It is feasible to flag 'near end-of-life' status in older patients from routine general practice data

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Background and objective
Prognostic uncertainty delays discussions and leads to unnecessary treatments for older patients who are dying. The aim of this study was to investigate the feasibility of using routinely collected data from MedicineInsight, a large Australian general practice database, to flag indicators of near end-of-life (nEOL) in patients aged ≥75 years and evaluate their association with death over 12 months.

Methods
A retrospective chart review was used to assess the feasibility of identifying these indicators in the data (160,897 patients from 464 practices across Australia). Conditional logistic regression was used to assess the independent contribution of nEOL indicators in patients aged 75–84 and ≥85 years using a case-control design matching by practice.

Results
The strongest indicators for nEOL status were advanced malignancy, residential aged care, nutritional vulnerability, anaemia, cognitive impairment and heart failure. Other indicators included hospital attendance, pneumonia, decubitus ulcer, chronic obstructive pulmonary disease, antipsychotic prescription, male sex and stroke.

Discussion
Consideration of routinely collected patient data may suggest nEOL status and trigger advance care planning discussions.

THE PROPORTION OF PEOPLE aged ≥80 years is predicted to increase by more than five times worldwide by 2050.[1] In Australia, the proportion of individuals aged ≥75 years is expected to increase to 10.4% in the same period.[2]

The rates of older patients using ambulances, emergency departments and acute hospitals in the last year of life are increasing.[3–6] Some of these hospital presentations may be avoided, but end-of-life (EOL) conversations are often delayed until a health crisis arises.[7] Proactive identification of patients in the near-EOL (nEOL) stage in the primary care setting may reduce presentations to acute hospitals.[8,9] Likewise, advance health directives, which are relatively rare (14%) in Australia,[10] may help curb avoidable hospital transfers and better align admissions with patient goals of care. Factors contributing to delays in discussing and planning terminal care in the general practice setting include prognostic uncertainty, lack of time, non-reimbursement and perceived difficulty in choosing the right time for these conversations.[11,12]

These authors previously developed and tested nEOL indicators for older hospital patients (aged ≥65 years).[13] In the community setting, there is currently no readily available screening tool to assist general practitioners (GPs) in identifying patients who may be nEOL. Automatic extraction from general practice clinical data systems potentially offers a structured way to identify risk factors that indicate nEOL, which may improve the GPs' engagement in initiating advance care planning and shared decision making.

The aim of this study was to 1) assess the feasibility of using an existing Australian general practice database, MedicineInsight, to identify potential indicators of nEOL in patients aged ≥75 years, and 2) to evaluate the association between the proposed nEOL indicators and death over the ensuing 12 months for patients in general practice.

Methods

A retrospective chart review design (Study 1: Feasibility) was used to assess the feasibility of identifying these indicators using MedicineInsight data routinely extracted from several hundred Australian general practices, and a subsequent retrospective case-control study (Study 2: Associations with nEOL) evaluated the association between these indicators and death for patients aged ≥75 years.

General practice data from the MedicineInsight database, managed by NPS MedicineWise to support quality improvement in Australian primary care and post-market surveillance of medicines, were used for this study. These sentinel surveillance data were considered fit for purpose as they comprise anonymised practice representation from every state and territory; are compatible with the two major medical software packages used by Australian GPs; and allow text data mining from date fields, numeric fields and free-form text fields, which contributes to documenting the pre-specified

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definitions (Appendix 1, available online only) without the use of numeric coding. Syntax from the statistical package SAS previously used in the same data source[14] to identify keywords related to patient clinical profiles and activities at the general practice encounter was modified to meet the needs of the present project. The data contain anonymised patient demographic and clinical data extracted directly from the clinical information systems of 464 general practices across all Australian states and territories. Items extracted from patient encounters include medical history (diagnoses/conditions), prescriptions, investigations, pathology test results, observations, allergies and immunisations.[15–17] Practices participating in the surveillance network have an opt-out system whereby individual patients have the right to refuse to their data being exported or used for research, and therefore their data are not used.

