

Medical Care

Should emergency department attendances be used with or instead of readmission rates as a performance metric? Comparison of statistical properties using national data --Manuscript Draft--

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Abstract:	Background: Hospital readmissions are common and are viewed as unfavourable. They are commonly used as a measure of quality of care and, in the US and England, are associated with financial penalties. Readmissions are not the only possible return-to-acute-care metric; patients may also attend Emergency Departments (ED). Objective: To assess hospital-level return-to-acute-care metrics using statistical criteria Research Design: Patient readmissions and/or ED attendances were aggregated to produce risk-standardised hospital rates. Return-to-acute-care rates at 7, 30, 90 and 365 days were assessed using key statistical properties: i) variability between hospitals; ii) the relative contribution of patient and non-patient factors to variation; and iii) the statistical power to detect performance differences. Subjects: We had pseudonymised administrative data on all inpatient hospital admissions and ED attendances in NHS hospitals in England between April 2009 and March 2011. Patients with an inpatient stay for chronic obstructive pulmonary disorder (COPD) or heart failure (HF) were eligible for inclusion. Measures: ED attendances and readmissions for patients discharged from an inpatient stay for COPD or HF. Results: Inter-hospital variation was greatest for ED attendance; in addition, readmission was more strongly determined by patient characteristics than was ED attendance or both combined. Due to smaller numbers, the statistical power to detect differences in rates at seven days for any indicator was limited. Conclusions: Despite the current emphasis on readmissions, we found that ED attendance within 30 days has more desirable statistical properties and therefore the potential to be a useful metric when comparing hospitals.

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29th Jan 2018

Dear Dr Schwartz,

Thank you for your recent correspondence regarding our manuscript entitled "Should emergency department attendances be used with or instead of readmission rates as a performance metric? Comparison of statistical properties using national data". Thank you for agreeing to publish, conditional upon a satisfactory revision and thank you for all your additional comments.

We have addressed all your comments and queries and these are highlighted in the text in blue font to make it clear where changes further to the previous response to the reviewers have been made.

Again, thank you for all your comments and suggestions and please do not hesitate to contact us if you have any further questions,

Yours sincerely

Kate Honeyford and Alex Bottle

RESPONSE TO EDITORS COMMENTS - MDC-D-17-00536R1: "Should emergency department attendances be used with or instead of readmission rates as a performance metric? Comparison of statistical properties using national data"

Below are our responses to your comments which we trust will meet with your approval.

1) last sentence, first paragraph: You state this somewhat more strongly than supported by the data. You might say "the variation was a similar order of magnitude for HF and COPD metrics, although the reduction in variation over time was somewhat less marked for COPD;

We have changed the sentence in line with the editor's recommendation.

2) In the analysis section, you do not mention anything about looking at covariance parameter estimates. What parameters specifically are you referring to and why do these provide evidence of clustering. By design data are clustered within hospitals;

Whilst the data is in theory clustered within hospitals, it is not inevitable that the outcomes for individual patients will show significant clustering at hospital level. If there was only random variation between hospitals then we would not expect to see significant clustering at hospital level, and the covariance parameter (the variance of the hospital-specific intercepts) would be zero. There is a strong argument that any variation in patient outcomes to be influenced by patient characteristics only.

We have added the following phrase to the analysis section (in blue):

To determine variability between hospitals we used the intraclass correlation coefficient (ICC) which expresses the proportion of variability explained by the presence of clusters, in this case, at hospital level. A random intercept, fixed slopes hierarchical model was used to determine estimates of the covariance parameter, which estimates the variance of the intercepts for the different hospitals, and the residual ICC, a measure of clustering used in hierarchical modelling.

3) In Table 1, you have a column SE of the intercept but never refer to it. Why include it? Also, what model are you referring to. Wouldn't the logistic regression model with random intercepts have a separate intercept for each hospital?

We think this is Table 2. As you suggest, there is a separate intercept for each hospital. The estimate of the covariance parameter gives an estimate of the variance in the intercepts for each hospital. This is now explained more fully, please see the response to the point raised above, We have included the standard error as it allows the significance of the estimates to be estimated. We have presented the data this way because we feel it is a more appropriate way to show the significance than presenting a p-value.

