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The Association of Geriatric Syndromes with Hospital Outcomes

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The Association of Geriatric Syndromes with Hospital Outcomes

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Abstract

BACKGROUND: frailty, history of dementia (HoD) and acute confusional states (ACS) are common in older patients admitted to hospital.

OBJECTIVE: to study the association of frailty (at least 6 points in the Clinical Frailty Scale: CFS), HoD and ACS with hospital outcomes, controlling for age, gender, acute illness severity (measured by a Modified Early Warning Score in the Emergency Department), comorbidity (Charlson Comorbidity Index), and discharging specialty (General Medicine, Geriatric Medicine, Surgery).

DESIGN: retrospective observational study.

SETTING: large university hospital in England.

PATIENTS: we analyzed 8202 first non-elective inpatient episodes of people aged ≥75 years between October 2014 and October 2015.

MEASUREMENTS: the outcomes studied were: prolonged length of stay (LOS≥10 days), inpatient mortality, delayed discharge, institutionalization, and 30-day readmission. Statistical analyses were based on multivariate regression models.

RESULTS: independently of controlling variables, prolonged LOS was predicted by CFS≥6: Odds Ratio [OR]=1.55, 95% Confidence Interval [CI]: 1.36-1.77, p<0.001, HOD: OR=2.16, 95% CI: 1.79-2.61, p<0.001, and ACS: OR=3.31, 95% CI: 2.64-4.15, p<0.001). Inpatient mortality was predicted by CFS≥6: OR=2.29, 95% CI: 1.79-2.94, p<0.001. Delayed discharge was predicted by CFS≥6: OR=1.46, 95% CI: 1.27-1.67, p<0.001, HOD: OR=2.17, 95% CI: 1.80-2.62, p<0.001, and ACS: OR=2.29, 95% CI: 1.83-2.85, p<0.001). Institutionalization was predicted by CFS≥6: OR=2.56, 95% CI: 2.09-3.14, p<0.001, HOD: OR=2.51, 95% CI: 2.00-3.14, p<0.001, and ACS: OR=1.93, 95% CI: 1.46-2.56, p<0.001). Readmission was predicted by ACS: OR=1.36, 95% CI: 1.09-1.71, p=0.006.

CONCLUSIONS: routine screening for frailty, HoD and ACS in hospitals may aid the development of acute care pathways for older adults.

Keywords

Hospitals

Frail Older Adults

Dementia

Delirium

Geriatric Health Services

INTRODUCTION

Geriatric syndromes are multifactorial health conditions that affect older people and include dementia, delirium, impaired mobility, falls, frailty, poor nutrition, weight loss, incontinence, and difficulties with activities of daily living.[1] These syndromes are highly prevalent among older patients admitted to acute hospitals[2,3] and often add complexity to the clinical status of hospitalized older adults with multimorbidity.[4] In the English National Health Service (NHS), the proportion of older people admitted to acute hospitals with geriatric syndromes has increased dramatically over recent years.[5]

The recognition and management of geriatric syndromes by hospitalists requires a specific set of knowledge and skills.[6] However, Geriatricians are a scarce resource in many settings, including the NHS. A challenge for service evaluation and research is that there is generally poor capture of information on geriatric syndromes compared to specific comorbidities in discharge summaries and hospital coding.[7] Developments are taking place in the NHS to address this issue, and in 2013 our center started the routine collection of data on clinical frailty, history of dementia (HoD) and acute confusional state (ACS) in all patients aged 75 years or more admitted non-electively to the hospital.[8]

The presence of geriatric syndromes in older inpatients is an important driver of adverse outcomes, particularly length of stay (LOS) and admission to institutional care.[9] However, acute illness severity (AIS) is also an important determinant of poor outcomes in the inpatient population, and may drive disproportionate changes in health status in the most vulnerable.[10] Previous research studies with geriatric syndromes in acute settings have not been able to simultaneously consider AIS.[11] In addition, comorbidity is not always associated with an increased number of geriatric syndromes.[12]

We aimed to study the association of geriatric syndromes measured in routine clinical care such as frailty, HoD and ACS with hospital outcomes (prolonged LOS, inpatient mortality, delayed discharge, institutionalization, and 30-day readmission), while controlling for demographics (age, gender), AIS, comorbidity, and discharging specialty (General Medicine, Geriatric Medicine, Surgery).

PATIENTS AND METHODS

Study Design and Setting

This retrospective observational study was conducted in a large tertiary university hospital in England with 1000 acute beds receiving over 102000 visits to the Emergency Department (ED) and admitting over 73000 patients per year; among the latter, over 12000 are aged 75 or more years.

Sample

We analyzed all first non-elective inpatient episodes (i.e. from ED admission to discharge) of people aged ≥75 years (all specialties) between the 26th of October 2014 and the 26th of October 2015. Data was obtained via the hospital's information systems following the implementation of a new electronic patient record on the 26th of October 2014.