Study population

The study population for Study 1: Feasibility was all patients aged ≥75 years either living in the community or in residential aged care who had at least three encounters within two years with a GP at a practice participating in MedicineInsight between 1 January 2014 and 31 December 2017. Patients were excluded if they had missing data on year of birth or sex, or their status was 'inactive' (ie they no longer attended the practice). Patients were assigned to the 'deceased' group if they had a record of death recorded between 2014 and 2017, while patients with no record of death and whose status was active were assigned to the survivor group.

A case-control design (Study 2: Associations with nEOL) was implemented matching only by practice to account for the influence of the practice characteristics on death. Based on the achieved sample size, there was at least 80% power to detect an odds ratio of 1.3 or higher as statistically significant at the 1% level assuming a control rate of at least 10%. Cases were defined as all patients whose status was recorded as 'died' or where 'died' was recorded as a reason for encounter during 2017 and the patient had no general practice encounters, prescriptions or tests following the status date. To maximise power,[18,19] five controls for each case were randomly identified; these were matched by practice and included patients whose status was last recorded as 'active' and who had a least one activity (ie encounter, prescription or test) recorded at the general practice in 2017. Given evidence of heterogeneous indicators of death by age, the eligible patients were divided into two age groups: patients aged 75–84 years and patients ≥85 years. These strata were included as explanatory variables alongside sex in the predictive models.

Potential predictors of death in the short term

A list of potential predictors of death within 3–12 months for older patients in general practice was identified from a range of sources: studies of mortality risk in general practice;[20–22] the Criteria for Screening and Triaging to Appropriate aLternative care (CriSTAL) tool,[13] a hospital-based tool to predict short-term risk of death; and consultations with a geriatrician, medical and nursing aged care practitioners. Factors flagging nEOL status were extracted from MedicineInsight data fields using text-mining techniques. Most of the practices have automated result transfer from the pathology provider, so the result data were also in MedicineInsight database. To make the data elements comparable across different medical software packages, a set of rules was developed to define the different predictors or conditions, including a related list of synonyms, a list of medicines and pathology test result values (Appendix 1, available online only).

Statistical methods

To assess the feasibility of using MedicineInsight data to identify indicators associated with death and establish the completeness and usefulness of the data to flag these indicators, the researchers 1) compared the prevalence of these indicators for all eligible patients in the study with their prevalence in available Australian population- or general practice–based studies, and 2) identified which of the nEOL indicators were more prevalent in those patients who died between 2014 and 2017 when compared with those who survived the entire study period.

Separate conditional logistic regression models for each age group (75–84 years and ≥85 years) were used to assess and quantify the association of each indicator with risk of death within 12 months using patients who died in 2017 and their matched controls. The decision to stratify by age group was based on previous knowledge that nEOL status for the very old (≥85 years) is mostly driven by factors such as frailty,[23] whereas the risk of death in the short term for patients aged 75–84 years is driven by underlying comorbidities.[24] All variables potentially associated with death (Appendix 1, available online only) were initially included in a multivariable model. Backwards stepwise elimination was used to remove statistically non-significant variables from the model based on a criterion of $P > 0.01$, with the exception of age and sex, which remained in all models regardless of statistical significance because of well-established biological plausibility.

Explanatory variables included in the final multivariable model are reported as odds ratios, 95% confidence intervals and P values. This work was approved by the Royal Australian Collage of General Practitioners National Research & Evaluation Ethics Committee in February 2018 [application MW01509].

