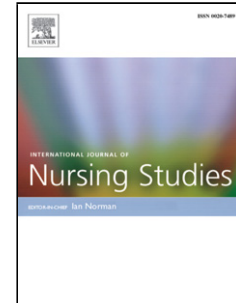


## Accepted Manuscript

Title: Cognitive impairment is independently associated with mortality, extended hospital stays and early readmission of older people with emergency hospital admissions: a retrospective cohort study

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PII: S0020-7489(19)30036-7  
DOI: <https://doi.org/10.1016/j.ijnurstu.2019.02.005>  
Reference: NS 3292



To appear in:

Please cite this article as: Fogg C, Meredith P, Culliford D, Bridges J, Spice C, Griffiths P, Cognitive impairment is independently associated with mortality, extended hospital stays and early readmission of older people with emergency hospital admissions: a retrospective cohort study, *International Journal of Nursing Studies* (2019), <https://doi.org/10.1016/j.ijnurstu.2019.02.005>

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Cognitive impairment is independently associated with mortality, extended hospital stays and early readmission of older people with emergency hospital admissions: a retrospective cohort study

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## ABSTRACT

### Background

Older adults admitted to hospital are often cognitively impaired. It is not clear whether the presence of cognitive impairment conveys an additional risk for poor hospital outcomes in this patient population.

**Objectives**

To determine whether cognitive impairment in hospitalised older adults is independently associated with poor outcomes.

**Design**

Retrospective cohort study using electronic, routinely collected data from linked clinical and administrative databases.

**Setting**

Large, acute district general hospital in England.

**Participants**

21,399 incident emergency admissions of people aged  $\geq 75$ , screened for cognitive impairment, categorised to 3 groups: (i) cognitive impairment with a diagnosis of dementia, (ii) cognitive impairment with no dementia diagnosis, (iii) no cognitive impairment.

**Methods**

Multivariable logistic regression and Fine and Gray competing risks survival models were employed to explore associations between cognitive impairment and mortality (in-hospital alone, and in-hospital plus up to 30 days after discharge), time to hospital discharge, and hospital readmission within 30 days of discharge. Covariates included age, severity of illness, main diagnosis, comorbidities and nutritional risk.

**Results**

Twenty-seven percent of patients had cognitive impairment; of these, 61.5% had a diagnosis of dementia and 38.5% did not. Patients with cognitive impairment and no diagnosis of dementia were most likely to die in hospital or be readmitted, they also had the longest hospital stays. Cognitive impairment was independently associated with mortality in hospital (Odds Ratio 1.34 [1.17 to 1.55] with dementia; Odds Ratio 1.78 [1.52 to 2.07] without), mortality in hospital or within 30 days of discharge (Odds Ratio 1.66 [1.48 to 1.86]; Odds Ratio 1.67 [1.46 to 1.90]); readmission (Odds Ratio 1.21 [1.04 to 1.40]; Odds Ratio 1.47 [1.25 to 1.73]), and increased time until discharge (sub-hazard ratio 0.80 [0.76 to 0.83]; sub-hazard ratio 0.66 [0.63 to 0.69]).

**Conclusions**

Cognitive impairment is associated with an increased risk of adverse outcomes in hospitalised older people with an unscheduled admission, by increasing hospital mortality, extending hospital stays and increasing frequency of readmissions. Future research should focus on understanding the mechanisms contributing to poorer outcomes in this population.

### **Keywords**

Cognitive impairments; dementia; hospitalization; length of stay; mortality; older adults; patient readmission;

### **Contribution of paper**

#### WHAT IS ALREADY KNOWN ABOUT THIS TOPIC?

- Higher mortality rates and longer lengths of stay have been described in older patients with cognitive impairment in hospital.
- The large and increasing proportion of older adults in hospital with cognitive impairment warrants a clear understanding of whether these are directly related to the presence of cognitive impairment, or occurs as a consequence of factors such as age and comorbidities.

#### WHAT THIS PAPER ADDS

- Using a large dataset from the UK, we have explored the relationship between cognitive impairment and hospital mortality, 30-day hospital re-admission and length of hospital stay.
- We have demonstrated independent associations between cognitive impairment and increased hospital mortality, longer hospital stays and increased readmissions after controlling for factors including severity of illness, primary diagnosis, nutritional risk scores, age and comorbidities.

## INTRODUCTION

Emergency hospital admissions of older people are increasing globally, and are likely to continue to rise given current demographic trends. Older adults now comprise around two-thirds of hospital inpatients, and up to 50% of these patients have some form of cognitive impairment, including that related to dementia. (Fogg et al., 2017, Goldberg et al., 2012, Jackson et al., 2016, Reynish et al., 2017, Sampson et al., 2009) This epidemiologic transition needs to be reflected in improved knowledge about hospital outcomes for this group, and subsequently in the evidence base of innovations for appropriate and effective care.

