Factors associated with hospital emergency readmission and mortality rates in patients with heart failure or chronic obstructive pulmonary disease: a national observational study

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Scientific summary

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Scientific summary

Background

Heart failure (HF) affects around 900,000 people in the UK, and the number is rising; chronic obstructive pulmonary disease (COPD) affects a similar number of people in the UK. Many more potentially have either one or both of the conditions undiagnosed. National audits and other studies have documented variations in care processes and outcomes for many patient groups, including those with HF and COPD. Understanding of the drivers of service use and outcomes remains limited. We took advantage of the wealth of hospital administrative and publicly available performance data in England's NHS to investigate what happens after a key milestone in the progression of these diseases – the first emergency hospitalisation – and to assess key statistical properties of readmission-type indicators.

Objectives

The objectives of the project were to answer these research questions:

1. What are the main patient, primary care and hospital factors associated with variation in readmission and mortality rates?
2. Should emergency department (ED) attendance and reattendance data be considered alongside readmission metrics when measuring hospital performance in terms of unplanned activity? If so, how?
3. How consistently do hospitals perform across different readmission-type metrics?
4. Are the results for COPD similar to those for HF?

Methods

We defined two cohorts based on the primary diagnosis of admission: patients with their first (index) emergency admission for HF or COPD for at least 3 years. Index admissions were included if they ended in financial years 2009/10 to 2010/11, and these were linked to the national death register up to 2012 to capture post-discharge deaths.

We obtained and collated information for each general practice and hospital on performance, including the Quality and Outcomes Framework, NHS patient experience (PE), NHS staff survey, hospital staffing levels and bed numbers. Using a list of cardiac and lung rehabilitation programmes from the national audits, we assessed those programmes' websites on the quality of their information for patients and calculated the distance between each patient's postcode and their nearest programme. For PE, we undertook descriptive analysis of time trends and correlation between hospital settings (ED, inpatient and outpatient departments) and assessed the consistency of hospital performance over time by using cluster analysis and dividing trusts into quartiles. This, in consultation with our two patient representatives, allowed us to reduce the large number of PE variables to a manageable number for inclusion in the regression models.

We defined two main outcome measures: total mortality within 365 days of the index admission date and unplanned readmission within 30 days of live index discharge. ED attendances not ending in admission were then considered alongside readmission as part of potential alternative outcome measures. For each cohort and outcome, we built risk adjustment models using logistic regression, adjusting for clustering if necessary and feasible. These included patient variables as per our previous work, in addition to the aggregated information listed above. Using ED attendance data, we estimated in different ways the 'busyness' of the ED at the time of attendance of each HF or COPD patient as well as noting the time and

day of attendance. Two types of time-to-event analysis allowed us to check for time-dependent covariate effects. We defined a *p*-value of < 0.01 as statistically significant.

Hospital-level relative risks were derived for mortality and readmission by summing patient-specific predicted probabilities and actual outcomes and calculating the ratio of the latter sum to the former sum. The numbers of funnel plot outliers at 95% and 99.8% control limits were counted. Overdispersion was assessed by fitting quasi-likelihood models. The omega statistic was calculated to help choose between similar readmission-type metrics for follow-up time frames between 7 and 365 days since index discharge.

Results

Our HF cohort for the mortality analysis comprised 77,801 patients aged ≥ 18 years and our COPD cohort comprised 96,053 patients aged ≥ 36 years; 66,219 HF patients and 90,351 COPD patients were discharged alive from their index admission and were included in the readmission analysis. The vast majority of both were elderly with multiple comorbidities, particularly hypertension, cardiac disorders and diabetes mellitus, with one in three HF patients aged ≥ 85 years. At least one in five patients lived > 10 km from a rehabilitation programme site. Following the index admission for HF, the 1-year mortality rate was 39.6%; for patients discharged alive, the 30-day all-cause readmission rate was 19.8%. Following the index admission for COPD, the 1-year mortality rate was 24.1%; for patients discharged alive, the 30-day all-cause readmission rate was 16.5%. Only around one-third of 30-day readmissions were for the index condition.

Overall, PE has been good, showing modest improvements between 2004/5 and 2014/15 across the three hospital settings. Hospital trust performance has been consistent over time: 72% of trusts ranked in the same cluster for > 5 years. The lowest-scoring questions, regarding information at discharge, were the same in all years and all settings.

