Do frailty and comorbidity indices improve risk prediction of 28-day ED reattendance? Reanalysis of an ED discharge nomogram for older people

Do frailty and comorbidity indices improve risk prediction of 28-day ED reattendance? Reanalysis of an ED discharge nomogram for older people.

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ABSTRACT

Background: In older people, quantification of risk of reattendance after ED discharge is important to provide adequate post ED discharge care in the community to appropriately targeted patients at risk.

Methods: We reanalysed data from a prospective observational study, previously used for derivation of a nomogram for stratifying people aged 65 and older at risk for ED reattendance. We investigated the potential effect of comorbidity load and frailty by adding the Charlson or Elixhauser comorbidity index and a 10-item frailty measure from our data to develop four new nomograms. Model I and model F built on the original nomogram by including the frailty measure with and without the addition of the Charlson comorbidity score; model E adapted for efficiency in the time-constrained environment of ED was without the frailty measure; and model P manually constructed in a purposeful stepwise manner and including only statistically significant variables. Areas under the ROC curve of models were compared. The primary outcome was any ED reattendance within 28 days of discharge.

Results: Data from 1357 patients were used. The point estimate of the respective areas under ROC were 0.63 (O), 0.63 (I), 0.68 (E), 0.71 (P) and 0.63 (F).

Conclusion: Addition of a comorbidity index to our previous model improves stratifying elderly at risk of ED reattendance. Our frailty measure did not demonstrate any additional predictive benefit.

Key words Risk Assessment; Frail Elderly; Comorbidity; Emergency Department

INTRODUCTION

There is strong clinical and research interest in identifying older patients at highest risk of early emergency department (ED) reattendance after discharge. To this end, a number of researchers have developed screening tools that attempt to predict certain adverse events after discharge. In the main, these tools have certain similarities: they report composite outcomes for an adverse event (such as death, loss of independent living and hospitalisation) and they dichotomise patients into high versus low risk. Systematic reviews published recently have concluded that the most well-known of these screening tools, the Identification of Seniors At Risk (ISAR) and the Triage Risk Stratification Tool (TRST), have quite limited predictive validity for composite adverse outcomes [1,2]. An even more comprehensive review of existing instruments determined that there were no pragmatic, accurate, and reliable instruments for geriatric ED patients[3].

We have previously attempted to take a different path, developing a risk nomogram (figure 1) that measured reattendance risk only, and no other outcomes, and provided an estimated percentage chance of reattendance rather than a high/low risk dichotomy[4]. In a validation study in a separate population we showed our nomogram performed very well at stratifying patients, with a strong relationship between projected and measured reattendance risk by stratum[5]. Yet the overall predictive performance remained unacceptably low to be used as a standalone tool, with an area under receiver operator characteristic (AUROC) curve of 0.65. This is because *individually* most discharged patients have a small projected risk of reattendance, yet collectively the very low risk groups make up a numerically large number of reattendances. For example, under ideal

performance there will be six reattendances both from a group of 600 patients with a 1% projected risk per patient, and a group of 12 patients with a 50% projected risk per patient.

However, in considering this, we hypothesised that the low AUROC may also be because the nomogram is underestimating risk for those projected to be low risk. When modelling the original nomogram, we incorporated a comorbid condition such as heart failure, or an indicator of frailty such as weight loss, as an individual risk factor for reattendance to be modelled. However, most authors agree that the cumulative effect of multimorbidity and frailty is greater than the sum of its parts. We hypothesised that calculating a composite measure of comorbidity and frailty and recalibrating the nomogram may improve its overall predictive value.

METHODS

Study cohort

The original derivation cohort for the development of our nomogram was reanalysed for this study[4]. The cohort consisted of 1439 male and female patients aged 65 years or older who were discharged home from the emergency departments of two hospitals in Western Australia. Prior to discharge, patients underwent a thorough assessment by medical, nursing and allied health staff, and a suite of variables were recorded including those related to the acute presentation, patient demographics, comorbid status, markers of geriatric syndromes and frailty, and post discharge planning and referral. Participants who were unintentionally enrolled in the study more than once after presenting to different EDs were identified and the oldest record of ED visit retained as the index ED visit. The study was approved by the respective hospital human research ethics committees.