Patients' Characteristics

The following anonymized variables were extracted:

- Age and gender.
- AIS information is routinely collected in our ED using a Modified Early Warning Score (ED-MEWS). The components and scoring of the ED-MEWS are shown in Table 1. Where more than one ED-MEWS was collected, the highest was used in the analyses.
- Charlson Comorbidity Index (CCI, without age adjustment).[13] The CCI is based on the discharge diagnoses, as coded by the 10th version of the WHO International Classification of Diseases (ICD-10). The CCI was calculated retrospectively and would have not been available to clinicians early during the patients' admission.
- Clinical Frailty Scale (CFS). The scoring of the CFS is based on a global assessment of patients' comorbidity symptoms, and their level of physical activity and dependency on

activities of daily living, estimated to reflect the status immediately before the onset of the acute illness leading to hospitalization. The possible scores are: 1 (very fit), 2 (well), 3 (managing well), 4 (vulnerable), 5 (mildly frail), 6 (moderately frail), 7 (severely frail), 8 (very severely frail), and 9 (terminally ill) (http://geriatricresearch.medicine.dal.ca/clinical_frailty_scale.htm).[14] The use of the CFS in admissions of people aged ≥75 years was introduced in our center in 2013 under a local Commissioning for Quality and Innovation (CQUIN) scheme.[8] The CQUIN required that all patients aged 75 years or over admitted to the hospital, via the emergency pathway, be screened for frailty using the CFS within 72 hours of admission. The admitting doctor usually scores the CFS on the electronic admission record, but it can also be completed by ED nurses or by nursing or therapy staff from the trust-wide Specialist Advice for the Frail Elderly (SAFE) team. Training on CFS scoring is provided to staff on induction and at regular educational meetings. Permission to use the CFS for clinical purposes was obtained from the principal investigator at Geriatric Medicine Research, Dalhousie University, Halifax, Canada.

- Cognitive variables were collected early during the admission in patients aged 75 or more, thanks to a parallel local CQUIN scheme. The cognitive CQUIN variables are not gold standard, but screening variables. The admission clerking is designed in such way that patients are clinically classified within 72 hours of admission into the following three mutually excluding categories:
    - Known history of dementia (HoD; in the database: no=0; yes=1).
    - Acute Confusional State (ACS), without HoD (in the database: no=0; yes=1).
    - Neither HoD nor ACS.

  The cognitive CQUIN assessment does not intend to diagnose dementia in those who are not known to have it, but tries to separate the dementias that General Practitioners (GPs)

already know about from hospital-identified acute cognitive concerns that GPs may need to assess or investigate further after discharge. The latter may include delirium and/or previously undiagnosed dementia.

In our routine hospital practice, the initial cognitive assessment is done by a clinician in the following fashion: firstly, if the patient is known to have dementia (i.e. based on the clinical history and/or chart review), the clinician selects the "known history of dementia" option in the admission navigator, and no further cognitive screening is conducted. If the patient has no known dementia, the clinician administers the 4-item Abbreviated Mental Test (AMT4): (1) Age, (2) Date of birth, (3) Place, and (4) Year, with impaired cognition indicated by an AMT4 <4 and triggering the selection of the "ACS without known HoD" option. If the AMT4 is normal, the clinician selects the "Neither HoD nor ACS" option.

Due to the service evaluation nature of our work, these measures could not be assessed for reliability within the electronic medical records system (e.g. as regards sensitivity and specificity against a gold standard, or as regards inter-rater reliability).

- Discharged from Geriatric Medicine (no=0; yes=1). Every year, our hospital admits over 12000 patients aged 75 or more, of which a quarter are managed by the Department of Medicine for the Elderly (DME). The DME specialist bed base currently consists of five core wards, which specialize in ward-based Comprehensive Geriatric Assessment (CGA) and are supported by dedicated nursing, physiotherapy, occupational therapy, and social work teams, as well as by readily available input from speech and language therapy, clinical nutrition, psychogeriatric, pharmacy and palliative care teams. Formal multidisciplinary team meetings occur at least twice weekly. A sixth specialist DME ward with a more acute perspective has been running for the past 7 years; this ward was restyled as the Frailty and Acute Medicine for the Elderly (FAME) ward in 2014 and has daily multidisciplinary team meetings. Although admission to FAME is through the

emergency pathway, admission to core DME wards can occur from FAME (i.e. within-DME transfer), via the emergency pathway, or from other inpatient specialty areas if older patients are perceived to be in high need of CGA after screening by the SAFE team. A previous audit in our center showed that up to 20% of patients discharged by DME were not initially admitted by DME, underscoring the significant role of core specialist DME wards in absorbing complex cases, especially from the general medical wards.[8]

- Discharged from General Medicine (no=0; yes=1). In our setting, virtually all patients discharged by General Medicine were admitted by General Medicine in the first place.[8]
- Discharged by a Surgical specialty (no=0; yes=1).