Older adults with a diagnosis of dementia are more likely to die during an emergency hospital admission. (Hsiao et al., 2015, Marengoni et al., 2013, Oreja-Guevara et al., 2012, Sampson et al., 2009) However, it is not clear whether dementia is an independent factor leading to increased mortality, or if other aspects of clinical presentation, patient characteristics or care pathways are responsible for the observed outcomes. An integrative review found that known predictors for deterioration and mortality, for example severity of illness, multimorbidity or risk of malnutrition, (Henderson et al., 2008, Smith et al., 2013, Steventon, 2018, Stratton et al., 2006) were not consistently adjusted for in observational studies exploring this relationship. (Fogg et al., 2018) There is also limited and discrepant information regarding the impact of cognitive impairment in the absence of a diagnosis of dementia on outcomes of hospitalisation. Several large cohorts have described similar frequencies of hospital mortality and lengths of stay in patients with cognitive impairment compared to patients with a diagnosis of dementia, but the role of cognitive impairment as an independent risk factor has not yet been explored. (Connolly and O'Shea, 2015, Fogg et al., 2017, Reynish et al., 2017) Additionally, mortality in the post-discharge period and early re-admissions are important outcomes for this population, as these may be influenced by increasing pressure for hospitals to shorten patient stays, and the variability of care available outside acute hospitals.

Understanding whether cognitive impairment is an independent risk factor for poor hospital outcomes could encourage the timely identification of these patients, thereby enabling planning of appropriate care within and outside hospital. Systematic screening to identify cognitive impairment in older hospitalised patients is becoming more widespread in the UK and elsewhere, with the aim of identifying people with potentially undiagnosed dementia, improving rates of dementia diagnosis, planning appropriate post-hospital care and detecting delirium. (Alzheimer's Australia, 2014, National Institute for Health and Care Excellence, 2010, NHS England, 2014) If cognitive impairment

in the absence of a dementia diagnosis also contributes directly to poor hospital outcomes, appropriate care solutions need to be devised and applied.

This study aimed to identify whether, after adjustment for known risk factors for poor outcomes, including primary diagnosis, severity of illness, age, comorbidities and risk of malnutrition, there are independent associations between cognitive impairment (with or without a diagnosis of dementia) and each of: mortality (in-hospital or within 30 days of discharge), days until hospital discharge, and readmission to hospital within 30 days of discharge.

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## METHODS

### Study Design

A retrospective cohort study using pseudonymised, routinely collected electronic healthcare records.

### Study Setting

A district general hospital in England, with a catchment of approximately 675,000 people.

### Study Population

Acute, non-elective incident admissions of people aged  $\geq 75$  with at least one cognitive screening performed ( $>80\%$  coverage), who were admitted and discharged between 29<sup>th</sup> January 2014 and 31<sup>st</sup> March 2017 inclusive.

### Data Sources

#### *I. Cognitive screening*

Patients aged  $\geq 75$  with unscheduled admissions were routinely screened for cognitive impairment as part of clinical care by trained staff, and results recorded using an electronic tool (CareFlow Vitals, System C, London). Patients with an existing diagnosis of dementia were identified from their medical history. In the absence of a diagnosis of dementia, the following screening questions were completed, based on clinical assessment, history from the patient, the patient's carers or relatives, or from accessing medical notes: (1) "Is the patient exhibiting disturbed behaviour?" (2) "Has the patient been increasingly forgetful over the last 12 months so that it has had an impact on their daily life?" If the answer to one or both questions was 'yes', an Abbreviated Mental Test Score (AMTS) was performed. If the patient was exhibiting disturbed behaviour, delirium was assessed and recorded.

#### *II. Administrative and clinical information*

Demographic data, details of admission and discharge (dates, route, primary diagnosis, specialty, ward), ward transfers, date of death (up to 30 days after discharge) and diagnoses (International Classification of Disease 10) were recorded in the Patient Administration System. Vital signs and other clinical assessments were recorded electronically on CareFlow Vitals, which generated a National Early Warning Score (NEWS) value indicating severity of illness. (Royal College of Physicians, 2012)

### Data extraction and statistical analysis

Pseudonymised electronic records were extracted from operational databases and stored in Microsoft Access. Stata MP version 15.1 (StataCorp, College Station, Texas) was used to link datasets on an anonymous identifier and perform analyses.

The primary explanatory variable was derived from cognitive screening data, categorising admissions into 3 groups: (1) 'dementia': a known diagnosis of dementia, (2) 'cognitive impairment': a positive response to one/both screening questions (i. disturbed behaviour, ii. forgetful in last 12 months) and an Abbreviated Mental Test Score of 8 or below with no known diagnosis of dementia, (3) 'no cognitive impairment': a negative response to both screening questions, or a positive response to one/both screening questions and an Abbreviated Mental Test Score of 9 or 10. Potential confounders that were controlled for in analyses are described in Table 1. Throughout the remainder of this paper, the term "patients with cognitive impairment" refers to patients with cognitive impairment **without** a diagnosis of dementia.