Results

A total of 160,897 patients were identified to be eligible for Study 1: Feasibility (Appendix 2, available online only). Sixteen per cent of these patients (n = 25,891) had a record of death over the entire period, and 135,006 were active patients and assigned survivor status. For almost all the potential indicators, except for liver disease and holder of a healthcare card, patients who died had a higher prevalence of nEOL indicators than survivors, as reflected in the unadjusted odd ratios (Table 1). When the prevalence of the potential indicators of death was compared for all patients to available Australian data, the survivor group of MedicineInsight patients had a higher prevalence of atrial fibrillation or anticoagulant use, anaemia, chronic

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Table 1. Prevalence (presence) of potential near end-of-life indicators in the study populations (Study 1 cohort)

		Prevalence estimates (% Yes)			
	Other Australian prevalence data	Eligible MedicineInsight patients aged ≥75 years			
Potential indicators of near end-of-life		All eligible patients n = 160,897	Survivors n = 135,006	Deceased n = 25,891	Unadjusted odds ratio (95% CI)
Demographic indicators					
SEIFA disadvantage		49.44	48.59	53.83	1.23 (1.20, 1.27)
Age >85 years		44.40	40.33	65.60	2.82 (2.74, 2.90)
Male sex		42.36	41.76	45.54	1.17 (1.14, 1.20)
Health Care Card holder		31.35	32.61	24.82	0.68 (0.66, 0.70)
Residential aged care facility resident		12.64	9.36	29.72	5.13 (4.96, 5.29)
Department of Veterans' Affairs card holder		8.29	6.98	15.09	2.37 (2.27, 2.46)
Condition indicators					
Chronic kidney disease (CKD) – moderate or severe or proteinuria (ever mentioned) or test results suggestive of CKD (previous 12 months)	25.2* (SAND 197)†	41.77	40.18	50.05	1.49 (1.45, 1.53)
Polypharmacy (≥7 current PBS medicines)	–	28.97	26.38	42.49	2.06 (2.01, 2.12)
Atrial fibrillation (ever) or anticoagulant prescribed (previous 12 months)	18.0* (atrial fibrillation only; SAND 174)†	24.13	22.45	32.87	1.69 (1.64, 1.74)
Diabetes (ever mentioned)	16.7* (SAND 238)†	22.17	21.59	25.18	1.22 (1.18, 1.26)
Anaemia (previous 12 months)	16.0* (ABS)[27]	20.68	19.82	25.16	1.36 (1.32, 1.40)
COPD (ever mentioned)	12.7* (SAND 247)†	14.67	13.47	20.88	1.69 (1.64, 1.75)
Stroke (ever mentioned)	6.7* (ABS)[28]	14.04	12.71	21.01	1.83 (1.77, 1.89)
Heart failure (ever mentioned)	13.8* (SAND 236)†	13.74	11.05	27.77	3.10 (3.00, 3.20)
Antipsychotic prescribed (previous 12 months)	–	11.66	9.66	22.08	2.65 (2.56, 2.74)
Cognitive impairment including dementia and intellectual handicap (ever mentioned)	17.1* (SAND 102)†	12.03	9.47	25.40	3.26 (3.15, 3.37)
Fall or fracture (previous six months)	–	6.80	6.04	10.80	1.88 (1.80, 1.97)
Myocardial infarction (ever mentioned)	7.3* (acute coronary syndrome; SAND 188)†	6.02	5.47	8.91	1.69 (1.61, 1.78)
Chronic liver disease (ever mentioned)	–	2.70	2.79	2.26	0.81 (0.74, 0.88)
Ulcer – decubitus or wound (previous 12 months)	–	1.84	1.38	4.22	3.15 (2.92, 3.40)
Advanced malignancy (ever mentioned)	8.2* (ABS, malignant neoplasms)[28]	1.78	1.10	5.34	5.08 (4.72, 5.48)
Pneumonia (previous six months)	2.5‡ (SAND 179)†	1.67	1.24	3.89	3.22 (2.97, 3.48)
Nutritional vulnerability (previous 12 months)§	–	1.65	1.19	4.06	3.52 (3.25, 3.81)
Frailty	–	0.48	0.36	1.10	3.06 (2.64, 3.54)
Depression (previous 12 months)	–	0.47	0.41	0.80	1.96 (1.67, 2.30)
Health service indicators					
Hospital attendance (previous 12 months)	18.2‖ (SAND 239)†	3.21	2.51	6.86	2.86 (2.70, 3.04)
ICU admission (previous 12 months)	–	0.03	0.02	0.08	4.97 (2.69, 9.17)

