prediction of positive predictive value of 86% for survival of less than three weeks PPV of 91% for survival of less than six weeks. Not generalisable to other conditions or longer term mortality predictions			
2008 Glare ⁸³	Clinical Prediction of Survival (CPS)	Combines clinical experience with performance assessment	☐	☑	☑	☐
			More accurate closer to death, overestimates survival if patient–doctor relationship is stronger			
2010 Prytherch ⁸⁴	ViEWS	Applies paper-based EWS score to a Vital Signs database and uses known relationship between deteriorated physiological measures and clinical outcomes such as in-hospital mortality with 24 h of the observations	☑	☑	☐	☑
			It appears to predict immediate mortality well but vital signs databases are not widely available in many health systems			
2012 & 2013 Rothman ^{44 56}	Rothman Index	Nurse-led assessment of whether minimum standards for each of 8 body systems, food intake, pain, risk of falls and 1 psychosocial (adequate support system) criteria are met or not met	☐	☑	☑	☑
			Based on well-defined minimum standards as documented by nurses in electronic medical records in one USA hospital; independent of expert opinion; data not routinely available in other hospitals			

APACHE, Acute Physiology and Chronic Disease Evaluation; CSHA, Canadian Study of Health and Aging; EWS, early warning score; ICU, intensive care unit; MEWS, modified early warning score; SAPS II, Simplified Acute Physiology Score II; SEWS, standardised early warning scoring system; ViEWS, VitalPAC™ early warning score.

and requires calculations. Further, the authors recommended a combination with other influential factors for a more accurate prediction of death in hospital.¹⁸

The Acute Physiology and Chronic Disease Evaluation (APACHE II) tool and its variants APACHE-L, APACHE III and APACHE IV and the Simplified Acute Physiology Score, SAPS II were designed to measure the severity of disease for adult patients and are all used to predict in-hospital death and risk-adjusted length of stay in intensive care units.^{65–67 70 89} The scores indicate the risk of death in patient groups rather than individual prognosis.⁹⁰ Moreover, the APACHE instruments are heavily dependent on laboratory-based data not generally available in all EDs in Australia.

Multiple attempts have been made to enhance objective early warning scores (EWS) for identification of critical illness and deterioration on admission and in intensive care. Improvement in serial EWS within 4 h of presentation to hospital predicts improved clinical outcomes^{75 79 84 91 92} hence EWS has been deemed as a potential triage tool in the ED for acute medical patients.^{75 79 81 84 93} While the developers of some EWS have emphasised that they did not intend

them as predictors of patient outcome,⁹⁴ experience has shown that these scores are being used in practice to predict death. Accordingly, we chose to include these in the construction of algorithms defining the diagnosis of *dying*.

In 2012, the Rothman Index was found to be a strong predictor of both in-hospital mortality, hospital readmission and post-discharge mortality at 2 days, 30 days and 1 year.^{44 56} Unfortunately the Rothman Index relies on comprehensive collection of nursing or doctors' assessments, not part of routine care in outpatients or ED in most hospitals.

DEVELOPMENT OF CRISTAL

To be considered useful on admission at ED or during an RRT attendance, the screening tool items should meet the following criteria: easily collected in routine practice,⁴² or readily available in electronic or paper medical records; does not require specialist clinical judgement; is sufficient to independently predict death in specific conditions; and with two exceptions, does not employ a value judgment. None of the 18 published predictive tools met the four criteria; five met three criteria but four of these instruments

involved clinical judgements and one involved value judgment; nine tools met two criteria and four tools only met one criterion. Figure 1 shows the distribution of criteria to justify the need for a fresh tool that met the four criteria.

In the absence of a comprehensive instrument combining acute and chronic predictors to increase certainty of diagnosis of imminent death or death within weeks or months, this review gathered recognised predictors of death for elderly patients with complex health profiles from existing prognostic tools to create a new screening instrument. We anticipated that incorporating objective variables would enhance certainty of the screening tool and could assist in the decision to appropriately generate do-not-resuscitate orders²⁵ and consider alternative end-of-life care orders.

The variables and values proposed for the CriSTAL screening tool were adopted from existing scales and from published research findings demonstrating their association with either in-hospital or 30-day mortality or survival to 12 weeks.^{42–45 56 76}

Old age and RRT criteria are priorities on the checklist. Supplementation with a quantifiable level of severity based on EWS^{75 79 84 91}; history of repeat hospitalisations with or without admissions to ICU⁹⁵; emergency admission⁹⁶; at least one of the predefined advanced comorbidities from the evidence-based list;³⁵ an objective measurement of frailty;⁸⁵ documentation of nursing home placement;^{33 46} evidence of cognitive impairment;^{25 42 63 73 83} and readily available test results: proteinuria and if ECG confirms abnormalities.⁹⁷

Table 3 shows our resulting 29-item screening tool, named CriSTAL, to denote our intention to introduce transparency in the identification of the dying patient and enable objective clinician decisions about prognosis and

justification for administering or de-escalating aggressive treatments.

A slight modification is proposed for the use of the tool following a RRT attendance (table 4). This might encourage reassessment of the need for continuing hospitalisation in an acute care facility and discussion about the need for limitations of treatment if death is imminent.