Data completeness for covariates was above 99%, apart from the Malnutrition Universal Screening Tool score, missing in 31.3% (n=6,688) of admissions. To maintain sample size and reduce selection bias, the primary analysis included a dummy category to represent missing Malnutrition Universal Screening Tool values, and a sensitivity analysis using only records with available Malnutrition Universal Screening Tool data was performed. Binary variables were analysed using logistic regression, i.e. death within hospital, death within hospital or within 30 days of discharge, and re-admission to hospital within 30 days of discharge. Categorical variables with similar levels of association in several categories in univariable analysis, such as discharge specialty, were re-grouped for multivariable analysis. A forward stepwise regression approach was used for multivariable analysis, first entering variables most significant in univariable analysis, and utilising the Akaike and Bayesian information criteria (AIC, BIC) to assess variable contribution to model fit by only maintaining inclusion of variables which decreased the Information Criteria in both cases. Interactions between the primary explanatory variable (cognitive impairment category) and covariates (age, severity of illness (National Early Warning Score value), Malnutrition Universal Screening Tool and comorbidity) were explored by comparing the model with both covariates with a nested model including the interaction term (or terms when considering three-way interactions) and applying the Likelihood Ratio test to determine if interactions were candidates for inclusion. However, the same inclusion criteria of improving model fit as measure by AIC/BIC were then



applied. The Area Under the Receiver Operating Characteristic curve (AUROC) was calculated for final models to provide a measure of usefulness of the model in predicting the outcome.

The association between cognitive impairment and length of hospital stay was explored using a Fine and Gray model for competing risk analysis for the 'time-to-discharge' from hospital, with in-hospital death as the competing risk, using Akaike and Bayesian Information Criteria to assess model fit. (Hutchings et al., 2018) As the majority of deaths and discharges occurred in the first three months of a hospital stay, follow-up duration was censored at 91 days. Regression modelling of the effect of covariates on the cumulative incidence frequency (CIF) were performed with the Fine and Gray semiparametric proportional hazard model for the subdistribution hazards. Proportionality of hazards was assessed by examining Schoenfeld residuals.

### **Patient and Public Involvement**

A group of patients and carers with recent experience of hospitalisation informed the selection of descriptive characteristics and outcomes, including ward transfers and indications of end-of-life. They will be involved in writing a lay summary of the results and identifying avenues for dissemination to patients and the public.

### **Ethics**

Ethical approval was obtained from the Isle of Wight, Portsmouth and South East Hampshire Research Ethics Committee, reference 08/02/1394. Consent from participants was not required for this study.

## RESULTS

### *Cohort characteristics*

Demographic, clinical and health service characteristics of the 21,399 eligible incident admissions are described in Table 2. Twenty-seven percent of patients (5,774/21,399) were found to be cognitively impaired at screening, of which 61.5% (n=3,547) had an existing diagnosis of dementia and 38.5% (n=2,227) did not. The mean age of the cohort was 84 years; 56.9% of patients were female. The Malnutrition Universal Screening Tool score was medium or high in 29.5% of the cohort, 54.7% had a Charlson score of 6 or more and 13.3% had a National Early Warning Score value in the medium or high risk categories on the first set of recorded vital signs. Most patients (87.6%) were admitted to medical wards, including 21.6% to Medicine for Older People, Rehabilitation and Stroke (MOPRS) wards. Of the cohort, 6.3% (n=1,343) were placed on end-of-life (EOL) pathways during admission, such that subsequent vital signs observations were not mandated. Patients with dementia were the least likely to have two or more ward transfers during their admission (35.4%), whereas those with cognitive impairment were the most likely (48.0%).

*Description of outcomes*

There were 1,704 deaths in hospital (8.0% of the cohort) (Table 3). Patients with cognitive impairment had the highest in-hospital mortality (12.6%), the longest lengths of stay (median 12 days) and the highest readmission rates (10.3%). Patients with a diagnosis of dementia had the highest mortality in the period covering hospitalisation and 30 days following discharge (20.8%).

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*Association between cognitive impairment and mortality*

Patients with cognitive impairment and those with a diagnosis of dementia had significantly increased risks of mortality both during hospitalisation and within 30 days of discharge in univariable (Supplementary Table 1) and multivariable analyses (Table 4). Interactions between the cognitive impairment category and both the Malnutrition Universal Screening Tool score and Charlson scores were present (all likelihood ratios significant at  $p \leq 0.005$ ). However, including interaction terms in the stepwise regression did not improve the parsimony of the multivariable model (death in hospital AIC 10288 vs 10286, BIC 10511 vs 10732, for full model vs full model with interactions respectively; death within 30 days AIC 13754 vs 13761, BIC 13993 vs 14222), and so were excluded from the model. For both categories of cognitive impairment and dementia, the odds of mortality increased with increasing severity of Malnutrition Universal Screening Tool and increasing levels of co-morbidity. The Area Under the Receiver Operating Characteristic curve for the model for death within hospital was 0.76, and 0.77 for death in hospital or within 30 days, indicating moderate ability of the model to predict patient mortality in this population. The sensitivity analysis including only patients with a Malnutrition Universal Screening Tool score available showed only minor differences in the adjusted Odds Ratios.