Hospital Outcomes

The following anonymized variables were extracted:

- Length of stay (LOS, days). Prolonged LOS was defined as 10 or more days (no=0; yes=1).
- Inpatient mortality (no=0; yes=1).
- Delayed discharge (no=0; yes=1). This was defined as the total LOS being at least one day longer than the LOS up to the last recorded clinically fit date (CFD). The CFD is used in NHS hospitals to indicate that the acute medical episode has finished and discharge-planning arrangements (often via social care providers) can commence.
- Institutionalization (no=0; yes=1). This was defined as the discharge destination being a care home, when a care home was not the usual place of residence.
- 30-day readmission (no=0; yes=1).

Statistical Analyses

Anonymized data was analyzed with IBM SPSS Statistics (version 22) software. Descriptive statistics were given as count (with percentage) or mean (with standard deviation: SD).

To avoid potential problems with multicollinearity in the multivariate regression models, the correlations among the predictor variables were checked using a correlation matrix of two-sided Spearman's *rho* correlation coefficients. Correlations of 0.50 or more were considered large.[15,16]

As all the outcomes under study were binary, multivariate binary logistic regression models were computed. In these models, the Odds Ratio (OR) reflects the effect size of each predictor. 95% Confidence Intervals (CI) were requested for each OR. Predictors with $p<0.01$ were considered as statistically significant. The classification performance of each logistic regression model was assessed calculating its area under the curve (AUC).

Sensitivity analyses were conducted after imputing missing data (SPSS multiple imputation procedure) and after fitting interaction terms between geriatric syndromes and discharge by Geriatric Medicine.

Ethics Approval

This study is based on a Service Evaluation Audit that was registered with our center's Safety and Quality Support Department (Project register number 4814). Formal confirmation was received that approval from the Ethics Committee was not required.

Funding

No funding was required for this study.

RESULTS

The initial database contained 12282 non-elective admission and discharge episodes of patients aged 75 or more years between the 26th of October 2014 and the 26th of October 2015 (all specialties). Among those, 8202 (66.8%) were first episodes. Table 2 shows the sample descriptives, and Table 3 shows the breakdown of geriatric syndromes (single and multiple) in the total sample (n=8282), including missing frailty data.

In the correlation matrix of two-sided Spearman's *rho* correlation coefficients, no correlations with large effect size were found to suggest issues with multicollinearity; the largest correlation coefficients were between age and the CFS (*rho*=0.35), history of dementia and the CFS (*rho*=0.32), and the CCI and the CFS (*rho*=0.26).

The results of the multivariate regression models are shown in Table 4. The best performing models were the ones for inpatient mortality (AUC=0.80), followed by institutionalization (AUC=0.76), and prolonged LOS (AUC=0.71). After full adjustment, clinical frailty was an independent predictor of prolonged LOS, inpatient mortality, delayed discharge, and institutionalization. HoD was an independent predictor of prolonged LOS, delayed discharge, and institutionalization. And ACS was an independent predictor of prolonged LOS, delayed discharge, institutionalization, and 30-day readmission (Table 4). Results did not significantly change in sensitivity analyses conducted after multiple imputation of missing data and after inclusion of interaction terms (see supporting information).

DISCUSSION

Our aim was to study the association of geriatric syndromes measured in routine clinical care with hospital outcomes. We found that geriatric syndromes such as clinical frailty, history of dementia, and acute confusional state were strong independent predictors. As regards prolonged LOS, delayed discharge, and institutionalization, geriatric syndromes had odds ratios that were greater than those of traditionally measured factors such as demographics, comorbidity and acute illness severity. Our findings add to the body of knowledge in this area because we accounted for the latter effects. Our experience shows that metrics on geriatric syndromes can be successfully collected in the routine hospital setting and add clear value to the prediction of operational outcomes. This may encourage other hospitals to do the same.

Our findings are consistent with previous suggestions that accounting for chronic conditions alone may be less informative than also accounting for the co-occurrence of geriatric syndromes.[17] The focus of the CFS is on the preadmission level of physical activity and dependency on activities of daily living, and poorer scores may confer vulnerability to adverse outcomes due to reduced physiological reserve and ability to withstand acute stressors.[18] Other studies have also found the CFS to be a good predictor of inpatient outcomes,[19-22] and it has been recommended as one of the possible means to identify vulnerable older adults in acute care settings.[23]

History of dementia and an acute confusional state had independent effects beyond frailty, particularly in prolonging LOS, delaying discharge, and requiring institutionalization. It is known that dementia prolongs LOS,[24] and delirium prolongs hospitalization for persons with dementia.[25] Older people with cognitive impairment may have an increased risk of acquiring new geriatric syndromes during the stay in hospital, particularly if it is long.[26] A previous

study showed that the risk of poor functional recovery can be as high as 70% in complex delirious patients in hospital.[27] All too often, delirium is neither benign nor reversible, with a significant proportion of patients not experiencing restoration *ad integrum* of cognition and function.[28]

Our results are consistent with previous observations that geriatric syndromes are associated with higher risk of institutionalization.[29] It was interesting that female gender seemed to be an independent predictor of institutionalization, which is consistent with the results of a previous systematic review showing that the male to female ratio of admission rates ranged between 1 to 1.4 and 1 to 1.6.[30]