**Age group ≥75 years*
†Supplementary analysis of nominated data (SAND) are sub-studies of the annual Bettering the Evaluation and Care of Health (BEACH) survey[29]
‡Age group ≥50 years
§Mention of appetite loss, malnutrition, supplementary feeding, feeding tube, unintentional weight loss, medicines or counselling/programs for weight loss
‖All ages
–, no comparator found in the Australian literature; ABS, Australian Bureau of Statistics; CI, confidence interval; COPD, chronic obstructive pulmonary disease; ICU, intensive care unit; PBS, Pharmaceutical Benefits Scheme; SAND, supplementary analysis of nominated data; SEIFA, Socioeconomic Index for Areas

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kidney disease and stroke (Table 1). The prevalence of advanced malignancy, cognitive impairment, pneumonia (previous six months) and hospitalisation (previous 12 months) was lower for the Study 1 group than for other Australian data.

Independent risk factors for near end of life

For Study 2: Association with nEOL, two sub-samples were included. A total of 2287 cases and 11,435 matched controls aged 75–84 years met the eligibility criteria for analysis, as did 4686 cases and 23,425 matched controls aged ≥85 years. Appendix 3 (available online only) compares the prevalence and unadjusted odds ratios of indicators for cases and matched controls in Study 2. Final models for both age groups suggest a similar group of variables associated with death within 12 months. Advanced malignancy, being in residential aged care, frailty, anaemia, nutritional vulnerability, cognitive impairment and heart failure were the strongest independent indicators for the younger age group. Other significant associations were hospital attendance in the past 12 months, pneumonia, decubitus ulcer, chronic obstructive pulmonary disease (COPD), prescription of antipsychotic medicines, myocardial infarction, male sex, ≥7 current Pharmaceutical Benefits Scheme medicines and stroke. Patients aged ≥85 years had a similar set of indicators, with the strongest predictors being advanced malignancy, residential aged care, nutritional vulnerability, anaemia and pneumonia (Table 2).

The model for patients aged ≥85 years included two additional variables: atrial fibrillation or anticoagulant prescribed, and diabetes. While only the younger patients' model included the variables frailty, myocardial infarction and current polypharmacy, the odds ratios for the variables common to both age groups were generally greater for the younger group of patients when compared with the older group.

Discussion

To the authors' knowledge, this is the first large-scale investigation of the ability of routinely extracted general practice data in Australia to identify potential indicators of nEOL status for older patients. The study supports the hypothesis that despite varying underreporting of some variables, MedicineInsight data routinely extracted from Australian general practices can be used to identify a set of potential indicators of nEOL for patients aged ≥75 years. The strongest indicators for nEOL status for both groups were advanced malignancy, residential aged care, nutritional vulnerability, anaemia, cognitive impairment and heart failure. Other factors associated with increased likelihood of death by 12 months included hospital attendance, pneumonia, decubitus ulcer, COPD, antipsychotic prescription, male sex and stroke. The increased risk associated with each of these indicators varied between the two age groups.

Comparison with other studies

While a checklist of combined nEOL indicators is not routinely used in general practice, many of the independent risk factors for nEOL in the present study had been previously identified as predictors of death.[20,21,25] The QMortality risk-prediction algorithm,[21] developed in the UK, used an extensive list of >50 baseline predictors from electronic medical records and >30 final validated demographic, clinical and social predictors of mortality. Although many of the clinical indicators overlap with those found in the present study, some social data items (such as ethnicity, living alone, loneliness) available in the UK are not recorded in extractable fields or are underreported in electronic clinical records in Australian general practices.