*Association between cognitive impairment and readmission*

Patients with cognitive impairment or a dementia diagnosis had a significantly higher risk of readmission within 30 days of discharge in univariable (Supplementary Table 1) and multivariable analyses (Table 4). The Area Under the Receiver Operating Characteristic curve for the multivariable model was 0.58, indicating low of ability of the model to predict readmission.

*Association between cognitive impairment and length of stay*

In the univariable Fine and Gray model, the cumulative incidence function of time to discharge, with death in hospital as a competing risk, was significantly lower (i.e. longer time to discharge) for patients in the cognitive impairment and dementia groups than those with no cognitive impairment (Gray test  $p$ -value  $< 0.001$ ) (Figure 1 – see supplementary material). This relationship was maintained after adjustment in the multivariable model for patients with cognitive impairment (subhazard ratio 0.66, 95% confidence interval 0.63-0.69) and dementia (subhazard ratio 0.80, 95% confidence interval 0.76-0.83) (Table 5).

## DISCUSSION

This study aimed to assess whether older patients admitted to hospital with cognitive impairment are at higher risk from poor outcomes than those with normal cognition, after adjustment for known risk factors. We found independent associations between cognitive impairment and increased mortality, both within hospital and including 30 days after discharge, increased time until discharge from hospital, and increased readmission within 30 days of discharge. This was also the case for patients with a diagnosis of dementia. Additionally, the risks of mortality in hospital, re-admission and extended hospital stay were higher in patients with cognitive impairment alone than in those with a diagnosis of dementia.

In previous research, an association between cognitive impairment and poor outcomes could not be ascertained due to key missing covariates and small sample sizes. This study highlights that patients with cognitive impairment are at considerably greater risk than those with normal cognition, taking into account other key factors which influence these outcomes.

Possible mechanisms for the increased risks observed in patients with cognitive impairment include differences in effective care for people with cognitive impairment in hospital, and intrinsic mechanisms which place these patients at higher risk of deterioration. Variations in care that may disadvantage patients with dementia have been described in the literature for patients with a known diagnosis of dementia include reduction in routine monitoring for deterioration, (Hope et al., 2017) increased time waiting for investigations, (Griffiths et al., 2014) and under-treatment of concurrent conditions such as chronic obstructive pulmonary disease. (Frohnhofen et al., 2011) It may be the case that such variations also apply to the wider group of cognitively impaired patients, especially given that these patients appeared to have even worse outcomes than those already known to have dementia. Higher rates of potentially preventable complications, including urinary tract infections, pressure ulcers, pneumonia and delirium, have been identified in hospitalised patients with dementia, and may provide areas of focus for nursing care for all patients with cognitive impairment. (Bail et al., 2013) Our study also highlighted that patients with cognitive impairment were the most likely to have two or more ward moves during their hospital stay, whereas those with dementia had the least moves, possibly because staff may have endeavoured not to further disorientate them and risk onset of delirium or other behavioural issues. It is possible that knowing patients had a diagnosis

of dementia also impacted on other areas of care in a positive manner, which may have contributed to our finding that patients in the cognitive impairment group had worse outcomes than patients with a diagnosis of dementia, as the cognitive impairment group is not yet recognised as a 'high-risk' group of patients.

The elongated stays in hospital and higher rate of readmissions experienced by patients with cognitive impairment and no diagnosis of dementia are key areas for future examination, as they lead to further deconditioning and dependence for patients, and increase hospital costs. Using an instrument such as Comprehensive Geriatric Assessment during admission, and monitoring rates of functional and cognitive decline as hospital performance indicators may be useful to better understand their care needs and how we can best assist maintenance of their function and independence whilst in hospital and support appropriate holistic discharge planning. (Ellis et al., 2011) It is interesting that patients with a diagnosis of dementia seemed to fare better in relation to these outcomes, possibly due to their diagnosis enabling focussed assessment and advanced care planning prior to or during hospitalisation, enabling quicker discharge and appropriate community care provision. However, the increased risk of mortality when including the 30 days after discharge was very similar for all cognitively impaired patients, suggesting that although care pathways may differ according to known diagnoses, the impact of acute illness and hospitalisation on these patients is equally significant.

The current emphasis on screening older patients for cognitive impairment in hospital to detect possible cases of dementia and refer to memory assessment clinics (National Collaborating Centre for Mental Health, 2018, NHS England, 2014) may need to be bolstered by clear guidelines on additional assessments and hospital care for those that are identified. These could explicitly include patients with cognitive impairment, who have not yet been assessed for dementia. What this would actually comprise is currently uncertain – although 'best practice' guidelines for patients with dementia, including prevention of delirium, may be considered (Alzheimer's UK, 2016, National Institute for Health and Care Excellence, 2010), there is limited evidence that these are effective in improving outcomes such as mortality. (Goldberg et al., 2013) People with a known diagnosis of dementia have lower conveyance rates to hospital, (Pocock H et al., 2018) and although admission avoidance is not appropriate in all cases, assessment of cognitive impairment in the community is important to identify people who may benefit from community-based care where possible. Achieving this may require additional support for people with cognitive impairment in the community, who, without a diagnosis of dementia, would not benefit from the services of Dementia Care Co-ordinators or other interventions. (National Collaborating Centre for Mental Health, 2018)

Although hospitals do refer patients with cognitive impairment for monitoring in General Practice within six weeks of discharge, it is unknown how often this referral is acted upon, and the high rate of re-admissions in this group suggests that this may be too long an interval prior to General Practitioner re-assessment, both for cognitive issues and for concurrent medical conditions.