As regards discharge specialty, discharge by General Medicine seemed to be associated with a lower likelihood of prolonged LOS, and discharge by Geriatric Medicine seemed to be associated with a higher likelihood of delayed discharge and institutionalization. Unsurprisingly, Geriatric Medicine wards tend to absorb the most complex cases, often with complex discharge planning needs.[8] In that light, comprehensive geriatric assessment (CGA) in geriatric wards may not be associated with reduced LOS (and it is possible that the LOS of complex patients might have been higher in non-geriatric wards). In addition, inpatient CGA increases frail patients' likelihood of survival.[31]

Our study suggests that routinely collected metrics on frailty, HoD and ACS may be helpful to better adapt hospital care to the real requirements of aged people. The proportion of older people admitted to acute hospitals with geriatric syndromes continues to increase[5] and Geriatricians are a scarce resource. It will be increasingly important to upskill non-geriatric hospitalists in the recognition and management of geriatric syndromes. Frail older people are

becoming the core business of acute hospitals,[32] making Geriatrics 'too important to be left to Geriatricians'.[33] Therefore, easily collected metrics on geriatric syndromes may help non-geriatricians identify these syndromes and address them early during the admission.

Our study has important limitations. Firstly, the geriatric syndromes were not identified with gold standard measures. For example, acute confusional state in the absence of known dementia should only be seen as a surrogate for delirium. ACS as a proxy measure is likely to underestimate the diagnosis of delirium, as the hypoactive type is commonly missed without valid measures. In addition, a patient with delirium superimposed upon dementia would have been coded as a 'known dementia'. The geriatric syndromes measures could not be assessed for reliability within the electronic medical records system (e.g. as regards sensitivity and specificity against a gold standard, or as regards inter-rater reliability).

As regards the potential limitations of the CFS, there have been concerns that an inter-observer discrepancy in CFS scoring may occur between health professionals. However, a previous study investigated the inter-rater reliability of the CFS between clinicians in 107 community-dwelling older adults aged 75 years and above, finding a substantial agreement with a weighted kappa coefficient of 0.76 (95% CI: 0.68 to 0.85).[34] Another study reported a CFS weighted kappa of 0.92.[35] Another limitation of the CFS in our center is the significant proportion of missing data (28%). As we have previously shown, missing CFS data is more frequent in situations of very high acuity (including in critical care or surgical areas), or in medical areas when the LOS was short (e.g. <72 hours).[8] We tried to address this bias by performing multiple imputation for missing data, revealing similar results.

Another limitation of our study is that we treated geriatric syndromes and the other predictors in the models as independent variables. However, many of the factors may be interrelated, and they present simultaneously in many patients. Indeed, the bivariate correlation between the CFS and history of dementia was of moderate strength, because worsening cognition should score higher on the CFS as per the scoring protocol. As expected, there was also a medium-sized correlation between the CFS and the CCI. It has been suggested that physical and cognitive frailty may be more informative as a single complex phenotype.[36] Indeed, the problems of old age tend to come as a package.[37]

For 30-day readmission, the AUC of the model was small, suggesting the existence of unmeasured explanatory variables. For example, even though our results agree that AIS and chronic illness predict readmission,[38] the latter still remains an elusive outcome, and a more accurate prediction may be attained by adding socioeconomic variables into models.[39]

Our study echoes the potential utility of incorporating common geriatric clinical features in routine clinical examination and disposition planning for older patients in acute settings.[40] Hospitals may find it informative to undertake large-scale screening for geriatric syndromes including frailty, dementia and delirium in all older adults admitted via the emergency pathways. When combined with other routinely collected variables such as demographics, AIS and comorbidity data, this process may provide hospitals with information that will help define the acute needs of the local population and aid in the development of care pathways for the growing population of older adults.

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Tables

Table 1. ED-MEWS: components and scoring. HR: heart rate (beats per minute); RR: respiratory rate (per minute); SBP: systolic blood pressure (mmHg); AVPU: Alert, responds to Voice, responds to Pain, Unresponsive; GCS: Glasgow Coma Scale; Temp: body temperature (degrees Celsius); minimum score = 0 points; maximum score = 15 points.

	3	2	1	0	1	2	3
HR	<40	41-50	51-60	61-90	91-110	111-129	≥130
RR	≤6	7-8	-	9-14	15-20	21-29	≥30
SBP	≤70	71-80	81-100	101-180	-	≥181	-
AVPU	U	P	V	A			
GCS				15	14	9-13	≤8
Temp	-	<35.0	-	35.0-38.4	-	38.5-39.0	≥39.0

Table 2. Sample descriptives (8202 first admission and discharge episodes).