4) In the second sentence in the 2nd paragraph of this section, why do you mention 0.5%. The values are less than 0.4%. And, why particularly flag the 3.9%? It is good to provide some numbers (see next comment) but they should flow from some point you are making. You jump from readmissions to the middle of ED attendances;

We have modified the text and thank the editor for highlighting a transcription error which we should have noticed during our proof reading. We have separated the readmission and attendance to make it clearer.

However, the ICCs suggested that the proportion of the variance which could be attributed to hospital was low for all outcomes, especially for readmission rates (0.4% or less). The proportion of variance attributed to hospitals for ED attendance was the highest, rising to 4.9% for ED attendance within 30 days for both COPD and HF.

5) In the next sentence, are you still referring to the ICCs. It would be helpful to the reader to attach some numbers to statements in the rest of this paragraph so it was clear what you were referring to;

Thank you for your comment – we believe the text is now improved:

~~Although the proportion of variance attributable to the hospital of the index hospitalisation was low in all cases, there was evidence to suggest that it was higher for ED attendances than readmission. For models of readmission, the degree of unexplained variability decreased as time since discharge increased (for COPD from 0.38% to 0.18%). In contrast, for ED attendance the proportion of variance attributable to hospitals increased as time since discharge increased (for COPD from 2.2% to 4.9%), but the opposite pattern was seen for readmission metrics.~~

6) I am not sure Figure 1 adds that much. I think it would be much more useful to have a Table summarizing your results. Because there are so many results, it is a little hard to keep track of things;

We will withdraw Figure 1. Below is a new table which will be included in order to clarify results.

Outcome \ Metric	Variability between hospitals (assessed using the ICC – proportion of variation attributed to hospitals)	Relative contribution of patient and non-patient factors (assessed using the Omega statistic)	Statistical power to detect performance differences from the average
Readmission within 7 days	Very low (<1%)	Patient factors dominate	Low
ED attendance within 7 days	Low (2-3%) ¹	Hospital factors are contributing more than patient factors (evidence is stronger for HF than COPD)	Low
Readmission and/or ED attendance within 7 days	Very low (<1%)	Patient factors dominate	Moderate for HF Low for COPD
Readmission within 30 days	Very low (<1%)	Patient factors dominate	High
ED attendance within 30 days	Low (3-4%) ¹	Hospital factors are contributing more than patient factors (evidence is stronger for HF than COPD)	High
Readmission and/or ED attendance within 30 days	Very low (<1%)	Patient factors dominate	High
Readmission within 90 days	Very low (<1%)	Patient factors dominate	High
ED attendance within 90 days	Low (≈4%)	Patient and hospital factors are equally important.	High
Readmission and/or ED attendance within 90 days	Very low (<1%)	Patient factors dominate	High
Readmission within 365 days	Very low (<1%)	Patient factors dominate	High
ED attendance within 365 days	Low (≈5%)	Patient and hospital factors are equally important.	High
Readmission and/or ED attendance within 365 days	Very low (<1%)	Patient factors dominate	High

¹A range is given to account for slightly lower percentages for heart failure metrics.

Table 4: Summary of statistical properties of different hospital return to care metrics.

7) Is the last row missing from all of your tables? It seems so;

No – We have included an additional foot note to clarify this – it is a combined outcome admission with two different time points.

8) Please number the pages in the next submission and check the final pdf file. The response to reviewers and some of the tables and figures are showing up twice in the pdf.

We have done this and checked the pdf carefully.

TITLE PAGE

Should emergency department attendances be used with or instead of readmission rates as a performance metric? Comparison of statistical properties using national data

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CONFLICTS OF INTEREST

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Brief title: Evaluating return-to-care metrics

TITLE PAGE

**Should emergency department attendances be used with or instead of readmission rates as a
performance metric? Comparison of statistical properties using national data**

ABSTRACT (250 words)

Background:

Hospital readmissions are common and are viewed as unfavourable. They are commonly used as a measure of quality of care and, in the US and England, are associated with financial penalties.