DISCUSSION

How would CriSTAL be used in practice? It may characterise ‘appropriateness of admission’ and appropriateness of subsequent treatment for patients at the *end of life* in a way that can be applicable to a wide variety of terminal health conditions. It could be used as a platform for beginning discussions with patients and their carers. It may also add more certainty identifying the irrevocably dying patient with chronic comorbidities and prevent further futile treatments to prolong life. We have omitted indicators of system failures or nursing staff workloads such as TISS or NEMS⁹⁰ that may potentially influence risk of death, as these did not fulfil our inclusion criteria of being routinely available

The Scottish health system implemented a national action plan for care at the end of life deriving from the realisation that 30% of all hospital bed-days were accounted for by multiple admissions of people in the final year of life.⁴¹ The ‘Dying well’ premise in Scotland is that alternative care is integral to continuity of care outside the hospital. The strategy includes among others, early identification of care needs for any terminal illness, holistic assessment and involvement of patients and families in the coordination of alternative care.²

Inspired by this development, our definition of *inappropriate hospital admission* is linked to the more objective scoring factors of the CriSTAL tool, whose accuracy is to be validated to more precisely establish the main determinants of death in the short term. Our review indicated that old age^{42 63 85 86} and concurrent illnesses^{18 25 42 46 63 101} were the strongest predictors of death in and outside intensive care.^{45 104}

Strengths of this developmental work are the evidence-base source of variables in the tool and the extensive range of predictors covering demographic, physiological and diagnostic prediction measures.

A limitation of this research is that the item selection was based on a narrative review with focused set of search terms. This may have led to overlook of some articles that would have been captured in a systematic and broader search strategy. However, the comprehensive search for tools and the breadth of instruments found using this approach provided a sufficiently large number of items to start the discussion on possible amalgamation of variables from existing instruments to meet our targeted need. Other researchers among the readership may choose to

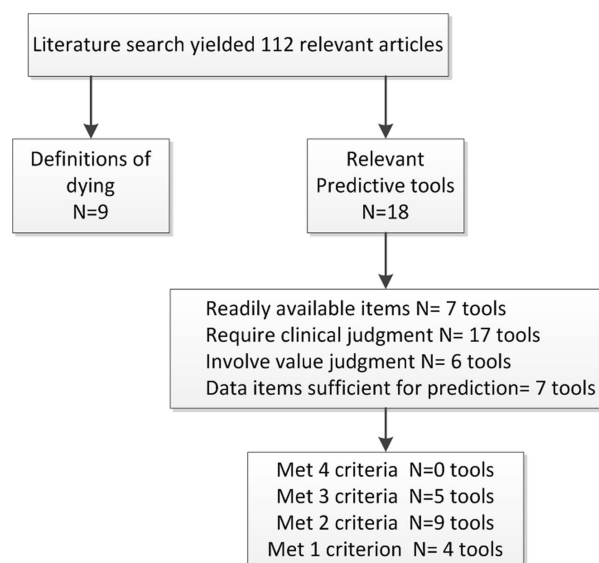


Figure 1 Outcome of the literature review.

Table 3 Proposed components of the Criteria for Screening and Triaging to Appropriate alternative care tool to identify *end-of-life* status before hospital admission

<input type="checkbox"/>	Age ≥ 65 ^{42 63 85 86} AND
<input type="checkbox"/>	Being admitted via emergency this hospitalisation ⁹⁶ (associated with 25% mortality within 1 year)
<input type="checkbox"/>	OR Meets 2 or more of the following deterioration criteria on admission ^{30 32 98}
<input type="checkbox"/>	1. Decreased LOC: Glasgow Coma Score change >2 or AVPU=P or U
<input type="checkbox"/>	2. Systolic blood pressure <90 mm Hg
<input type="checkbox"/>	3. Respiratory rate <5 or >30
<input type="checkbox"/>	4. Pulse rate <40 or >140
<input type="checkbox"/>	5. Need for oxygen therapy or known oxygen saturation $<90\%$ ³³
<input type="checkbox"/>	6. Hypoglycaemia: BGL ⁹⁹
<input type="checkbox"/>	7. Repeat or prolonged seizures ⁹⁹
<input type="checkbox"/>	8. Low urinary output (<15 mL/h or <0.5 mL/kg/h) ¹⁰⁰
<input type="checkbox"/>	OR MEW or SEWS score >4 ^{46 79}
AND	OTHER RISK FACTORS /PREDICTORS OF SHORT-MEDIUM-TERM DEATH
<input type="checkbox"/>	Personal history of active disease (at least one of): ^{18 25 42 46 63 101 102}
<input type="checkbox"/>	Advanced malignancy
<input type="checkbox"/>	Chronic kidney disease
<input type="checkbox"/>	Chronic heart failure
<input type="checkbox"/>	Chronic obstructive pulmonary disease
<input type="checkbox"/>	New cerebrovascular disease
<input type="checkbox"/>	Myocardial infarction
<input type="checkbox"/>	Moderate/severe liver disease
<input type="checkbox"/>	Evidence of cognitive impairment (eg, long term mental disorders, dementia, behavioural alterations or disability from stroke) ^{25 42 63 73 83}
<input type="checkbox"/>	Previous hospitalisation in past year ¹⁰
<input type="checkbox"/>	Repeat ICU admission at previous hospitalisation ⁹⁵ (associated with a fourfold increase in mortality)
<input type="checkbox"/>	Evidence of frailty : 2 or more of these: ^{42 46 63 85 89 98}
<input type="checkbox"/>	Unintentional or unexplained weight loss (10 lbs in past year) ^{18 83 85}
<input type="checkbox"/>	Self-reported exhaustion (felt that everything was an effort or felt could not get going at least 3 days in the past week) ⁸⁵
<input type="checkbox"/>	Weakness (low grip strength for writing or handling small objects, difficulty or inability to lift heavy objects ≥ 4.5 Kg) ⁶³
<input type="checkbox"/>	Slow walking speed (walks 4.5 m in ≥ 7 s)
<input type="checkbox"/>	Inability for physical activity or new inability to stand ^{46 98}
<input type="checkbox"/>	Nursing home resident/in supported accommodation ^{33 46}
<input type="checkbox"/>	Proteinuria on a spot urine sample: positive marker for chronic kidney disease & predictor of mortality: >30 mg albumin/g creatinine ^{56 103}
<input type="checkbox"/>	Abnormal ECG (Atrial fibrillation, tachycardia, any other abnormal rhythm or ≥ 5 ectopics/min, Changes to Q or ST waves) ^{18 42 97}