Outcome measure

The primary outcome measure was any attendance at an ED (not just the ED in which the study was conducted) within 28 days of discharge from the index ED visit. Subsequent ED reattendance were identified by patient level linkage to the Emergency Department Data Collection, a state-wide administrative data collection of all public and private hospital EDs obtained from the Data Linkage Branch, Department of Health. [6]

Comorbidity and frailty indices

To reanalyse the data we calculated two comorbidity indices, the Charlson[7] and Elixhauser[8] indices, and a modified version of a composite frailty measure. We used

the Australian modification of the International Classification of Diseases, version10 (ICD-10-AM) codes related to the index ED visit and all person-level linked hospital inpatient records three years before the index ED visit to calculate the comorbidity indices. Both the Elixhauser and Charlson Comorbidity Index were coded using the Quan algorithm.[9]

A review of available frailty indices was carried out using OneSearch, a platform that allows searching various library and online databases (MEDLINE & OVID simultaneously (http://guides.library.uwa.edu.au/onesearch). Seventeen frailty indices were identified with at least 1 frailty-related variable in common with our dataset. Our data were unable to match an entire published frailty index. Therefore, we composed a 10-item frailty measure, whilst excluding all frailty-related variables already appearing in the original nomogram or the comorbidity indices (Table 1).

Table 1. Variables used for 10 item frailty measure

Variable
Weight loss greater than 5kg in last 6 months
Mobility aids used
Visual aids used
Any urinary incontinence
Any faecal incontinence
Living alone
Needing formal community support
Needing informal community support
Anxiety
One or more falls in past 6 months

Patient variables

Variables tested in the nomogram development were: age, sex, history of ED use, history of recent hospital admission (within 10 days), comorbid conditions collected at index ED visit, triage category at index ED visit, history of multiple falls, history of weight loss, poor vision, history of alcohol misuse, diagnosis at index ED presentation, sum of Elixhauser comorbid conditions (excluding depression) and the Charlson comorbidity index (with or without malignancy) in recent past history, our composed 10 item frailty measure, polypharmacy, current malignancy, current accommodation status, carer status and the Six-item Screener (SIS) cognition score. Polypharmacy was defined as taking six or more different medications.

Statistical analysis

Data were structured into the counting process format so that each participant had 28 observations representing the 28 days from date of index ED presentation until the end of the follow-up period. A participant was not considered at risk of an ED admission while in hospital and was removed from the risk pool during each hospital stay (interval truncation). Participants were censored at date of death if it occurred during the follow-up period.

Two types of time-to-event approaches were considered. The first was as a single failure approach where factors that predict the rate of first ED revisit only were modelled. That is, once a participant experienced a first ED revisit, they were no longer considered at further risk. The second approach was a multiple failure one where a participant remained the risk pool during the full 28 days and allowed to experience multiple ED revisits during follow-up.

Flexible parametric proportional hazards models that used restricted cubic splines (Royston-Parmar models[10]) to describe the baseline hazard were constructed for each

of the prognostic models. Baseline complexity was described using three degrees of freedom in each of the models. The original nomogram (O) plus four other prognostic factor combinations were chosen (Table 2).

a. The original nomogram with the Charlson comorbidity index (minus malignancy as this featured already in the original nomogram) and the frailty index added but no other adjustments (I)
b. A maximally efficient nomogram (E)
c. A maximally predictive nomogram (P)
d. The original nomogram with the frailty score added but no other adjustments (F)