	% (N) or mean (range; SD)
Age, years	84.1 (75 to 105; 5.9)
Female gender	56.5% (4631)
ED-MEWS	2.9 (0 to 12; 1.8)
CCI	2.9 (0 to 23; 3.1)
CFS	4.8 (1 to 9; 1.7)
CFS 1: very fit	1.1% (92)
CFS 2: fit	4.6% (381)
CFS 3: managing well	14.1% (1159)
CFS 4: vulnerable	11.8% (968)
CFS 5: mildly frail	12.4% (1021)
CFS 6: moderately frail	16.1% (1324)
CFS 7: severely frail	9.0% (736)
CFS 8: very severely frail	2.1% (169)
CFS 9: terminally ill	0.6% (49)
CFS missing	28.1% (2303)
History of dementia	9.9% (812)
Acute confusional state	6.3% (519)
Discharge from General Medicine	33.1% (2715)
Discharge from Geriatric Medicine	22.2% (1817)
Discharge from Surgery	27.9% (2289)
LOS, days	8.9 (0 to 209; 12.7)
LOS ≥10 days	30.3% (2488)
Inpatient mortality	7.4% (604)
Delayed discharge	26.3% (2158)
Institutionalization	9.9% (809)
30-day readmission	29.8% (2447)

N: number; SD: standard deviation; ED-MEWS: Emergency Department Modified Early Warning Score; CCI: Charlson Comorbidity Index; CFS: Clinical Frailty Scale; LOS: length of stay.

Table 3. Breakdown of geriatric syndromes (single and multiple) in the total sample (n=8282), including missing frailty data. CFS: Clinical Frailty Scale; HoD: history of dementia; ACS: acute confusional state.

						Count
CFS 6 or more	No (3621)	HoD	No (3493)	ACS	No	3332
					Yes	161
			Yes (128)	ACS	No	128
					Yes	0
	Yes (2278)	HoD	No (1742)	ACS	No	1490
					Yes	252
			Yes (536)	ACS	No	536
					Yes	0
	Missing (2303)	HoD	No (2155)	ACS	No	2049
					Yes	106
			Yes (148)	ACS	No	148
					Yes	0

Table 4. Results of the Multivariate Regression Models.

Dependent Variable: LOS ≥10 Days (N=5546; Chi-square=708.1; p<0.001; AUC=0.71)						
	Unstandardized Coefficients		Odds ratio	95% Confidence Interval for Odds ratio		p
	B	Std. Error		Lower Bound	Upper Bound	
Age	0.01	0.01	1.01	1.00	1.03	0.009
Gender	0.07	0.06	1.08	0.95	1.22	0.234
ED-MEWS	0.11	0.02	1.12	1.08	1.16	<0.001
CCI	0.09	0.01	1.09	1.07	1.11	<0.001
CFS 6 or more	0.44	0.07	1.55	1.36	1.77	<0.001
HoD	0.77	0.10	2.16	1.79	2.61	<0.001
ACS	1.20	0.12	3.31	2.64	4.15	<0.001
Dc Gen Med	-0.87	0.09	0.42	0.35	0.51	<0.001
Dc Geri Med	0.00	0.10	1.00	0.83	1.21	0.995
Dc Surgery	0.08	0.10	1.09	0.89	1.32	0.411
Dependent Variable: Inpatient Mortality (N=5546; Chi-square=447.7; p<0.001; AUC=0.80)						
	B	Std. Error	Odds ratio	95% Confidence Interval for Odds ratio		p
Age	0.05	0.01	1.05	1.03	1.07	<0.001
Gender	-0.17	0.12	0.85	0.67	1.06	0.145
ED-MEWS	0.40	0.03	1.49	1.41	1.57	<0.001
CCI	0.15	0.02	1.17	1.13	1.20	<0.001
CFS 6 or more	0.83	0.13	2.29	1.79	2.94	<0.001
HoD	-0.37	0.16	0.69	0.50	0.95	0.024
ACS	0.17	0.19	1.19	0.82	1.72	0.363
Dc Gen Med	0.22	0.18	1.24	0.88	1.75	0.222
Dc Geri Med	0.06	0.19	1.06	0.74	1.52	0.759
Dc Surgery	0.07	0.22	1.07	0.70	1.65	0.746