Readmissions are not the only possible **return-to-acute-care** metric; patients may also attend Emergency Departments (ED).

Objective:

To assess hospital-level **return-to-acute-care** metrics using statistical criteria

Research Design:

Patient readmissions and/or ED attendances were aggregated to produce risk-standardised hospital rates.

Return-to-acute-care rates at 7, 30, 90 and 365 days were assessed using key statistical properties: i) variability between hospitals; ii) the relative contribution of patient and non-patient factors to variation; and iii) the statistical power to detect performance differences.

Subjects: We had pseudonymised administrative data on all inpatient hospital admissions and ED attendances in NHS hospitals in England between April 2009 and March 2011. Patients with an inpatient stay for chronic obstructive pulmonary disorder (COPD) or heart failure (HF) were eligible for inclusion.

Measures: ED attendances and readmissions for patients discharged from an inpatient stay for COPD or HF.

Results: Inter-hospital variation was greatest for ED attendance; in addition, readmission was more strongly determined by patient characteristics than was ED attendance or both combined. Due to smaller numbers, the statistical power to detect differences in rates at seven days for any indicator was limited.

Conclusions: Despite the current emphasis on readmissions, we found that ED attendance within 30 days has more desirable statistical properties and therefore the potential to be a useful metric when comparing hospitals.

Introduction

Hospital readmissions are common and are viewed as an unfavourable patient outcome with high financial costs.¹ Although estimates of the proportion of readmissions that are preventable vary,² there is a widely accepted view that many can be avoided. They have become an established indicator of quality of care of an index condition and the early post discharge period.³ Pay for performance initiatives have been introduced in both the US (Hospital Readmission Reduction Program)⁴ and UK.⁵ These initiatives focus on inpatient-to-inpatient readmissions as the only return-to-acute-care metric. They ignore Emergency Department (ED) attendances not ending in admission, which constitute a significant amount of costly, unplanned activity, much of which is known to be preventable.⁶

The need to reduce avoidable ED attendance is a priority in many countries. In the UK there have been various initiatives to reduce avoidable ED attendance including the promotion of helplines, walk-in centres and extended opening hours for primary care.⁷ In the US a policy of copayments, or cost-sharing, has been introduced in many states which can deter the use of emergency departments by Medicaid patients.⁸ However, it is more common for penalties and targets to be associated with reattending the ED after an ED attendance rather than after an inpatient spell.⁹

In the US particularly, there has been concern that targeting readmissions will result in the increased use of observation units and ED attendance; analyses of Medicare patients in the US has provided evidence of this unintended consequence.¹⁰⁻¹¹

Some commentators have advocated the use of post-discharge ED attendances, perhaps in combination with readmissions, as a performance metric¹²⁻¹³ but without giving clear guidance on how this should be done. Given that there is evidence that many readmissions and post-discharge ED attendances are at least partly preventable by the healthcare system **and a possible unintended consequence of readmission**

reduction programmes, we consider whether the two should be combined in performance indicators. In addition to considering the precise nature of the return-to-acute-care, the most appropriate time window also needs to be considered. 72 hours to seven days has been used as the ED reattendance time window,¹⁴ whereas the 30-day window is most commonly used for readmissions but is arbitrary: the 7-day window is more specific to the index **hospitalisation**, whereas a longer follow-up period will lead to more numerically robust rates.

Determining a useful return-to-hospital metric to compare hospitals is complicated and depends on the purpose, and whilst there is no gold standard measure, we can test each candidate for certain desirable statistical properties. In this paper, we consider three key properties: i) variability between hospitals in the rates; ii) the relative contribution of patient and non-patient factors to variation in outcome, and iii) the statistical power to detect performance differences.

Each of these three statistical properties provides information about the potential utility of the metric. If there is too little variability between hospitals the measure will not be useful for discriminating between them. In contrast, too much variability (sometimes called overdispersion) could suggest problems with data quality and/or insufficient risk adjustment.¹⁵ Secondly, although it is difficult to ascertain the relative contribution of patient and non-patient factors, different statistical approaches have been suggested. For an indicator to usefully compare hospitals it is desirable that much of the variation is explained by non-patient, and especially in this case, hospital factors.¹⁶ Lastly, given that performance on hospital indicators can influence policy and hospital income as well as public confidence, it is important that they take into account sample size, that the sample size is adequate to detect performance differences between hospitals, and that such apparent differences are not subject simply to random variation.