### **Strengths and Limitations**

This study utilised a large dataset reflective of routine care in a general district hospital, which has comparative mortality and performance statistics representative of similar institutions in NHS England. The demonstration of known predictors of mortality in the final models increase confidence in the validity of the data and the study conclusions as regards the additional independent risk posed by presence of cognitive impairment and dementia. In contrast to previous literature, the use of a competing risks model to evaluate length of stay removes biases introduced by considering death as a form of discharge. Data on frailty or function, which have also been related to poor outcomes, (Dani et al., 2018, Kojima et al., 2018) were not available as these are not currently measured systematically or electronically as part of routine care. Missing Malnutrition Universal Screening Tool score data was unavoidable, as this assessment should be performed within 24 hours of admission, thus missing those with early mortality and shorter lengths of stay, as illustrated by the 'missing' category. However, the sensitivity analysis showed that when the same covariates were included in the final model, Odds Ratios and Area Under the Receiver Operating Characteristic Curve were very similar and these results did not alter the main conclusions. The follow-up period was limited to 30 days, but this is more reflective of outcomes of acute care, and outcomes are therefore not overly diluted by differing community care pathways. Although the cohorts were grouped based on characteristics at admission (as in the majority of other studies), occurrence of delirium during the admission would be an important mediator to assess in future work.

Patients with hypoactive delirium may possibly have been misclassified as non-cognitively impaired in this study as this is often undetected in routine practice, and, as these patients are known to have worse outcomes, may have reduced the effect sizes between groups. Due to the broad nature of the cognitive screening pathway and its "real-life" implementation in routine clinical practice, other sources of misclassification between exposure groups are possible, for example patients with undiagnosed non-amnesic dementia may have been classified as non-cognitively impaired, and systematic differences in response to the question regarding memory loss over the last 12 months associated with the responder (patients vs carer/relative). However, the purpose of the screening process is to identify those with a current diagnosis of dementia, and to provide a broad screen to identify other patients who may be undiagnosed or benefit from further assessment. The results of

the study do suggest that the screening process is indeed identifying a large cohort of older patients with additional vulnerability to poor hospital outcomes.

### **Conclusions**

This study demonstrated an independent association of cognitive impairment and dementia with poorer outcomes for older adults in hospital. Furthermore, patients with cognitive impairment and no diagnosis of dementia experienced poorer outcomes than those with dementia, thus representing a high-risk patient group with high costs. Whilst increased risks of hospitalisation for people with dementia are widely recognised and consequently can be acted upon, older patients with cognitive impairment may be largely undetected unless routine screening is in place. There is now a need to understand more about the mechanisms leading to these outcomes, including the relative contributions of intrinsic pathological pathways of deterioration, and extrinsic factors relating to context of care received, such as workforce arrangements, transfers of care, availability and content of care at home. Combined with systematic, enhanced recognition of cognitive impairment, future research may enable development of informed interventions for modification of care in hospital to improve care for this vulnerable group of older people.

### **CONTRIBUTORSHIP**

CF conceptualised the paper, performed the analyses and drafted the paper. PM acquired the data. DC, PM and PG provided statistical input. JB, PG and CS provided critical revision with clinical context. All authors contributed to the design of the study, interpretation of the results and revising the paper. All authors approve the final submitted version.

### **ROLE OF THE FUNDING SOURCE / DISCLAIMER**

The research was supported by the National Institute for Health Research (NIHR) Collaboration for Leadership in Applied Health Research and Care (CLAHRC) Wessex at Southampton NHS Hospitals Foundation Trust and Portsmouth Hospitals Trust. The views expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care.

### **ACKNOWLEDGEMENTS**



The authors would like to thank Dr Paul Schmidt for his assistance with defining clinical diagnostic groupings and Professor Gary Smith for his comments on the manuscript.

#### **DATA SHARING**

The ethics and governance permissions for this study do not include sharing of the dataset.