Table 2. Included variables of all modelled nomograms

Available variables	O	I	E	P	F
Age	x	x	x	x	x
Gender	x	x			x
Number of ED presentations in last year	x	x	x	x	x
Polypharmacy	x	x			x
Malignancy	x	x			x
Depression	x	x	x	x	x
CCT intervention	x	x			x
SIS cognition score	x	x		x	x
Dementia			x		
Six or more falls in past 12 months			x	x	
Visual problems			x	x	
Hospital admission in last 10 days			x	x	
Charlson score (minus malignancy)		x			
Charlson score			x		
Frailty score		x			x
Elixhauser score (excluding depression)				x	
Presentation for fracture, DVT or gastroenteritis				x	

SIS, The six-item screening; CCT, patient seen by care coordination team in ED

Some elements, such as age and depression, are common across the four models, whereas other elements of model O such as polypharmacy were excluded for models E

and P. Each were tested under both single and multiple failure analyses. For the more complex prognostic models, the variables describing ED history and sum of Elixhauser comorbid conditions were transformed using fractional polynomials to improve model fit. Receiver operating characteristic (ROC) curve analysis of the sensitivity and specificity for the prognosis of ED reattendance for each model was conducted. The degree variation was explained by each model was estimated by using Royston and Sauerbrei's R^2_D measure. The probabilities of ED reattendance were plotted against time at specified centiles of the distribution of the prognostic index where the 95^{th} percentile corresponded to highest risk and lowest 5^{th} percentile corresponded to lowest risk.

RESULTS

After removing non-index records for 65 participants who were enrolled twice, there remained 1,357 study participants with an index ED presentation. During the 28 days of follow-up, there were 322 ED revisits by 254 (19%) participants. Most of the participants who had an ED revisit had just one ED revisit (n=202; 80%). Two participants each had five ED revisits during the 28 day follow-up.

Participant factors tabulated by whether they experienced an ED revisit during follow-up or not is shown in Table 3. Most participant factors show a statistically significant difference in proportions by ED revisit status. Participants with at least one ED revisit within 28 days were more likely to have a greater history of ED visits, take six or more medications, have depression, malignancy, dementia, a higher frailty score and comorbidity index score, have a history of a recent hospital admission, poor vision and have had CCT intervention.

Table 3. Patient demographic and health summary by ED reattendance.

		ED reattendance within 28 days				
		No (n=1103)		Yes (n=254)		p-value
Age (years)	Mean (SD)	77.7	8.1	79.8	8.1	<0.001
	Median IQR)	77	71-84	80	74-86	
Sex	Male	624	56.6	143	56.3	0.937
	Female	479	43.4	111	43.7	
Previous ED visits (n, %)	None	842	76.5	166	64.6	<0.001
	1	172	15.6	38	14.8	
	2	47	4.3	22	8.6	
	3	29	2.6	15	5.8	
	4	4	0.4	10	3.9	
	5+ visits	7	0.6	5	2.0	
Hospital discharge within last 10 days	No	1051	89.5	207	81.5	0.001
	Yes	52	10.5	47	18.5	
Polypharmacy	No	762	69.1	148	58.3	0.001
	Yes	341	30.9	106	41.7	
Depression	No	1093	99.2	247	97.2	0.010
	Yes	9	0.8	7	2.8	
Malignancy	No	1048	95.1	232	91.3	0.019
	Yes	54	4.9	22	8.7	
CCT intervention	No	782	70.9	163	64.2	0.036
	Yes	321	29.1	91	35.8	
Charlson index score	None	846	76.7	174	68.5	0.010
	1 to 3	208	18.9	65	25.6	
	4 or more	49	4.4	14	5.5	
Frailty score	Mean (SD)	2.8	1.8	3.2	1.9	0.001
	Median (IQR)	2	1-4	3	1-5	
SIS cognition score	Mean (SD)	5.2	0.1	4.7	0.1	<0.001
	Median (IQR)					
Dementia	No	1087	98.6	243	95.7	0.002
	Yes	15	1.9	11	4.3	
History of 6 or more falls	No	1064	96.5	228	89.8	<0.001
	Yes	39	3.5	26	10.2	
Vision difficulties	No	987	89.5	207	81.5	<0.001
	Yes	116	10.5	47	18.5	