Dependent Variable: Delayed Discharge (N=4984; Chi-square=416.6; p<0.001; AUC=0.68)						
	B	Std. Error	Odds ratio	95% Confidence Interval for Odds ratio		p
Age	0.03	0.01	1.03	1.02	1.05	<0.001
Gender	0.00	0.07	1.00	0.88	1.13	0.953
ED-MEWS	-0.03	0.02	0.98	0.94	1.01	0.182
CCI	0.03	0.01	1.03	1.00	1.05	0.018
CFS 6 or more	0.38	0.07	1.46	1.27	1.67	<0.001
HoD	0.78	0.10	2.17	1.80	2.62	<0.001
ACS	0.83	0.11	2.29	1.83	2.85	<0.001
Dc Gen Med	-0.23	0.10	0.80	0.66	0.97	0.021
Dc Geri Med	0.36	0.10	1.44	1.18	1.75	<0.001
Dc Surgery	-0.10	0.11	0.90	0.73	1.12	0.358
Dependent variable: Discharge to Care Home (Institutionalization) (N=5546; Chi-square=473.5; p<0.001; AUC=0.76)						
	B	Std. Error	Odds ratio	95% Confidence Interval for Odds ratio		p
Age	0.03	0.01	1.03	1.02	1.05	<0.001
Gender	0.34	0.10	1.40	1.16	1.69	<0.001
ED-MEWS	0.03	0.03	1.03	0.98	1.08	0.266
CCI	0.03	0.02	1.03	1.00	1.06	0.055
CFS 6 or more	0.94	0.10	2.56	2.09	3.14	<0.001
HoD	0.92	0.11	2.51	2.00	3.14	<0.001
ACS	0.66	0.14	1.93	1.46	2.56	<0.001
Dc Gen Med	-0.02	0.16	0.98	0.71	1.34	0.884
Dc Geri Med	0.64	0.16	1.90	1.40	2.58	<0.001
Dc Surgery	0.11	0.18	1.12	0.79	1.60	0.535

Dependent variable: 30-day readmission (N=5546; Chi-square=103.0; p<0.001; AUC=0.59)						
	B	Std. Error	Odds ratio	95% Confidence Interval for Odds ratio		p
Age	0.02	0.01	1.02	1.01	1.03	0.001
Gender	-0.05	0.06	0.95	0.85	1.07	0.412
ED-MEWS	-0.06	0.02	0.94	0.91	0.98	0.001
CCI	0.05	0.01	1.06	1.04	1.08	<0.001
CFS 6 or more	0.09	0.07	1.10	0.96	1.25	0.171
HoD	0.10	0.10	1.10	0.91	1.34	0.309
ACS	0.31	0.11	1.36	1.09	1.71	0.006
Dc Gen Med	0.19	0.09	1.21	1.01	1.44	0.041
Dc Geri Med	-0.03	0.10	0.97	0.80	1.17	0.737
Dc Surgery	-0.22	0.11	0.80	0.66	0.99	0.037

LOS: length of stay; N: number; AUC: area under the curve; ED-MEWS: Emergency Department Modified Early Warning Score; CCI: Charlson Comorbidity Index; CFS: Clinical Frailty Scale; HoD: history of dementia; ACS: acute confusional state; Dc: discharge; Gen Med: General Medicine; Geri Med: Geriatric Medicine. The reference category for gender is male (male=0; female=1).

Supporting information 1 (sensitivity analysis). Results of the Multivariate Regression Models with multiple imputation of missing data.

Dependent Variable: LOS ≥10 Days (N=8202; Chi-square=1044.8; p<0.001; AUC=0.72)						
	Unstandardized Coefficients		Odds ratio	95% Confidence Interval for Odds ratio		p
	B	Std. Error		Lower Bound	Upper Bound	
Age	0.01	0.01	1.01	1.00	1.02	0.020
Gender	0.10	0.05	1.11	1.00	1.23	0.056
ED-MEWS	0.12	0.01	1.13	1.10	1.17	<0.001
CCI	0.08	0.01	1.08	1.06	1.10	<0.001
CFS 6 or more	0.40	0.06	1.49	1.33	1.67	<0.001
HoD	0.92	0.08	2.51	2.13	2.96	<0.001
ACS	1.41	0.10	4.08	3.35	4.96	<0.001
Dc Gen Med	-0.85	0.08	0.43	0.37	0.50	<0.001
Dc Geri Med	0.10	0.08	1.11	0.94	1.30	0.213
Dc Surgery	0.02	0.08	1.02	0.88	1.19	0.777
Dependent Variable: Inpatient Mortality (N=8202; Chi-square=828.0; p<0.001; AUC=0.82)						
	B	Std. Error	Odds ratio	95% Confidence Interval for Odds ratio		p
Age	0.05	0.01	1.05	1.04	1.07	<0.001
Gender	-0.28	0.09	0.76	0.63	0.91	0.003
ED-MEWS	0.50	0.02	1.66	1.58	1.73	<0.001
CCI	0.13	0.01	1.14	1.11	1.17	<0.001
CFS 6 or more	0.75	0.10	2.13	1.74	2.60	<0.001
HoD	-0.52	0.15	0.59	0.45	0.79	<0.001
ACS	-0.09	0.17	0.92	0.66	1.28	0.608
Dc Gen Med	0.34	0.14	1.40	1.07	1.84	0.014
Dc Geri Med	0.19	0.15	1.21	0.90	1.63	0.202
Dc Surgery	0.30	0.16	1.35	0.99	1.83	0.057