A recently published Australian case-control study of 215 deceased patients and 267 controls combined data from a chart audit of patients from three large general practices and data from a published randomised controlled trial of unguided intuition versus screening tools to identify risk of death.[22] There was very little overlap between potential indicators collected in this study when compared with the present study. Many of the variables came from structured screening tools supplemented by general practice record audits. Only three independent variables overlapped with the present results for nutritional vulnerability, cognitive impairment and COPD: weight loss, neurological deterioration and advanced lung disease. However, the study is based on a very small sample of patients selected from those consenting to be part of a randomised controlled trial, and it used indicators that are not easily extracted from the clinical software. Others in Australia have proposed the use of the number of chronic diseases as a predictor of primary care encounters.[26] For the present study, the researchers did not attempt the use of a summary measure of comorbidities as a predictor of death because it was more informative to personalise risk by identifying specific conditions.

Strengths and limitations of this study

This study uses MedicineInsight data, which provides a large and heterogeneous sample of participating general practices (representing approximately 10% of Australian general practices), GPs and patients located across the seven Australian states and territories. Where pathology results data were available, these enabled improved definitions of some of the potential indicators investigated. As management of patients may differ across practices, the researchers controlled for this potential confounder by matching those who died with survivors attending the same practice in the case-control study.

General practices participating in MedicineInsight were not randomly selected but are a convenience sample of practices so may not represent all Australian general practices. The low prevalence of advanced malignancy, cognitive impairment and pneumonia or hospitalisation in the preceding months when compared with other sources of Australian data[27–29] suggests that these conditions may be underreported in the MedicineInsight data. It is not known whether the data gaps would tend to overestimate or underestimate the nEOL status. Although the researchers attempted to minimise misclassification bias using

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the available data, it is likely that patients in the survivor (control) group may have died and information about their deaths was not available and/or recorded in the general practice data. To confirm the deceased status of all individuals and validate the findings by providing estimates of sensitivity, specificity and predictive values for likelihood of dying within 12 months, a further study linking the general practice data to national death registry data is needed. It is acknowledged that large sample sizes provide a more precise estimate but also increase the chances of finding a statistically significant result. The researchers chose a cut-off *P* value of 0.01 for inclusion of variables in the model to ensure only variables with strong evidence of association were retained in the model.

The completeness of information in these data is dependent on information provided by the patient, the clinician recording practices and the availability of that information being in designated data fields that are retrieved from the clinical information systems by MedicineInsight. Difficulties in obtaining comprehensive data to assist clinical decisions in primary care in Australia have been identified recently,[30] highlighting a reduced capacity for large-scale meaningful translational research.

Conclusions and implications for practice

Considering the known underreporting of some of the MedicineInsight extractable fields, this study yields encouraging results about the potential for identifying nEOL status from routinely collected data from

Table 2. Adjusted associations of near end-of-life by age group (Study 2 cohort)