We assess a set of hospital-level indicators that use readmissions and/or ED attendances not resulting in admission based on these three statistical criteria. **We focus on three key outcomes: i) ED attendances – this includes attendances which end in hospitalisation and attendances from which the patient is**

discharged without hospitalisation; ii) emergency hospitalisations (readmissions) through the ED or via other routes; and iii) a combined outcome which includes all hospitalisations (either through ED or other routes) and ED attendances which do not end in hospitalisation. The combined outcome is important because it represents all unscheduled contacts with hospitals after discharge from an initial (index) emergency hospitalisation. We compared the outcomes over four different time periods after discharge. We illustrate this approach with national administrative data for England for two common patient groups with high ED use and readmission rates: **heart failure (HF) and chronic obstructive pulmonary disorder (COPD)**.

METHODS

Data and patient groups

England's national hospital administrative database, Hospital Episodes Statistics (HES), comprises all inpatient, day case, outpatient department (OPD) appointment and ED attendance records for all NHS (public) hospitals in England. Records belonging to the same person were linked using a combination of the patient's unique NHS number, date of birth, sex and postcode; those with an invalid postcode were excluded (<1%). Inter-hospital transfers were linked together to form admissions ("superspells") and avoid double-counting. The day of final discharge after any inter-hospital transfers was taken as day zero for time-to-event calculation.

We identified a set of adult patients who were discharged alive from a **first emergency hospitalisation (index hospitalisation)** with a primary diagnosis of heart failure (ICD-10 I50) and separately COPD (ICD-10 J40-44) that ended between April 2009 and March 2011 by tracking back 10 years and excluding patients with an HF or COPD admission during that time. This simplifies the readmission trajectory, as multiple admissions are common in this patient group, and represents an important milestone in the progression of the patient's disease.¹⁷⁻¹⁸ For simplicity and because the coding system used in HES ED attendance records is not specific enough to judge whether the attendance was related to HF or COPD, we considered all ED attendances combined within a given timeframe.

Outcomes

For all patients discharged alive, patients were followed within the database for 365 days after discharge to determine if they were readmitted as an emergency or attended the ED. **In line with current quality indicators linked to readmissions, we used all-cause emergency readmissions and ED attendances.** Only the first contact with acute care **after the index hospitalisation** was considered: for example, ED attendances following a subsequent elective or emergency admission within 30 days were not included in

analyses. Key outcomes were emergency readmission (through any route), ED attendance, and readmission or ED attendance combined. **Throughout this paper a readmission is an emergency hospitalisation via any route, not necessarily the ED, after discharge from an index hospitalisation.** We considered time periods of 7, 30, 90 and 365 days since discharge from the index **hospitalisation**.

Analysis Strategy

Crude and risk-adjusted outcome rates were derived for each hospital and patient group. Risk-adjustment models using logistic regression and a set of patient covariates described more fully elsewhere¹⁹: age group, sex, ethnicity, socioeconomic status, comorbidities, procedures during or in the year prior to the index **hospitalisation** and whether the patient lives alone. **Risk-adjusted ratios of observed to expected outcomes for all hospitals were determined. Expected outcomes were calculated by summing the predicted outcomes, derived from logistic models, for each patient whose index hospitalisation was at that hospital. Ratios were first summarised across hospitals using descriptive statistics.**

To determine variability between hospitals we used the intraclass correlation coefficient (ICC), which expresses the proportion of variability explained by the presence of clusters, in this case, at hospital level. A random intercept, fixed slopes hierarchical model was used to determine **estimates of the covariance parameter, which estimates the variance of the intercepts for the different hospitals,** and the residual ICC, a measure of clustering used in hierarchical modelling. The ICC is the ratio of the between-hospital variation to the sum of the between-hospital and within-hospital variation: higher ICC values therefore suggest that a greater proportion of variability in the outcome is explained by between-hospital variation. Higher ICC values are therefore desirable in an indicator. It was computed as $ICC = \tau_H / (\tau_H + \pi^2/3)$, where τ_H is the hospital-level variance and $\pi = 3.14159$.²⁰