ICU, intensive care unit; MEW, modified early warning.

expand the search or enhance the tool. In fact, a limitation of CriSTAL's development at this stage is its length for routine administration, and the number of potential predictors which may lead to model 'overfitting'. The testing of too many variables is known to reduce the generalisability of the predictive model.¹⁰⁵ By retrospective testing and future prospective validation we hope to reduce the total number of items without sacrificing predictive accuracy or generalisability. Initially, CriSTAL's 29 subitems will be tested in a retrospective data review using a case-control study design where cases are all deaths reported from the RRT attendances system in a teaching hospital during 2012–2013. Controls will be age-sex-ward matched records of patients admitted in the same period with an RRT call but did not die before or within 3 months of discharge. Sensitivity, specificity and positive and negative predictive values will be calculated from logistic regression models of matched

cases and controls. This retrospective validation has been endorsed by the South Western Sydney Local Health District Ethics Committee. The next step after retrospective testing will be the prospective administration of the validated tool as part of the admissions procedure in emergency and after the RRT calls on general wards.

The accuracy of models with different number of variables will be determined using the area under the receiver-operating characteristics (AUROC) curve.¹⁰⁶ Minimum accuracy will be defined as area under the ROC curve $\geq 80\%$, and variables not contributing significantly to the model will be dropped from the instrument. Survival analysis and Cox proportional hazards regression will investigate the most significant predictors of imminent death. A 5% chance of survival to hospital discharge among those predicted to die will be chosen as the maximum error allowed for the tool to be considered useful.

Table 4 Proposed components of the Criteria for Screening and Triaging to Appropriate alternative care tool to identify *end-of-life* status after a rapid response call where a *do-not-resuscitate* order is not in place

<input type="checkbox"/>	Age ≥ 65 ^{42 63 85 86}
<input type="checkbox"/>	AND admitted via emergency this hospitalisation ⁹⁶ (associated with 25% mortality within 1 year)
<input type="checkbox"/>	OR met 2 or more of the selected MET calling criteria below ^{30 32 98}
<input type="checkbox"/>	1-Decreased LOC: Glasgow Coma Score change >2 or AVPU=P or U
<input type="checkbox"/>	2-Systolic blood pressure <90 mm Hg
<input type="checkbox"/>	3-Respiratory rate <5 or >30
<input type="checkbox"/>	4-Pulse rate <40 or >140
<input type="checkbox"/>	5-Need for oxygen therapy or known oxygen saturation $<90\%$ ³³
<input type="checkbox"/>	6-Hypoglycaemia: BGL ⁹⁹
<input type="checkbox"/>	7-Repeat or prolonged seizures ⁹⁹
<input type="checkbox"/>	8-Low urinary output (<15 mL/h or <0.5 mL/kg/h) ¹⁰⁰
<input type="checkbox"/>	OR MEW or SEWS score >4 ^{46 79}
AND	OTHER RISK FACTORS /PREDICTORS OF SHORT-MEDIUM-TERM DEATH
<input type="checkbox"/>	Personal history of active disease (at least one of): ^{18 25 42 46 63 96 101}
<input type="checkbox"/>	Advanced malignancy
<input type="checkbox"/>	Chronic kidney disease
<input type="checkbox"/>	Chronic heart failure,
<input type="checkbox"/>	Chronic obstructive pulmonary disease
<input type="checkbox"/>	New cerebrovascular disease
<input type="checkbox"/>	Myocardial infarction
<input type="checkbox"/>	Moderate/severe liver disease
<input type="checkbox"/>	Evidence of cognitive impairment (eg, long-term mental disorders, dementia, behavioural alterations or disability from stroke) ^{25 42 63 73 83 96}
<input type="checkbox"/>	Length of stay before this RRT call (≥ 5 days predicts 1-year mortality) ^{46 96}
<input type="checkbox"/>	Previous hospitalisation in past year ¹⁰
<input type="checkbox"/>	repeat ICU admission at this or previous hospitalisation ⁹⁵ (associated with a fourfold increase in mortality)
<input type="checkbox"/>	Evidence of frailty : 2 or more of these: ^{42 46 63 85 89 98}
<input type="checkbox"/>	Unintentional or unexplained weight loss (10 lbs in past year) ^{18 83 85}
<input type="checkbox"/>	Self-reported exhaustion (felt that everything was an effort or felt could not get going at least 3 days in the past week) ⁸⁵
<input type="checkbox"/>	Weakness (low grip strength for writing or handling small objects, difficulty or inability to lift heavy objects ≥ 4.5 kg) ⁶³
<input type="checkbox"/>	Slow walking speed (walks 4.5 m in ≥ 7 s)
<input type="checkbox"/>	Inability for physical activity or new inability to stand ^{46 98}
<input type="checkbox"/>	Nursing home resident/in supported accommodation ^{33 46 96}
<input type="checkbox"/>	Proteinuria on a spot urine sample: positive marker for chronic kidney disease & predictor of mortality: >30 mg albumin/g creatinine ^{56 103}
<input type="checkbox"/>	Abnormal ECG (Atrial fibrillation, tachycardia, any other abnormal rhythm or ≥ 5 ectopics/min, Changes to Q or ST waves) ^{18 42 97}