Near end-of-life indicators on record	Patients aged 75–84 years (n = 13,722)		Patients aged ≥85 years (n = 28,111)	
	Odds ratio (95% CI)	*P* value	Odds ratio (95% CI)	*P* value
Age	1.07 (1.04, 1.10)	<0.0001	1.12 (1.11, 1.13)	<0.0001
Advanced malignancy (ever mentioned)	7.59 (5.78, 9.96)	<0.0001	4.57 (3.68, 5.68)	<0.0001
Residential aged care resident	4.60 (3.88, 5.46)	<0.0001	2.59 (2.38, 2.82)	<0.0001
Frailty*	3.96 (1.85, 8.49)	0.0004		
Anaemia (previous 12 months)	2.94 (2.62, 3.31)	<0.0001	1.93 (1.79, 2.08)	<0.0001
Nutritional vulnerability (previous 12 months)	2.77 (2.01, 3.82)	<0.0001	2.05 (1.68, 2.50)	<0.0001
Cognitive impairment (ever mentioned)	2.29 (1.95, 2.70)	<0.0001	1.62 (1.48, 1.77)	<0.0001
Heart failure (ever mentioned)	2.21 (1.91, 2.56)	<0.0001	1.62 (1.49, 1.77)	<0.0001
Hospital attendance (previous 12 months)	1.95 (1.51, 2.52)	<0.0001	1.54 (1.32, 1.80)	<0.0001
Pneumonia (previous six months)	1.93 (1.35, 2.75)	0.0003	1.72 (1.41, 2.10)	<0.0001
Decubitus ulcer (previous 12 months)	1.70 (1.28, 2.25)	0.0003	1.61 (1.47, 1.77)	<0.0001
COPD (ever mentioned)	1.69 (1.48, 1.93)	<0.0001	1.37 (1.25, 1.50)	<0.0001
Antipsychotic prescribed (previous 12 months)	1.49 (1.28, 1.74)	<0.0001	1.45 (1.25, 1.69)	<0.0001
Myocardial infarction (ever mentioned)*	1.38 (1.12, 1.69)	0.0020		
Male sex	1.34 (1.20, 1.49)	<0.0001	1.26 (1.17, 1.36)	<0.0001
Polypharmacy (≥7 current PBS medicines)*	1.24 (1.10, 1.40)	0.0005		
Stroke (ever mentioned)	1.23 (1.06, 1.43)	0.0053	1.23 (1.13, 1.34)	<0.0001
Atrial fibrillation or anticoagulant prescribed (previous 12 months)†			1.31 (1.21, 1.42)	<0.0001
Diabetes†			1.16 (1.07, 1.26)	0.0005

**Only the younger patients' model included the variables frailty, myocardial infarction and current polypharmacy.*
†The model for patients aged ≥85 years included two additional variables: atrial fibrillation or anticoagulant prescribed, and diabetes.
CI, confidence interval; COPD, chronic obstructive pulmonary disease; PBS, Pharmaceutical Benefits Scheme

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older patients. This may be useful to assist clinicians in deciding when to start advance care planning discussions with older patients affected by progressive life-limiting illness. Widespread automated data extraction will save documentation time, and consistent and complete documentation of all relevant fields by GPs could enhance accuracy of prognostic factors. Early identification of patients potentially approaching the EOL stage before imminent dying begins is important but not sufficient. This needs to be followed by opportunities to clarify personal values and priorities around EOL, and ensure patients' EOL wishes are incorporated into management plans. This is the first step in developing an algorithm to facilitate risk score calculations that could be incorporated in general practice clinical software to prompt advance care planning discussions with older high-risk patients. Several practical hurdles would need to be overcome to develop nEOL risk scores. This includes further research linking MedicineInsight data to national death data to confirm the survival status of every patient. This study also paves the way for a review of other interventions that may be informed by these estimates of nEOL risk.

The services provided by GPs, including the conduct of complex and successful discussions on EOL planning, may also be currently limited by a number of barriers including time and reimbursement. Acceptability of any intervention and the potential effect on real-world practice warrants further investigation.

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Competing interests: MC reports jointly developing and validating the CriSTAL tool as an Open Access (no charge) instrument to predict risk of death in hospitals. She does not earn any financial income from its adoption by any clinicians, services or publications whatsoever. MW reports that she worked for NPS MedicineWise as an analyst of the MedicineInsight database before involvement in this project, which facilitated understanding of the contents and analytical strategies. She received fees for analysis of study data from the University of NSW (UNSW). MW also reports developing the SAS programming code used for this study which is jointly owned by herself and UNSW. KH reports jointly developing and validating the CriSTAL tool as an Open Access (no charge) instrument to predict risk of death in hospitals. He does not earn any financial income from its adoption by any clinicians, services or publications. MM reports he receives income for consultancy work with the Gold Coast Primary Health Network and The Royal Australian College of General Practitioners for work unrelated to this research project.

Funding: This work was supported by a 2018–2019 grant from the HCF Research Foundation [#172099].

Provenance and peer review: Not commissioned, externally peer reviewed.

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