The relative contribution of patient and hospital variables to the variance in the model was assessed using the Omega statistic.¹⁶ With patient variables in the numerator and community and hospital variables in the denominator, $\omega = 0$ would mean that all the variation in the candidate indicator is predicted by factors other than patient characteristics. Low values of ω are therefore desirable. This statistic cannot be used to judge an individual indicator but is useful for comparing them. In line with the approach of Brown et al²¹ in their comparison of measures for ICU performance, we carried out two analyses. Initially we included all patient and hospital variables. In a second analysis, to determine the extent to which hospital characteristics which we could not measure or quantify affected the results, we also determined ω in models that treated hospitals as a fixed effect. Hospital characteristics were selected based on a review of previous literature and available data as per the project proposal²²: hospital size (in terms of number of beds),²³ doctor supply as doctors per bed,²⁴ mean bed occupancy,²³ and patients' experience of quality of care based on patient and staff surveys:²⁵⁻²⁶ patient experience of waiting for a bed after arrival, patient experience of discharge, staff satisfaction of care being given, staff rating of effective team working and whether staff would recommend to friends and family. Omega analysis was carried out using the relimp package in R.²⁷

To determine the statistical power to detect performance differences, illustrative power calculations were carried out to determine the power to detect a change equivalent to 1.5 times the national rate in a small (25th percentile based on HF discharges) hospital (n=320). This means that one would have greater power than this to detect larger differences than 1.5 for these hospitals or to detect the same difference at larger hospitals: our calculations are clearly not exhaustive but are fairly conservative. Power calculations were carried out using an online calculator provided by the Statistics Department of the University of British Columbia.²⁸⁻²⁹

Lastly, as funnel plots are increasingly used to identify providers with unusually "good" or "poor" performance,³⁰ we noted the number and proportion of hospitals with outcome rates beyond 99.8% and 95% control limits, which were labelled as outliers. A weighted Kappa was determined to evaluate funnel

plot outlier agreement between different outcome metrics. This was done for each outcome and patient group.

Unless noted above, all analysis was carried out using SAS v9.4.

Results

Descriptive analysis

During our two study years, we extracted 79750 HF and 99090 COPD index **hospitalisations from 140 hospitals**. 67866 HF patients (85.1%) and 93188 COPD patients (**94.0%**) were discharged alive and were included in the analysis. **We analysed results from 140 hospitals**. Overall, the proportions of patients who return-to-acute-care, either through attending ED or hospitalisation through another route, were high: 6.0% of COPD and 8.0% of HF patients returned to care within 7 days, and approximately 1 in 5 returned to hospital care within 30 days. **For HF patients, 17.4% attended the ED within the 30 days; of these 76.9% were admitted as inpatients. In total, 19.8% of HF patients were readmitted for an inpatient stay by any route. Proportions were slightly lower for COPD: 15.5% attended the ED within 30 days, of whom 74.0% were admitted. The 30-day readmission rate for COPD patients was 16.5%. Hospital level summaries are provided in Table 1.**

Inter-hospital variation

Variation in proportions of patients returning to hospital care, quantified using the quantile based coefficient of variation, decreased as time since discharge from the index hospitalisation increased. Inter-hospital variation was higher for ED attendance than readmission or readmission/ED attendance combined (Table 1). *The variation was a similar order of magnitude for HF and COPD metrics, although the reduction in variation over time was somewhat less marked for COPD.*

The covariance parameter estimates were significantly greater than zero, suggesting that there was evidence of clustering at hospital level. However, the ICCs suggested that the proportion of the variance which could be attributed to the hospital was low for all outcomes, especially for readmission rates (0.4% or less). *The proportion of variance attributed to hospitals for ED attendance was the highest, rising to 4.9% for ED attendance within 30 days for both COPD and HF, although this is still low.- For*

models of readmission, the degree of unexplained variability decreased as time since discharge increased (for COPD from 0.38% to 0.18%). In contrast, for ED attendance the proportion of variance attributable to hospitals increased as time since discharge increased (for COPD from 2.2% to 4.9%).