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Table 1 Description of covariates

Variable description	Categorisation
<b>Patient demographics</b>	
Age	5-year age bands: 75-79, 80-84, 85-89, 90-94, ≥95
Gender	Male, female
<b>Clinical characteristics</b>	
Primary diagnosis group, based on Clinical Coding System (CCS) bundles (Clinical Indicators Team, 2017)	System-organ classes, with the exception of codes relating to 'infection' which were grouped as a separate category, regardless of organ system
Charlson co-morbidity index (CCI)	CCI 0=1; CCI 1-5=2; CCI>5=3 as per Summary Hospital Mortality Indicator (SHMI) categorisation (Clinical Indicators Team, 2017)
National Early Warning Score (NEWS) value at admission	Severity of illness categories: NEWS value 0-4=low; NEWS value 5-6=medium; NEWS value ≥7=high (Royal College of Physicians, 2012)
Malnutrition Universal Screening Tool (MUST) score at admission	0=low risk, 1=medium risk, ≥2=high risk (British Association for Parenteral and Enteral Nutrition (BAPEN), 2011)
Presence of pain on first vital signs set	Yes, No
<b>Health service characteristics</b>	
Route of admission	"Emergency - Accident and Emergency Department" and "Other" – which includes Emergency – GP, outpatient, other NHS provider etc.
Discharge specialty	Gynaecology, medicine, surgery, trauma and orthopaedics, other

Table 2 Cohort characteristics

	Total N=21,399		Dementia n=3,547		Cognitive impairment (no dementia diagnosis) n=2,227		No Cognitive impairment n=15,625	
<b>Demographics</b>								
Mean Age (Standard Deviation)	84.4	(5.8)	86.4	(5.8)	86.4	(5.9)	83.6	(5.7)
Female (n, %)	12,171	56.9%	2,217	62.5%	1,368	61.4%	8,586	55.0%
<b>Clinical characteristics<sup>1</sup></b>								
Reason for admission (n, %)								
Cardiovascular disorders	4,766	22.4%	472	13.4%	315	14.2%	3,979	25.7%
Infection	4,472	21.0%	928	26.3%	628	28.3%	2,916	18.8%
Trauma, orthopaedics and injury	2,951	13.9%	625	17.7%	378	17.0%	1,948	12.6%
Gastrointestinal disorders	2,107	9.9%	210	6.0%	84	3.8%	1,813	11.7%
Rheumatology	1,299	6.1%	296	8.4%	209	9.4%	794	5.1%
Neurological and psychiatric disorders	1,488	7.0%	480	13.6%	275	12.4%	733	4.7%
Respiratory disorders	1,214	5.7%	138	3.9%	58	2.6%	1,018	6.6%
Endocrine, metabolic, blood disorders	761	3.6%	138	3.9%	93	4.2%	530	3.4%
Genitourinary disorders (including renal)	835	3.9%	114	3.2%	72	3.3%	649	4.2%
Cancer	635	3.0%	39	1.1%	52	2.3%	544	3.5%
Adverse events related to substances/medical procedures	366	1.7%	32	0.91%	20	0.90%	314	2.0%
Ear, nose, throat and eyes	160	0.75%	13	0.37%	5	0.23%	142	0.92%
Dermatological disorders	101	0.48%	18	0.51%	16	0.72%	67	0.43%
Other	96	0.45%	20	0.57%	13	0.59%	63	0.41%
<i>missing</i>	<i>148</i>		<i>9</i>		<i>24</i>		<i>115</i>	
Charlson Comorbidity Index (n, %)								
0	6,136	29.0%	257	7.3%	606	27.4%	5,273	34.1%

1 to 5	3,462	16.3%	119	3.4%	301	13.6%	3,042	19.7%
6 or more	11,595	54.7%	3,147	89.3%	1,306	59.0%	7,142	46.2%
<i>missing</i>	206		24		14		168	
Median <sup>2</sup> NEWS value (inter-quartile range)	1	(3)	1	(3)	1	(3)	1	(3)
NEWS severity of illness category <sup>2</sup> (n, %)								
Low	18,503	86.7%	3,037	85.9%	1,922	86.4%	13,544	86.9%
Medium	1,823	8.5%	294	8.3%	179	8.1%	1,350	8.7%
High	1,022	4.8%	206	5.8%	123	5.5%	693	4.5%
<i>missing</i>	51		10		3		38	
MUST category (n, %)								
Low	10,368	70.5%	1,275	55.8%	940	60.3%	8,153	75.0%
Medium	1,424	9.7%	244	10.7%	192	12.3%	988	9.1%
High	2,919	19.8%	767	33.6%	426	27.3%	1,726	15.9%
<i>missing</i>	6,688		1,261		669		4,758	
Pain <sup>2</sup> (n, %)	4,255	20.0%	513	14.8%	338	15.3%	3,404	21.9%
<i>missing</i>	166		89		14		63	
Confusion <sup>2</sup> (n, %)	2,984	14.1%	1,723	49.8%	630	28.5%	631	4.1%
<i>missing</i>	172		87		15		70	
<b>Healthcare processes</b>								
Admitted through emergency department (n, %)	17,550	82.0%	3,154	88.9%	1,946	87.4%	12,450	79.7%
Admission ward (n, %)								
Surgical	2,657	12.4%	269	7.6%	120	5.4%	2,268	14.5%
Medicine - Medicine for Older People, Rehabilitation and Stroke (MOPRS)	4,620	21.6%	1,567	44.2%	904	40.6%	2,149	13.8%
Medicine - other	14,122	66.0%	1,711	48.2%	1,203	54.0%	11,208	71.7%
Two or more ward transfers during admission <sup>3</sup>	8,820	41.2%	1,254	35.4%	1,069	48.0%	6,497	41.6%