SIS, The six-item screening; CCT, patient seen by care coordination team; SD, standard deviation; IQR, interquartile range

Each of the five time-to-event multivariable regression models listed in Table 2 were run for both single and multiple failure times. Summary model discrimination measures are shown in Table 4. The point estimate of the respective AUROC were 0.63 (O), 0.63 (I), 0.68 (E), 0.71 (P) and 0.63 (F). This suggests that the addition of a composite measure of frailty provided no benefit to the overall predictive power of the nomogram, but that comorbidity indices may yield modest improvement. An estimate of the variation in outcome explained by each model shows that it is generally low for all models. The most predictive model P explains only 30% of the variation in ED revisits, although this is double the 15% explained by the original nomogram (O).

Table 4. Discrimination and explained variance measures

	Area under ROC		**R^2_D**	
Model	**Estimate**	**95%CI**	**Estimate**	**95%CI**
Single failure				
O	0.63	0.60-0.66	0.15	0.09-0.21
I	0.63	0.60-0.66	0.15	0.09-0.21
E	0.68	0.65-0.71	0.24	0.17-0.30
P	0.71	0.68-0.73	0.31	0.25-0.38
F	0.63	0.60-0.66	0.15	0.09-0.21
Multiple failure				
O	0.63	0.60-0.66	0.14	0.09-0.20
I	0.63	0.60-0.66	0.14	0.10-0.20
E	0.68	0.65-0.71	0.24	0.19-0.30
P	0.70	0.67-0.73	0.31	0.25-0.36
F	0.63	0.60-0.66	0.14	0.10-0.19

The distribution of the prognostic index from the four models is visualised in Figure 1. The plots give an impression of the range of discrimination from each model and show what might happen to patients at the extremities and in the middle of the risk profiles. Model P shows the greatest discrimination, particularly in the high risk centiles, but discrimination in the middle and low ranges of the risk spectrum is less well defined.

[Insert Fig 1 here]

Fig 1 Probability of ED reattendance stratified into 20 percentiles of risk score estimated by the original nomogram time-to-event model O and models I, E and P. Bold line represents the 50th centile

DISCUSSION

In a reanalysis of a large dataset of patients, the addition of a composite measure of comorbidity, but not frailty, increased the predictive performance of a discharge risk assessment nomogram. The integration of a comorbidity index has improved the previously developed nomogram at the cost of increased complexity of this risk stratification tool. This modest improvement and the limited predictive validity of all other ED screening tools for older people once again demonstrates the complexity of predicting ED revisits in complex older people post discharge.

Placing people into reattendance risk strata before discharge from ED has several potential advantages, particularly in selecting high risk patients for intensive follow up after discharge[11]. With the worldwide ageing population, ED encounters with frail and multimorbid patients will be more common[12]. Frailty is a medical syndrome of increased vulnerability to a stressor that makes recovery from an acute illness or injury less likely[13]. It is intuitive to believe that a discharged frail person may be more likely to return to ED after discharge, but this was not the case in our work. Reasons for this may include a) the most severely frail patients tend to be admitted rather than discharged; b) that those with recognised frailty already have increased home supports

to reduce hospitalisation risk; or c) our frailty measure was not sufficiently selective. Incorporation of other measures of frailty like grip strength[14] or inflammatory, nutritional or clinical biomarkers may be helpful[15].

Review articles have concluded that no published tool is yet robust enough to predict adverse outcomes in older people after discharge[16]. Largely this is because of their poor specificity, with many false positives. A two-step screening method, combining a sensitive tool with a specific one, may be a way forward. Alternatively, tools for specific individual presenting problems, such as infection or heart failure, may improve the clinical utility.

CONCLUSION

Addition of multimorbidity but not frailty measures increases the accuracy of a discharge risk nomogram.