These results are summarised in Table 2.

Relative contribution of patient and hospital characteristics

In the initial analysis, when hospital and patient characteristics were included in the model, none of the hospital based outcomes had ω less than 1, indicating that the patient characteristics contributed more to the variance in our models (Table 3). For readmission, the relative contribution of patient characteristics compared with hospital ones increased (as shown by increasing ω) as time from discharge increased, although confidence intervals suggested considerable overlap. For ED attendance, associations between time from discharge and the relative contribution for patient characteristics were less clear. ED attendance and readmission combined showed similar patterns to readmission.

When hospitals were modelled as a fixed effect to account for unmeasured hospital factors, all ω values were smaller, indicating a lower contribution of patient characteristics relative to hospital ones. This occurs because hospital characteristics which we were not able to measure were now accounted for by these models. For ED attendance for HF patients, ω was less than 1, that is, the relative contribution of hospital characteristics to variation is greater than that of patients, although the confidence interval included 1 when time from discharge increased to 365 days. For COPD, ω was less than 1 for seven and 30 days, although the confidence interval included 1, suggesting that patient and hospital characteristics may be equally important in explaining variation in the outcomes.

Sample size and power

The number of patients discharged alive varied from a minimum of 189 for HF to a maximum of 2044 for COPD. We considered the power to detect change in a small hospital, based on the lower quartile for HF patients discharged alive. In a small hospital ($n=320$) the power to detect a change of 1.5 times the national

rate was greater than 90% for all outcomes for 30 or more days since discharge. However, for seven days since discharge the power was reduced to less than 50% for COPD and for HF ranged from 48% for ED attendance to 71% for the combined measure.

Impact of outcome selection on outliers

The number of outliers based on 95% and 99.8% control limits is higher for ED attendance than for readmissions (see Table S4 in the supplementary material). In the majority of cases the number of outliers is greater for COPD than for HF. When ED attendance within 30 days is compared with readmissions in the same time period, more outliers were identified, and there were differences in the specific hospitals identified as outliers. Neither outcome identified any hospitals as being above the upper control limit. Seven hospitals for readmissions and eight for ED attendance were identified as being above the 95% control limit: only three of these hospitals were identified as outliers by both outcomes. 16 hospitals were identified as being below the lower 99.8% control limit for ED attendance, but only two of these were identified as being below the control limit for readmission (Figure 1).

Discussion

Main Findings

This study provides evidence of how different hospital readmission-type return-to-acute-care metrics perform across three desirable statistical qualities: 1) the amount of variability between hospitals; 2) the relative contribution of patient and non-patient factors; and 3) statistical power to detect performance differences from the average. **These are summarised in Table 4.** Regarding the first two properties of higher inter-hospital variation and larger contribution of non-patient factors as indicated by the omega statistic, our results suggest that ED attendance is a more useful metric than either readmission or a combination of the two. With a 7-day window, the combination measure did best on the third property by having superior statistical power to detect important performance differences from the average rate, but there was no advantage at 30 days. Funnel plots found low agreement on which hospitals were outliers, with ED attendance labelling the most outliers. This suggests that the three types of measures we assessed provide different views of performance. Results were very similar for COPD and HF.

Comparison with previous work

Some statistical properties have been assessed for other indicators. One is statistical power,³¹ and another is reliability, for instance by comparing one time period's set of hospital-level rates with those for the subsequent time period,³² or for a single time period for other types of surgery.³³ However, few have employed multiple approaches as we have here. Our results suggest that patient characteristics made a higher relative contribution to readmissions than to ED admissions. We followed an approach by Brown et al²¹ who, in a very different hospital setting, found that readmission rates to the ICU rather than to any inpatient ward were strongly influenced by ICU and hospital characteristics. Like that study, we found that ω values were lower when hospitals were included as a fixed effect to account for unmeasured hospital factors.