Vital signs observations stopped during admission <sup>4</sup> (n, %)	1,343	6.3%	407	11.5%	227	10.2%	709	4.5%
Discharge specialty								
Medicine	16,441	76.8%	2,923	82.4%	1,859	83.5%	11,659	74.6%
Surgery	2,352	11.0%	204	5.8%	57	2.6%	2,091	13.4%
Trauma and Orthopaedics	1,712	8.0%	305	8.6%	176	7.9%	1,231	7.9%
Other	722	3.4%	99	2.8%	132	5.9%	491	3.1%
ENT and Oral Surgery	151	0.71%	16	0.45%	2	0.09%	133	0.85%
Gynaecology	21	0.10%	0	0%	1	0.04%	20	0.13%

<sup>1</sup> percentages are expressed as a proportion of known values for characteristics with missing data

<sup>2</sup> first set of vital signs observations on admission

<sup>3</sup> does not include transfer from Medical Assessment Unit to initial admission ward

<sup>4</sup> patient removed from requirement for regular observations according to Royal College of Physicians schedule, for example due to end-of-life care pathways

Table 3 Description of outcomes by category of cognitive impairment

	Total N=21,399		Dementia n=3,547		Cognitive Impairment (no dementia diagnosis) n=2,227		No Cognitive Impairment n=15,625	
<b>Died in hospital (95% CI)</b>	1,704	8.0% (7.6% to 8.3%)	413	11.6% (10.6% to 12.7%)	281	12.6% (11.3% to 14.1%)	1,010	6.5% (6.1% to 6.9%)
<b>Died in hospital or within 30 days of discharge (95% CI)</b>	2,746	12.8% (12.4% to 13.3%)	737	20.8% (19.5% to 22.2%)	406	18.2% (16.6% to 19.9%)	1,603	10.3% (9.8% to 10.7%)
<b>Length of stay (median, inter- quartile range)</b>	6 (13)		10 (19)		12 (18)		5 (11)	
	N=19,695		n=3,134		n=1,946		n=14,615	
<b>Readmitted to hospital within 30 days of discharge (95% CI)</b>	1,519	7.7% (7.3% to 8.1%)	286	9.1% (8.1% to 10.2%)	201	10.3% (9.0% to 11.8%)	1,032	7.1% (6.6% to 7.5%)



**Table 4 Multivariable logistic regression results for cognitive impairment and death in hospital, within 30 days of discharge, and readmission within 30 days (for patients discharged alive from hospital)<sup>1</sup>**

Characteristic	Death in hospital N=21,143 <sup>2</sup>			Death in hospital and within 30 days of discharge N=21,028 <sup>2</sup>			Readmission within 30 days of discharge N=19,481 <sup>2</sup>		
	Adjusted Odds ratio	95% CI	p- value	Adjusted Odds ratio	95% CI	p- value	Adjusted Odds ratio	95% CI	p- value
<b><i>Cognitive impairment</i></b>									
No cognitive impairment <sup>α</sup>	1.0			1.0			1.0		
Dementia	1.34	1.17 to 1.55	<0.001	1.66	1.48 to 1.86	<0.001	1.21	1.04 to 1.40	0.014
Cognitive impairment (no dementia diagnosis)	1.78	1.52 to 2.07	<0.001	1.67	1.46 to 1.90	<0.001	1.47	1.25 to 1.73	<0.001
<b><i>Demographics</i></b>									
Age group (years)									
75-79 <sup>α</sup>	1.0			1.0			γ		
80-84	1.25	1.06 to 1.47	0.008	1.31	1.15 to 1.49	<0.001	-	-	-
85-89	1.54	1.32 to 1.81	<0.001	1.51	1.32 to 1.72	<0.001	-	-	-
90-94	1.85	1.56 to 2.21	<0.001	2.00	1.72 to 2.30	<0.001	-	-	-
95 and above	2.35	1.87 to 2.92	<0.001	2.37	1.94 to 2.89	<0.001	-	-	-
Sex									
male <sup>α</sup>	1.0			1.0			β		
female	0.82	0.73 to 0.91	<0.001	0.79	0.72 to 0.86	<0.001	-	-	-
<b><i>Clinical characteristics</i></b>									
Charlson comorbidity score									
zero <sup>α</sup>	1.0			1.0			1.0		