MET, medical emergency team; MEW, modified early warning; RRT, rapid response team.

While it is acknowledged that predictions based on population subgroups are not meant to be used for individuals,¹⁰⁷ the calculated risk can be used as a reference to inform the decision by the individual under the clinician's guidance, on whether or not to continue aggressive treatment, given the odds of dying based on the well-established predictors. Careful use of the CriSTAL tool care for decision-making would involve alignment with quality of care principles and patient values and preferences, and should not be driven by hospital financial pressures or need to meet health system performance indicators.²⁴

Finally, it is important to recognise that the use of a screening tool for identifying patients who have a high probability of dying within 3 months can only provide an indication of those who with a low probability of survival and will not be a signal of absolute certainty.⁵⁰ Testing its appropriateness, reliability and

predictive value in different patient subpopulations will help reduce this uncertainty but its predictive value may vary in different settings and for different timeframes and this needs to be ascertained. Further, its values after an RRT response will need to be assessed in relation to its value at the time of admission for patients when trialled. As emphasised before, testing in different settings could yield different predictive performance depending on the patient profile and possibly the influence of factors not accounted for in the tool. Readers and researchers are encouraged to train and validate the CriSTAL tool in their facility to generate the most valid and relevant set of variables for their subpopulations.

CONCLUSIONS AND RECOMMENDATIONS

This tool does not intend to preclude access to health-care for the terminal elderly, but to provide an

objective assessment and definition of the *dying* patient as a starting point for honest communication with patients and families,³ about recognising that *dying* is part of the life cycle. Dignified withdrawal of intensive and inappropriate treatment^{29 52} and triage into alternative care in non-acute facilities^{10 38} is an area where there is still ample room for improvement.^{1 29 39} Standard guidelines for alternative end-of-life care are not yet broadly adopted in Australia and discussions with policy-makers need to continue.² However, increasing evidence of alternative out-of-hospital care acceptable to clinicians¹⁰⁸ and others are known to include sedation to minimise distress, pain management,¹⁰⁹ spiritual support,⁴¹ music therapy and home-based palliative care.¹¹⁰ If proven accurate in the prediction of short-term death, a reduced version of CriSTAL could be proposed for routine use at hospital admission. We acknowledge that the Australian health system may not yet be equipped to respond to the demand for alternative healthcare facilities for the dying.¹¹¹ However, it is hoped that using such predictive tools may encourage more appropriate services for managing patients at the end of life.

Training for nurses and doctors in the use of the screening tool and in approaching patients and families with concrete information about inevitability of death and lack of benefit of further intensive treatment are paramount.^{27 112} They will be better equipped to communicate the responsible decision to suspend efforts and handle potential requests for futile treatment.^{41 49}

Automation of CriSTAL and its scoring would facilitate use at time of admission and production of instant or retrospective locally relevant profiles of patients imminently dying. Potential uses include as a clinical support tool for decision-making on triage to appropriate *end-of-life* care facilities; to prevent death in some cases; and to examine variation in risk-of-death levels, differences in admission practices, and inform triage policies across hospitals,⁴³ as a first step into cost-effectiveness and patient satisfaction studies.

Contributors MCM conceived the idea of an objective assessment. KH and MCM led the literature searches. MCM summarised findings, wrote the first and final draft manuscript and refined all versions. KH contributed to the literature review, provided ongoing intellectual input and revised subsequent manuscript drafts.

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Competing interests KH is an advocate for dying with dignity and has written books and articles on the subject.

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Data sharing statement No additional unpublished data exists from this study. A retrospective validation of the screening tool is in preparation. Protocols and materials for the conduct of

that validation could be shared with other research groups interested in testing the screening tool in their patient populations.