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CONFLICT OF INTEREST

On behalf of all authors, the corresponding author states that there is no conflict of interest

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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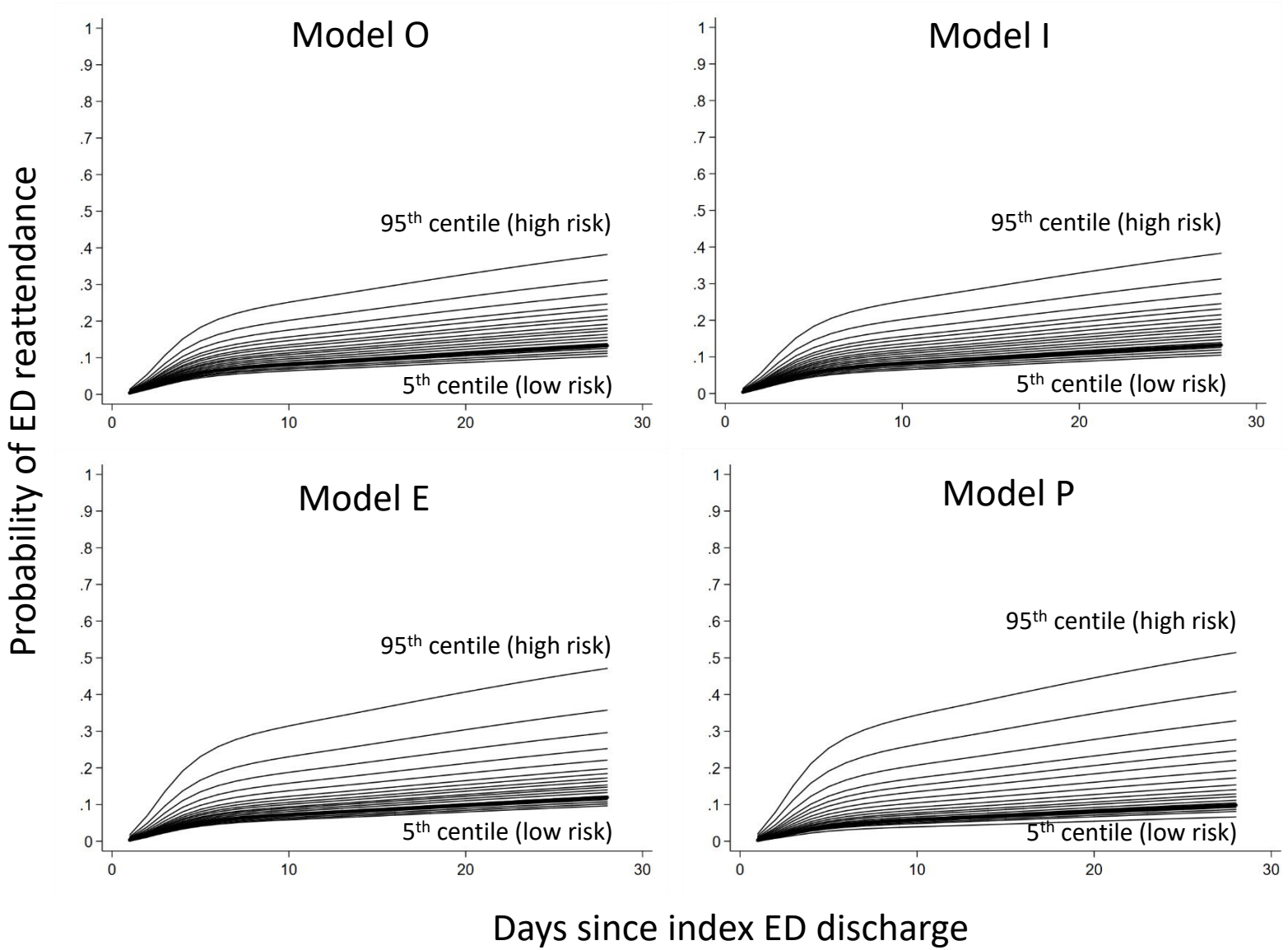
Model O
Model I
Model E
Model P
95th centile (high risk)
5th centile (low risk)
Probability of ED reattendance
Days since index ED discharge
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1
0
10
20
30