Logistic regression models for mortality and readmission were fairly well calibrated but with low or moderate discrimination (HF: $c = 0.71$ for mortality and 0.58 for readmission; COPD: $c = 0.76$ for mortality and 0.63 for readmission). Significant predictors of 1-year mortality for both cohorts included a number of patient factors, such as age, male sex, white ethnicity, prior missed outpatient appointments, index length of hospital stay (LOS) and some comorbidities, such as renal disease and cancer. Only more doctors per 10 beds [odds ratio (OR) 0.95 per doctor; $p < 0.001$] was significant for both cohorts, with staff recommending to friends and family (OR 0.80 per unit increase; $p < 0.001$) and number of general practitioners (GPs) per 1000 patients (OR 0.89 per extra GP; $p = 0.004$) important for COPD.

Significant patient predictors of readmission for both cohorts were older age, missed outpatient appointments, index LOS (same-day discharges for HF, 2-night stays for COPD) and a number of comorbidities, such as ischaemic heart disease, renal disease, cognitive impairment and mental health conditions. Hospital size [OR per 100 beds = 2.16, 95% confidence interval (CI) 1.34 to 3.48 for HF, and 2.27, 95% CI 1.40 to 3.66 for COPD] and doctors per 10 beds (OR 0.98; $p < 0.001$) were significantly associated. No PE scores or GP factors that we considered were retained.

Regarding disease-specific readmissions, many predictors were the same as for all-cause readmissions. A few variables showed significant associations only with readmissions for HF: black ethnicity (OR 1.44, 95% CI 1.16 to 1.79; $p = 0.001$); valvular disease (OR 1.26, 95% CI 1.17 to 1.36; $p < 0.0001$); defibrillation (OR 1.61, 95% CI 1.18 to 2.20; $p = 0.002$); and same-day index discharge. For example, compared with an index LOS of 0, an index LOS of 1 night had an OR of 0.77 (95% CI 0.65 to 0.90) and a *p*-value of 0.001. In contrast, a few variables showed significant associations only with readmissions for non-HF diagnoses: deprivation ($p = 0.009$); cancer with metastases (OR 1.38, 95% CI 1.09 to 1.73; $p = 0.006$); cognitive impairment (senility and dementia: OR 1.37, 95% CI 1.27 to 1.47, $p < 0.0001$; and mental health conditions excluding dementia: OR 1.21, 95% CI 1.12 to 1.30; $p < 0.0001$); and living alone (OR 1.11, 95% CI 1.04 to 1.19; $p = 0.002$). For COPD, the main similarities were for sex (females had lower odds of readmission), pneumonia, mental health conditions except dementia, echocardiography (15% higher odds if recorded), prior missed outpatient appointments (stronger effect for non-COPD readmissions) and, as with HF, the lack of any significant associations with any of the hospital, GP or community factors that we tried. Age relations differed considerably by readmission diagnosis. Compared with patients aged 60–69 years, those aged < 55 years had lower odds of COPD readmissions but similar odds of other readmissions; those aged ≥ 70 years had only slightly higher odds of COPD readmission but much higher odds of non-COPD readmission, rising to a peak OR of 1.75 (95% CI 1.55 to 1.97) and p-value of < 0.0001 for those aged ≥ 90 years. Just two variables showed significant associations only with readmissions for COPD: deprivation and non-invasive ventilation on admission (OR 1.29, 95% CI 1.15 to 1.45; $p < 0.0001$). A much larger number of variables showed significant associations only with non-COPD readmissions: almost all comorbidities, living alone (OR 1.21, 95% CI 1.13 to 1.29; $p < 0.0001$) and index LOS [the lowest odds were for 2-night stays (OR compared with same-day discharges 0.88, 95% CI 0.79 to 0.98; $p = 0.017$) and the highest odds were for stays of ≥ 3 nights (OR 1.10, 95% CI 1.02 to 1.19; $p = 0.017$)]. The direction of the association for hypertension differed by readmission diagnosis, with 9% lower odds if readmitted for COPD but 7% higher odds if readmitted for any other diagnosis (both $p < 0.01$).