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REFERENCES

- 1 Tsim S, Davidson S. End-of-life care in a general respiratory ward in the United Kingdom. *Am J Hosp Palliat Med* 2014;31:172–4.
- 2 The Scottish Government. Living and dying well: building on progress. Secondary living and dying well: building on progress 2011. <http://www.scotland.gov.uk/Resource/Doc/340076/0112559.pdf>
- 3 Hillman K. Dying safely. *Int J Qual Health Care* 2010;22:339–40.
- 4 Higginson IJ, Sen-Gupta GJ. Place of care in advanced cancer: a qualitative systematic literature review of patient preferences. *J Palliat Med* 2000;3:287–300.
- 5 Beccaro M, Costantini M, Giorgi Rossi P, et al. Actual and preferred place of death of cancer patients. Results from the Italian survey of the dying of cancer (ISDOC). *J Epidemiol Community Health* 2006;60:412–16.
- 6 Brazil K, Howell D, Bedard M, et al. Preferences for place of care and place of death among informal caregivers of the terminally ill. *Palliat Med* 2005;19:492–9.
- 7 Cohen J, Bilsen J, Addington-Hall J, et al. Population-based study of dying in hospital in six European countries. *Palliat Med* 2008;22:702–10.
- 8 Wilson DM, Truman CD, Thomas R, et al. The rapidly changing location of death in Canada, 1994–2004. *Soc Sci Med* 2009;68:1752–8.
- 9 Lowthian JA, Jolley DJ, Curtis AJ, et al. The challenges of population ageing: accelerating demand for emergency ambulance services by older patients, 1995–2015. *Med J Aust* 2011;194:574–8.
- 10 Rosenwax LK, McNamara BA, Kevin Murray K, et al. Hospital and emergency department use in the last year of life: a baseline for future modifications to end-of-life care. *Med J Aust* 2011;194:570–73.
- 11 Hillman K. The changing role of acute-care hospitals. *Med J Aust* 1999;170:325–28.
- 12 Earle CC, Landrum MB, Souza JM, et al. Aggressiveness of cancer care near the end of life: is it a quality-of-care issue? *J Clin Oncol* 2008;26:3860–6.
- 13 Earle CC, Park ER, Lai B, et al. Identifying potential indicators of the quality of end-of-life cancer care from administrative data. *J Clin Oncol* 2003;21:1133–8.
- 14 Senthuran S, Bandeshe H, Ranganathan D, et al. Outcomes for dialysis patients with end-stage renal failure admitted to an intensive care unit or high dependency unit. *Med J Aust* 2008;188:292–5.
- 15 Stolman CJ, Gregory JJ, Dunn D, et al. Evaluation of the do not resuscitate orders at a community hospital. *Arch Intern Med* 1989;149:1851–6.
- 16 Weissman D. Policy Forum. Policy Proposal: Do Not Resuscitate Orders: A Call for Reform. Virtual Mentor [Internet]. 2003 [cited 2014 August]; 5(1). Available from: <http://virtualmentor.ama-assn.org/2003/01/pfor2-0301.html>