Dependent Variable: Delayed Discharge (N=8202; Chi-square=657.5; p<0.001; AUC=0.68)						
	B	Std. Error	Odds ratio	95% Confidence Interval for Odds ratio		p
Age	0.03	0.01	1.03	1.02	1.04	<0.001
Gender	0.05	0.05	1.05	0.95	1.16	0.378
ED-MEWS	0.01	0.02	1.01	0.98	1.04	0.437
CCI	0.02	0.01	1.02	1.00	1.03	0.078
CFS 6 or more	0.36	0.06	1.43	1.28	1.60	<0.001
HoD	0.89	0.08	2.43	2.07	2.86	<0.001
ACS	1.00	0.10	2.71	2.25	3.27	<0.001
Dc Gen Med	-0.18	0.08	0.84	0.72	0.97	0.021
Dc Geri Med	0.38	0.08	1.46	1.24	1.71	<0.001
Dc Surgery	-0.17	0.08	0.84	0.72	0.99	0.038
Dependent variable: Discharge to Care Home (Institutionalization) (N=8202; Chi-square=710.4; p<0.001; AUC=0.77)						
	B	Std. Error	Odds ratio	95% Confidence Interval for Odds ratio		p
Age	0.04	0.01	1.04	1.03	1.06	<0.001
Gender	0.38	0.08	1.46	1.24	1.72	<0.001
ED-MEWS	0.00	0.02	1.00	0.96	1.05	0.860
CCI	0.03	0.01	1.03	1.00	1.05	0.041
CFS 6 or more	0.96	0.09	2.60	2.18	3.11	<0.001
HoD	1.02	0.10	2.77	2.27	3.38	<0.001
ACS	0.74	0.13	2.09	1.63	2.68	<0.001
Dc Gen Med	0.07	0.13	1.08	0.83	1.40	0.584
Dc Geri Med	0.67	0.13	1.94	1.50	2.52	<0.001
Dc Surgery	0.06	0.15	1.06	0.79	1.41	0.703

Dependent variable: 30-day readmission (N=8202; Chi-square=175.9; p<0.001; AUC=0.59)						
	B	Std. Error	Odds ratio	95% Confidence Interval for Odds ratio		p
Age	0.02	0.00	1.02	1.01	1.03	<0.001
Gender	-0.06	0.05	0.95	0.86	1.04	0.272
ED-MEWS	-0.08	0.01	0.92	0.90	0.95	<0.001
CCI	0.06	0.01	1.06	1.04	1.07	<0.001
CFS 6 or more	0.07	0.06	1.08	0.96	1.20	0.189
HoD	0.07	0.09	1.07	0.91	1.27	0.407
ACS	0.34	0.10	1.40	1.16	1.70	0.001
Dc Gen Med	0.24	0.07	1.27	1.10	1.47	0.001
Dc Geri Med	0.08	0.08	1.08	0.92	1.27	0.321
Dc Surgery	-0.18	0.08	0.84	0.72	0.98	0.026

LOS: length of stay; N: number; AUC: area under the curve; ED-MEWS: Emergency Department Modified Early Warning Score; CCI: Charlson Comorbidity Index; CFS: Clinical Frailty Scale; HoD: history of dementia; ACS: acute confusional state; Dc: discharge; Gen Med: General Medicine; Geri Med: Geriatric Medicine. The reference category for gender is male (male=0; female=1).

Supporting information 2 (sensitivity analysis). Results of the Multivariate Regression Models with multiple imputation of missing data and including interaction effects.

Dependent Variable: LOS ≥10 Days (N=8202; Chi-square=1031.5; p<0.001; AUC=0.72)						
	Unstandardized Coefficients		Odds ratio	95% Confidence Interval for Odds ratio		p
	B	Std. Error		Lower Bound	Upper Bound	
Age	0.01	0.01	1.01	1.00	1.02	0.010
Gender	0.10	0.05	1.10	1.00	1.23	0.062
ED-MEWS	0.11	0.02	1.12	1.09	1.15	<0.001
CCI	0.08	0.01	1.08	1.07	1.10	<0.001
CFS 6 or more	0.23	0.07	1.25	1.09	1.43	0.001
HoD	1.28	0.11	3.60	2.91	4.45	<0.001
ACS	1.57	0.13	4.80	3.74	6.17	<0.001
Dc Gen Med	-0.88	0.08	0.42	0.36	0.49	<0.001
Dc Geri Med	0.15	0.10	1.16	0.95	1.41	0.149
CFS 6 or more * Dc Geri Med	0.23	0.13	1.26	0.99	1.61	0.062
HoD * Dc Geri Med	-0.81	0.17	0.45	0.32	0.62	<0.001
ACS * Dc Geri Med	-0.43	0.20	0.65	0.44	0.97	0.036
Dc Surgery	-0.01	0.08	0.99	0.85	1.15	0.868