Twenty-five per cent of all 30-day readmissions were not via the ED, but 18.2% of our HF cohort and 16.2% of our COPD cohort visited the ED within 30 days with no intervening elective or emergency admission; 75% of visits in each cohort resulted in admission. Predictors of 30-day ED attendance were similar to those for readmission, with the addition of deprivation. ED attendance was more likely in COPD patients when the hospital scored worse on the Friends and Family Test, when there was a lower GP supply and, for HF, when there was a lower HF prevalence at the practice. The main predictors for admission at this ED attendance were:

- older age (for HF, with weaker evidence for COPD), but also ages < 60 years (COPD only)
- index LOS of ≥ 3 nights
- non-invasive ventilation during the index COPD admission
- evening or night attendance (both conditions)
- comorbidities of HF, pneumonia, obesity or cancer (all COPD only – having a coded mental health condition was associated with 13% lower odds of admission; $p = 0.009$)
- two hospital-level variables:

  i. for each patient admitted for any condition from the ED during the hour of arrival, the odds of the HF or COPD patient being admitted rose by 5% for HF and 2% for COPD
  ii. the odds of HF patients being admitted from the ED were 40% higher if the overall proportion of waiting patients who were seen within 4 hours was < 98% than if it was ≥ 98%.

In contrast to the crude cross-tabulations, the regression model found no association by day of arrival or with the number of elderly patients waiting. The number of prior outpatient department appointments missed was a strong predictor of readmission and ED attendance, but was not associated with admission from the ED. Index LOS showed different patterns, with same-day discharges having higher odds of any readmission but much lower odds of admission from the ED. Hospital size and doctors per bed were significantly associated with readmission via any route but not with admission from the ED. Of those not admitted at this visit, about 25% reattended within 30 days of index discharge and about 60% of these second ED visits resulted in admission.

Correlation between the HF and COPD cohorts' hospital-level rates of mortality ($\rho = 0.58$; $p < 0.0001$) and readmission ($\rho = 0.30$, $p < 0.0001$) were lower than for ED visits within 30 days ($\rho = 0.81$; $p < 0.0001$). In contrast, when we considered diagnosis-specific readmissions for each cohort, dividing them into those for the index condition and those for any other primary diagnosis, the correlations were much smaller and not statistically significant: 0.11 ($p = 0.20$) for HF versus non-HF readmissions and 0.03 ($p = 0.75$) for COPD versus non-COPD readmissions.

Few hospitals were funnel plot outliers at the 95% or 99.8% level for hospital readmission or 1-year mortality rates, but ED attendance rates were overdispersed. Multilevel modelling, quasi-likelihood modelling and the omega statistic suggested that there was more hospital-level variation in rates of ED attendance than in the rates of readmission or of the combination of the two, and that the relative importance of hospital to patient factors was greatest for attendances. These statistical features favour ED attendances as a performance indicator over readmissions either alone or in combination with ED attendances.

Conclusions

Mortality and readmission rates following an index admission for HF or COPD are high, with older age, prior missed outpatient appointments and many comorbidities being important predictors of both. Of the aggregated practice and hospital information, only doctors per bed and numbers of hospital beds were strongly associated with either outcome (both negatively). Our results for HF and COPD were often similar, and hospital-level outcome rates for HF were moderately correlated with those for COPD. Long index stays predict ED attendance and mortality, but short ones predict readmission.

Despite a frequent lack of diagnostic information, the ED portion of Hospital Episodes Statistics (HES) can be used for outcome measures and for exploring the effects of the time of presentation. Admission from the ED was most likely if the patient arrived when the hospital was admitting patients, implying available inpatient beds. Diagnosis-specific readmission rates (HF/COPD vs. other conditions) should be considered for quality improvement. The hospital-level rate of ED attendances within 30 days of the index stay should also be considered as a performance indicator.

Recommendations for future research

There is surprisingly little work done on variation by hospital of ED visits, especially after an index discharge or in the UK. The diagnostic coding in data HES ED limits what one can do to explore the reasons for the visits, but broad categories could be used if the proportion with missing values falls in the future. Primary care management of these patients could be explored at the individual level using linked databases, such as the Clinical Practice Research Datalink (CPRD), and a more complete picture would be obtained in the future if CPRD can be linked to the relevant national clinical audits.

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