- 17 Holloway RG, Benesch CG, Burgin WS, *et al.* Prognosis and decision making in severe stroke. *JAMA* 2005;294:725–33.
- 18 van Walraven C, Austin PC, Jennings A, *et al.* A modification of the Elixhauser comorbidity measures into a point system for hospital death using administrative data. *Med Care* 2009;47:626–33.
- 19 Phillips G. Do not resuscitate orders: a reappraisal. *HEC Forum* 1990;2:101–4.
- 20 Wright AA, Zhang B, Ray A, *et al.* Associations between end-of-life discussions, patient mental health, medical care near death, and caregiver bereavement adjustment. *JAMA* 2008;300:1665–73.
- 21 National Health Service. End of Life Care Strategy. Promoting high quality care for all adults at the end of life. July. Secondary End of Life Care Strategy. Promoting high quality care for all adults at the end of life. July 2008. http://webarchive.nationalarchives.gov.uk/20130107105354/http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_086345.pdf
- 22 van Weel C, Michels J. Dying, not old age, to blame for costs of health care. *Lancet* 1997;350:1159–60.
- 23 Curtis JR, Engelberg RA, Bensink ME, *et al.* End-of-life care in the intensive care unit. Can we simultaneously increase quality and reduce costs? *Am J Respir Crit Care Med* 2012;186:587–92.
- 24 Oshima Lee E, Emanuel EJ. Shared decision making to improve care and reduce costs. *N Engl J Med* 2013;368:6–8.
- 25 Downar J, Rodin D, Barua R, *et al.* Rapid response teams, do not resuscitate orders, and potential opportunities to improve end-of-life care: a multicentre retrospective study. *J Crit Care* 2013;28:498–503.
- 26 Gleeson K. The do-not-resuscitate order: still too little too late. *Arch Intern Med* 1990;150:1057–60.
- 27 Mead GE, Turnbull CJ. Cardiopulmonary resuscitation in the elderly: patients' and relatives' views. *J Med Ethics* 1995;21:39–44.
- 28 Heyland DK, Dodek P, Rocker G, *et al.* What matters most in end-of-life care: perceptions of seriously ill patients and their family members. *CMAJ* 2006;174:627–33.
- 29 Kompanje EJ, Piers RD, Benoit DD. Causes and consequences of disproportionate care in intensive care medicine. *Curr Opin Crit Care* 2013;19:630–5.
- 30 Hillman K, Chen J, Cretikos M, *et al.* Introduction of the medical emergency team (MET) system: a cluster-randomised controlled trial. *Lancet* 2005;24:2091–7.
- 31 Mitchell IA, McKay H, Van Leuvan C, *et al.* A prospective controlled trial of the effect of a multi-faceted intervention on early recognition and intervention in deteriorating hospital patients. *Resuscitation* 2010;81:658–66.
- 32 Goldhill DR, McNarry AF. Physiological abnormalities in early warning scores are related to mortality in adult inpatients†. *Br J Anaesth* 2004;92:882–84.
- 33 Jones DA, Bagshaw SM, Barrett J, *et al.* The role of the medical emergency team in end-of-life care: a multicenter, prospective, observational study. *Crit Care Med* 2012;40:98–103.
- 34 Jones D, Moran J, Winters B, *et al.* The rapid response system and end-of-life care. *Curr Opin Crit Care* 2013;19:616–23.
- 35 Jones DA, McIntyre T, Baldwin I, *et al.* The medical emergency team and end-of-life care: a pilot study. *Crit Care Resusc* 2007;9:151–56.
- 36 Stacey D, Legare F, Col NF, *et al.* Decision aids for people facing health treatment or screening decisions. *Cochrane Database Syst Rev* 2014;1: CD001431.
- 37 van Walraven C, Forster AJ, Stiell IG. Derivation of a clinical decision rule for the discontinuation of in-hospital cardiac arrest resuscitations. *Ann Intern Med* 1999;159:129–34.
- 38 Kennedy C, Brooks-Young P, Brunton Gray C, *et al.* Diagnosing dying: an integrative literature review. *BMJ Support Palliat Care* 2014;4:263–70.
- 39 Curtis JR, Engelberg RA, Nielsen EL, *et al.* Patient-physician communication about end-of-life care for patients with severe COPD. *Eur Respir J* 2004;24:200–5.
- 40 Gomes B, Higginson IJ. Home or hospital? Choices at the end of life. *J Royal Soc Med* 2004;97:413–14.
- 41 Paterson BC, Duncan R, Conway R, *et al.* Introduction of the Liverpool Care Pathway for end of life care to emergency medicine. *Emerg Med J* 2009;26:777–9.
- 42 Viganò A, Dorgan M, Buckingham J, *et al.* Survival prediction in terminal cancer patients: a systematic review of the medical literature. *Palliat Med* 2000;14:363–74.
- 43 Escobar GJ, Greene JD, Scheirer P, *et al.* Risk-adjusting hospital inpatient mortality using automated inpatient, outpatient, and laboratory databases. *Med Care* 2008;46:232–9.
- 44 Rothman SI, Rothman MJ, Solinger AB. Placing clinical variables on a common linear scale of empirically based risk as a step towards construction of a general patient acuity score from the electronic health record: a modelling study. *BMJ Open* 2013;13:e002367.
- 45 Wang CY, Calfee CS, Paul DW, *et al.* One-year mortality and predictors of death among hospital survivors of acute respiratory distress syndrome. *Intensive Care Med* 2014;40:388–96.
- 46 Kellett J, Deane B. The Simple Clinical Score predicts mortality for 30 days after admission to an acute medical unit. *QJM* 2006;99:771–81.
- 47 Sharif N, Irfan M, Hussain J, *et al.* Factors Associated within 28 Days In-Hospital Mortality of Patients with Acute Respiratory Distress Syndrome BioMed Research International 2013; Article ID 564547:5 pages doi: <http://dx.doi.org/10.1155/2013/564547> [published Online First: Epub Date]].
- 48 President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research. Defining death. medical, legal and ethical issues in the determination of death. 1981 https://bioethicsarchive.georgetown.edu/pcbe/reports/past_commissions/defining_death.pdf (accessed Mar 2013).
- 49 Blackhall LJ. Must we always use CPR? *New England J Med* 1987;317:1281–5.
- 50 Tomlinson T, Brody H. Futility and the ethics of resuscitation. *JAMA* 1990;264:1276–80.
- 51 Australian Government Department of Health and Ageing. Guidelines for a Palliative Approach in Residential Aged Care. Secondary Guidelines for a Palliative Approach in Residential Aged Care 2006. http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/pc29.pdf
- 52 Schmidt RJ, Moss AH. Dying on dialysis: the case for a dignified withdrawal. *Clin J Am Soc Nephrol* 2014;9:174–80.
- 53 Clark A, Fallowfield LJ. Quality of life measures in patients with malignant disease. *J Royal Soc Med* 1986;79:165–69.
- 54 Addington-Hall MacDonald, LD Anderson HR. Can the Pitzer quality of life index help to reduce prognostic uncertainty in terminal care? *Br J Cancer* 1990;62:695–99.