Dependent Variable: Inpatient Mortality (N=8202; Chi-square=728.6; p<0.001; AUC=0.80)						
	B	Std. Error	Odds ratio	95% Confidence Interval for Odds ratio		p
Age	0.06	0.01	1.06	1.04	1.08	<0.001
Gender	-0.26	0.09	0.77	0.64	0.92	0.005
ED-MEWS	0.47	0.02	1.60	1.53	1.67	<0.001
CCI	0.13	0.01	1.14	1.11	1.17	<0.001
CFS 6 or more	0.38	0.11	1.46	1.17	1.82	0.001
HoD	0.38	0.11	1.46	1.17	1.82	0.001
ACS	-0.15	0.23	0.86	0.55	1.34	0.499
Dc Gen Med	0.32	0.13	1.38	1.06	1.79	0.017
Dc Geri Med	0.01	0.21	1.01	0.67	1.53	0.957
CFS 6 or more * Dc Geri Med	0.29	0.23	1.34	0.85	2.12	0.209
HoD * Dc Geri Med	-0.20	0.30	0.82	0.46	1.46	0.496
ACS * Dc Geri Med	0.23	0.34	1.26	0.65	2.45	0.501
Dc Surgery	0.19	0.15	1.21	0.90	1.62	0.219

Dependent Variable: Delayed Discharge (N=8202; Chi-square=492.4; p<0.001; AUC=0.67)						
	B	Std. Error	Odds ratio	95% Confidence Interval for Odds ratio		p
Age	0.03	0.01	1.03	1.02	1.04	<0.001
Gender	0.04	0.06	1.04	0.93	1.16	0.467
ED-MEWS	0.02	0.02	1.02	0.99	1.05	0.306
CCI	0.02	0.01	1.02	1.00	1.04	0.018
CFS 6 or more	0.28	0.07	1.32	1.14	1.53	<0.001
HoD	0.91	0.11	2.48	2.01	3.06	<0.001
ACS	0.99	0.13	2.69	2.10	3.43	<0.001
Dc Gen Med	-0.26	0.08	0.77	0.66	0.91	0.002
Dc Geri Med	0.38	0.11	1.46	1.18	1.79	<0.001
CFS 6 or more * Dc Geri Med	0.00	0.13	1.00	0.78	1.29	0.986
HoD * Dc Geri Med	-0.27	0.17	0.76	0.55	1.06	0.108
ACS * Dc Geri Med	-0.22	0.20	0.80	0.54	1.18	0.259
Dc Surgery	-0.08	0.09	0.93	0.78	1.10	0.388

Dependent variable: Discharge to Care Home (Institutionalization) (N=8202; Chi-square=670.9; p<0.001; AUC=0.76)						
	B	Std. Error	Odds ratio	95% Confidence Interval for Odds ratio		p
Age	0.05	0.01	1.05	1.03	1.06	<0.001
Gender	0.38	0.08	1.47	1.24	1.73	<0.001
ED-MEWS	0.01	0.02	1.01	0.97	1.05	0.730
CCI	0.03	0.01	1.03	1.01	1.06	0.021
CFS 6 or more	0.66	0.11	1.94	1.56	2.40	<0.001
HoD	1.20	0.13	3.32	2.56	4.32	<0.001
ACS	0.76	0.18	2.13	1.50	3.03	<0.001
Dc Gen Med	0.09	0.13	1.09	0.84	1.42	0.502
Dc Geri Med	0.59	0.18	1.80	1.27	2.55	0.001
CFS 6 or more * Dc Geri Med	0.26	0.18	1.30	0.91	1.86	0.155
HoD * Dc Geri Med	-0.25	0.20	0.78	0.53	1.15	0.211
ACS * Dc Geri Med	0.03	0.25	1.03	0.62	1.68	0.923
Dc Surgery	0.05	0.14	1.05	0.79	1.39	0.741

Dependent variable: 30-day readmission (N=8202; Chi-square=189.6; p<0.001; AUC=0.59)						
	B	Std. Error	Odds ratio	95% Confidence Interval for Odds ratio		p
Age	0.02	0.00	1.02	1.01	1.03	<0.001
Gender	-0.06	0.05	0.95	0.86	1.04	0.263
ED-MEWS	-0.09	0.02	0.92	0.89	0.94	<0.001
CCI	0.05	0.01	1.06	1.04	1.07	<0.001
CFS 6 or more	0.15	0.06	1.17	1.03	1.32	0.018
HoD	-0.02	0.11	0.98	0.79	1.22	0.883
ACS	0.34	0.13	1.40	1.09	1.79	0.008
Dc Gen Med	0.24	0.07	1.27	1.10	1.47	0.001
Dc Geri Med	0.21	0.10	1.23	1.01	1.49	0.040
CFS 6 or more * Dc Geri Med	-0.35	0.13	0.70	0.55	0.90	0.005
HoD * Dc Geri Med	0.29	0.17	1.34	0.95	1.88	0.096
ACS * Dc Geri Med	0.06	0.20	1.06	0.72	1.57	0.767
Dc Surgery	-0.18	0.08	0.84	0.72	0.98	0.023

LOS: length of stay; N: number; AUC: area under the curve; ED-MEWS: Emergency Department Modified Early Warning Score; CCI: Charlson Comorbidity Index; CFS: Clinical Frailty Scale; HoD: history of dementia; ACS: acute confusional state; Dc: discharge; Gen Med: General Medicine; Geri Med: Geriatric Medicine. The reference category for gender is male (male=0; female=1).