1 to 5	1.03	0.84 to 1.26	0.763	1.06	0.90 to 1.26	0.483	1.06	0.89 to 1.25	0.521
6 or more	1.85	1.60 to 2.13	<0.001	2.04	1.81 to 2.29	<0.001	1.28	1.12 to 1.46	<0.001
<b>NEWS severity of illness category</b>									
low <sup>α</sup>	1.0			1.0			1.0		
medium	2.39	2.06 to 2.77	<0.001	2.22	1.95 to 2.53	<0.001	1.35	1.12 to 1.63	0.001
high	3.57	3.02 to 4.23	<0.001	3.22	2.75 to 3.76	<0.001	1.25	0.97 to 1.62	0.088
<b>Pain on first vital signs set</b>									
no <sup>α</sup>	**			1.0			β		
yes	-	-	-	1.22	1.08 to 1.37	0.001	-	-	-
<b>MUST category</b>									
low <sup>α</sup>	1.0			1.0			β		
medium	1.18	0.94 to 1.48	0.157	1.52	1.28 to 1.82	<0.001	-	-	-
high	2.86	2.50 to 3.28	<0.001	3.30	2.94 to 3.71	<0.001	-	-	-
missing	1.33	1.17 to 1.51	<0.001	1.35	1.21 to 1.50	<0.001	-	-	-
<b>Health service characteristics</b>									
<b>Admission route</b>									
GP/ outpatients etc <sup>α</sup>	***	-	-	1.0			γ	-	-
Accident and emergency	-	-	-	0.86	0.77 to 0.97	0.012	-	-	-
<b>Discharge specialty</b>									
non-medicine <sup>α</sup>	1.0			1.0			γ		
medicine	1.53	1.30 to 1.80	<0.001	1.50	1.31 to 1.71	<0.001	-	-	-

<sup>1</sup> Diagnostic groups were adjusted for in the analysis, and were retained in the two final mortality models, but not in the re-admission model.

<sup>2</sup> Number of observations in final model

<sup>α</sup> Reference category

<sup>β</sup> Not included in final model due to non-significance in univariable regression

<sup>γ</sup> Not included in final model due to AIC/BIC assessment

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Table 5 Competing risks regression analyses of demographic and clinical predictors of time to discharge<sup>1</sup>

Characteristic	Univariable analysis for time to discharge			Multivariable analysis for time to discharge N=20,933 <sup>2</sup>		
	Sub-hazard ratio	95% CI	p-value	Sub-hazard ratio	95% CI	p-value
<b>Cognitive impairment</b>						
No cognitive impairment <sup>a</sup>	1.0			1.0		
Dementia	0.69	0.66 to 0.71	<0.001	0.80	0.76 to 0.83	<0.001
Cognitive impairment (no dementia diagnosis)	0.62	0.60 to 0.65	<0.001	0.66	0.63 to 0.69	<0.001
<b>Demographics</b>						
Age group (years)						
75-79 <sup>a</sup>	1.0			1.0		
80-84	0.90	0.86 to 0.93	<0.001	0.92	0.89 to 0.96	<0.001
85-89	0.77	0.74 to 0.80	<0.001	0.84	0.80 to 0.87	<0.001
90-94	0.71	0.69 to 0.74	<0.001	0.78	0.75 to 0.82	<0.001
95 and above	0.64	0.60 to 0.68	<0.001	0.74	0.69 to 0.79	<0.001
Sex						
male <sup>a</sup>	1.0			1.0		
female	1.03	1.00 to 1.06	0.059	1.05	1.02 to 1.08	<0.001
<b>Clinical characteristics</b>						
Charlson						
zero <sup>a</sup>	1.0			1.0		
1 to 5	1.00	0.96 to 1.04	0.917	0.98	0.94 to 1.02	0.337
6 or more	0.70	0.68 to 0.73	<0.001	0.76	0.73 to 0.78	<0.001
NEWS category						
low <sup>a</sup>	1.0			1.0		
medium	0.69	0.66 to 0.73	<0.001	0.68	0.64 to 0.72	<0.001
high	0.54	0.50 to 0.58	<0.001	0.54	0.50 to 0.58	<0.001

Pain on first vital signs set						
no <sup>α</sup>	1.0			1.0		
yes	0.94	0.91 to 0.97	<0.001	0.95	0.91 to 0.98	0.003
MUST category						
low <sup>α</sup>	1.0			1.0		
medium	0.74	0.70 to 0.78	<0.001	0.77	0.73 to 0.81	<0.001
high	0.50	0.48 to 0.52	<0.001	0.55	0.53 to 0.58	<0.001
missing	1.05	1.02 to 1.09	0.003	1.11	1.07 to 1.15	<0.001
<b>Health service characteristics</b>						
Admission route						
General Practice/ outpatients etc <sup>α</sup>	1.0					
Accident and emergency	0.97	0.94 to 1.01	0.130	<sup>β</sup> -	-	-
Discharge specialty						
non-medicine <sup>α</sup>	1.0			1.0		
medicine	1.19	1.15 to 1.22	<0.001	1.36	1.31 to 1.41	<0.001

<sup>1</sup> Diagnostic groups were adjusted for in the analysis but not presented

<sup>2</sup> Number of observations in final model

<sup>α</sup> Reference category

<sup>β</sup> Not included in final model due to non-significance in univariable regression