- 55 Péus D, Newcomb N, Hofer S. Appraisal of the Karnofsky performance status and proposal of a simple algorithmic system for its evaluation. *BMC Med Inform Decis Mak* 2013;13:72.
- 56 Rothman MJ, Solinger AB, Rothman SI, *et al.* Clinical implications and validity of nursing assessments: a longitudinal measure of patient condition from analysis of the Electronic Medical Record. *BMJ Open* 2012;2: pii: e000646
- 57 Fromme EK, Smith MD, Bascom PB, *et al.* Incorporating routine survival prediction in a US hospital-based palliative care service. *J Palliat Med* 2010;13:1439–44.
- 58 Rockwood K, Song X, MacKnight C, *et al.* A global clinical measure of fitness and frailty in elderly people. *CMAJ* 2005;173:489–5.
- 59 Weiche RE, Mundy BJ, Skokan L, *et al.* Patient-centered research. Identifying patients nearing the end of life from congestive heart failure or chronic obstructive pulmonary disease. *J Gen Intern Med* 2000;15(Suppl 2):9–10.
- 60 Mossey JM, Shapiro E. Self-rated health: a predictor of mortality among the elderly. *Am J Public Health* 1982;72:800–8.
- 61 Jylhä M. What is self-rated health and why does it predict mortality? Towards a unified conceptual model. *Soc Sci Med* 2009;69:307–16.
- 62 Heistaro S, Jousilahti P, Lahelma E, *et al.* Self rated health and mortality: a long term prospective study in eastern Finland. *J Epidemiol Community Health* 2001;55:227–32.
- 63 Saliba D, Elliott M, Rubenstein LZ, *et al.* The vulnerable elders survey: a tool for identifying vulnerable older people in the community. *J Am Geriatr Soc* 2001;49:1691–9.
- 64 Knaus WA, Draper EA, Wagner DP, *et al.* APACHE II: a severity of disease classification system. *Crit Care Med* 1985;13:818–29.
- 65 McMahon LF Jr, Hayward RA, Bernard AM, *et al.* APACHE-L: a new severity of illness adjuster for inpatient medical care. *Med Care* 1992;30:445–2.
- 66 Del Bufalo C, Morelli A, Bassein L, *et al.* Severity scores in respiratory intensive care: APACHE II predicted mortality better than SAPS II. *Respir Care* 1995;40:1042–7.
- 67 Zimmerman JE, Kramer AA, McNair DS, *et al.* Acute Physiology and Chronic Health Evaluation (APACHE) IV: hospital mortality assessment for today's critically ill patients. *Crit Care Med* 2006;34:1297–310.
- 68 Charlson ME, Pompei P, Ales KL, *et al.* A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;40:373–83.
- 69 Pompei P, Charlson ME, Gordon Douglas R Jr. Clinical assessments as predictors of one year survival after hospitalization: Implications for prognostic stratification. *J Clin Epidemiol* 1988;41:275–84.
- 70 Le Gall J, Lemeshow S, Saulnier F. A new simplified acute physiology score (saps ii) based on a European/north American multicenter study. *JAMA* 1993;270:2957–63.
- 71 Anderson F, Downing GM, Hill J, *et al.* Palliative performance scale (PPS): a new tool. *J Palliat Care* 1996;12:5–11.
- 72 Virik K, Glare P. Validation of the Palliative Performance Scale for Inpatients admitted to a palliative care unit in Sydney, Australia. *J Pain Symptom Manage* 2002;23:455–7.
- 73 Elixhauser A, Steiner C, Harris DR, *et al.* Comorbidity measures for use with administrative data. *Med Care* 1998;36:8–27.
- 74 Austin SR, Wong YN, Uzzo RG, *et al.* Why summary comorbidity measures such as the Charlson comorbidity index and Elixhauser score work. *Med Care* 2013. Published Online First (May 23) doi:10.1097/MLR.0b013e318297429c
- 75 Subbe CP, Kruger M, Rutherford P, *et al.* Validation of a modified early warning score in medical admissions. *QJM* 2001;94:521–26.
- 76 Glare PA, Eychmueller S, McMahon P. Diagnostic accuracy of the palliative prognostic score in hospitalized patients with advanced cancer. *J Clin Oncol* 2004;22:4823–8.
- 77 Maltoni M, Scarpi E, Pittureri C, *et al.* Prospective comparison of prognostic scores in palliative care cancer populations. *Oncologist* 2012;17:446–54.
- 78 Paterson R, MacLeod DC, Thetford D, *et al.* Prediction of in-hospital mortality and length of stay using an early warning scoring system: clinical audit. *Clin Med* 2006;6:281–84.
- 79 Kuo S-H, Tsai C-F, Li C-R, *et al.* Rapid emergency medicine score as a main predictor of mortality in *Vibrio vulnificus*-related patients. *Am J Emerg Med* 2013;31:1037–41.
- 80 Kellett J, Rasool S, McLoughlin B. Prediction of mortality 1 year after hospital admission. *QJM* 2012;105:847–53.
- 81 Groarke JD, Gallagher J, Stack J, *et al.* Use of an admission early warning score to predict patient morbidity and mortality and treatment success. *Emerg Med J* 2008;25:803–6.
- 82 Stone CA, Tiernan E, Dooley BA. Prospective validation of the palliative prognostic index in patients with cancer. *J Pain Symptom Manage* 2008;35:617–22.
- 83 Glare P, Sinclair C, Downing M, *et al.* Predicting survival in patients with advanced disease. *Eur J Cancer* 2008;44:1146–56.
- 84 Prytherch DR, Smith GB, Schmidt PE, *et al.* ViEWS—Towards a national early warning score for detecting adult inpatient deterioration. *Resuscitation* 2010;81:932–7.
- 85 Fried LP, Tangen CM, Walston J, *et al.* Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 2001;56:M146–57.
- 86 Hucker TR, Mitchell GP, Blake LD, *et al.* Identifying the sick: can biochemical measurements be used to aid decision making on presentation to the accident and emergency department. *Br J Anaesth* 2005;94:735–41.
- 87 Alloway L, Minton O. The accuracy of the clinical prediction of survival: a comparison of doctors' and nurses' estimations and the failure to validate the Palliative Prognostic Score [abstract for the 5th palliative care congress, UK]. *Palliat Med* 2004;18:155.
- 88 Lübke T, Möning SP, Schneider PM, *et al.* Does Charlson-comorbidity index correlate with short-term outcome in patients with gastric cancer? [Article in German]. *Zentralbl Chir* 2003;128:970–6.
- 89 Le Maguet P, Roquilly A, Lasocki S, *et al.* Prevalence and impact of frailty on mortality in elderly ICU patients: a prospective, multicenter, observational study. *Intensive Care Med* 2014;1–9.
- 90 Vincent JL, Moreno R. Clinical review: scoring systems in the critically ill. *Crit Care* 2010;14:207.
- 91 Hands C, Reid E, Meredith P, *et al.* Patterns in the recording of vital signs and early warning scores: compliance with a clinical escalation protocol. *BMJ Qual Saf* 2013;22:719–26.
- 92 Moon A, Cosgrove JF, Lea D, *et al.* An eight year audit before and after the introduction of modified early warning score (MEWS) charts, of patients admitted to a tertiary referral intensive care unit after CPR. *Resuscitation* 2011;82:150–54.
- 93 Parham G. Recognition and response to the clinically deteriorating patient. *MJA* 2012;3:18–22.

- 94 Morgan RJM, Wright MM. In defence of early warning scores. *Br J Anaesth* 2007;99:747–48.
- 95 Kramer AA, Higgins TL, Zimmerman JE. Intensive care unit readmissions in US hospitals: patient characteristics, risk factors, and outcomes. *Crit Care Med* 2012;40:3–10.
- 96 Levine SK, Sachs GA, Jin L, *et al.* A prognostic model for 1-year mortality in older adults after hospital discharge. *Am J Med* 2007;120:455–60.
- 97 Copeland GP, Jones D, Walters M. POSSUM: a scoring system for surgical audit. *Br J Surg* 1991;78:355–60.
- 98 DeVita MA, Smith GB, Adam SK, *et al.* “Identifying the hospitalised patient in crisis”—a consensus conference on the afferent limb of Rapid Response Systems. *Resuscitation* 2010;81:375–82. <http://dx.doi.org/10.1016/j.resuscitation.2009.12.008>
- 99 Cretikos M, Parr M, Hillman K, *et al.* Guidelines for the uniform reporting of data for Medical Emergency Teams. *Resuscitation* 2006;68:11–25.
- 100 Cerda J. Oliguria: an earlier and accurate biomarker of acute kidney injury [quest]. *Kidney Int* 2011;80:699–701.
- 101 Krumholz HM, Merrill AR, Schone EM, *et al.* Patterns of hospital performance in acute myocardial infarction and heart failure 30-day mortality and readmission. *Circ Cardiovasc Qual Outcomes* 2009;2:407–13.
- 102 Knaus WA, Harrell FE Jr, Lynn J, *et al.* The SUPPORT prognostic model. Objective estimates of survival for seriously ill hospitalized adults. Study to understand prognoses and preferences for outcomes and risks of treatments. *Ann Intern Med* 1995;122:191–203.
- 103 Peralta CA, Shlipak MG, Judd S, *et al.* Detection of chronic kidney disease with creatinine, cystatin c, and urine albumin-to-creatinine ratio and association with progression to end-stage renal disease and mortality. *JAMA* 2011;305:1545–52.
- 104 Kaukonen K, Bailey M, Suzuki S, *et al.* Mortality related to severe sepsis and septic shock among critically ill patients in Australia and New Zealand, 2000–2012. *JAMA* 2014;311:1308–16.
- 105 Lynn J, Teno JM, Harrell FE Jr. Accurate prognostications of death. Opportunities and challenges for clinicians. *West J Med* 1995;163:250–7.
- 106 Fawcett T. An introduction to ROC analysis. *Pattern Recognit Lett* 2006;27:861–74.
- 107 Brabrand M, Folkestad L, Clausen NG, *et al.* Risk scoring systems for adults admitted to the emergency department: a systematic review. *Scand J Trauma Resusc Emerg Med* 2010;18:1–8.
- 108 Simon ST, Martens M, Sachse M, *et al.* Liverpool Care Pathway” (LCP) in Deutschland. Care of the dying in hospital: initial experience with the Liverpool Care Pathway (LCP) in Germany. *Dtsch Med Wochenschr* 2009;134:1399–404.
- 109 Waldrop DP, Kirkendall AM. Comfort measures: a qualitative study of nursing home-based end-of-life care. *J Palliat Med* 2009;12:719–24.
- 110 Ryder-Lewis M. Going home from ICU to die: a celebration of life*. *Nurs Crit Care* 2005;10:116–21.
- 111 Horey DE, Street AF, Sands AF. Acceptability and feasibility of end-of-life care pathways in Australian residential aged care facilities. *Med J Aust* 2012;197:106–9.
- 112 Cherniack E. Increasing use of DNR orders in the elderly worldwide: whose choice is it? *J Med Ethics* 2002;28:303–07.