The small amount of the total variation in readmission attributable to hospitals, as shown by ICCs, is consistent with previous studies of both readmission³⁴ and mortality.³⁵ In addition, Thompson et al³⁶ concluded that most of the variation for both COPD and HF risk-standardized readmission rates was due to random statistical variation.

As confidence intervals overlapped, the impression that, as time since discharge increased, the importance of patient characteristics in explaining variation in ED attendance rates decreased, was not confirmed statistically. There was also evidence that the variability between hospitals increased as time from discharge increased, as shown by the coefficient of variation. These findings combined may indicate that other factors, including unmeasured characteristics of the index hospital, become more important as time since discharge increases. In England, a high proportion of patients attend their nearest hospital.³⁷ It is possible that the index hospital becomes a proxy for factors in their local area such as access to primary care.³⁸ In addition, there is evidence that as elderly patients become more familiar with a hospital through other appointments or previous ED attendances³⁹ they are more likely to attend ED for urgent care than see their primary care physician. Both of our index conditions, especially HF, affect mostly the elderly.

In line with other studies, there was insufficient power to detect changes when the outcome was not common,⁴⁰⁻⁴¹ which was a result of a shorter time frame. Although some consider unscheduled return-to-care within seven days a better measure of quality of care as fewer non-hospital factors are likely to affect the outcome, the lower power raises concerns about the use of this metric.⁴²

Strengths and weaknesses

This study contributes to our understanding of the potential utility of hospital metrics by considering desirable statistical properties of two key patient outcomes following discharge from an inpatient spell and

comparing different time periods. To our knowledge this is the first study which has compared readmission and ED attendance as hospital metrics.

This study benefitted from national data, so we were able to consider readmission and ED attendance rates for all acute hospitals in England, which includes the vast majority of the population, as private emergency care in England is very rare. We were able to link individual patient-level records for **the index hospitalization to** those for ED attendances rather than rely on aggregated counts for both. In addition when considering the combined measure, we could identify individual patients and therefore were not double-counting patients.

This study analysed patients for whom this was their first hospitalisation for the specific condition as the study was part of a larger project.⁴³ This may limit its generalisability to all admissions for patients who have frequent hospital contacts. We analysed COPD and HF separately. Results showed similar patterns for both diseases, which provides some confidence in extending the conclusions to other chronic diseases. COPD and HF have been shown to have similar rates for hospital readmissions to other diseases, although readmission rates are higher for HF and ED attendance without admission is higher for COPD.¹³ We could have analysed all index **hospitalisations** combined, which would have yielded much greater statistical power to detect performance differences, but we chose to use two common chronic conditions because we believe that diagnosis-specific outcomes are more actionable. It would be interesting to extend the study to other conditions and specialties that are less similar, such as cancer and elective surgery.

This study has several limitations. Regarding the relative importance of patient and hospital factors as reflected by the omega statistic, we were limited to including factors available from the data. We were thus not able to account for patient factors such as disease severity or physiological parameters. When we determined the omega statistic with hospital as a fixed effect there was evidence that unmeasured

hospital characteristics explained more of the variance in the model than measured hospital characteristics. This is a key strength of this statistical approach. Hospital characteristics included were annual measures which applied to all wards, not specific to the patients included in the analysis. We hypothesised that the proportion of readmissions and ED attendances that relate to the index **hospitalisation** reduces over time.

Although primary diagnosis codes for admissions are reliable,⁴⁴ information on reasons for ED attendance in HES is less reliable and we therefore considered only all-cause ED **attendances**. Combining all the reasons for attendance has the advantages of being simpler, giving greater numbers and being less vulnerable to gaming. In addition, the reason for presenting at ED may not appear to be linked to the index **hospitalisation**, but may be revealed as linked only after further tests and investigations that would not be obvious from the data.

Conclusions

Although there is no gold standard **return-to-acute-care** metric that can be used to compare hospital performance, and the purpose will affect metric choice, metrics can be compared based on their statistical properties. We found that ED attendance within 30 days has statistical properties that suggest it has the potential to be a useful metric when comparing hospitals.

We appreciate that there are other considerations when choosing metrics such as data issues (e.g. data availability, data quality, casemix adjustment potential) and user issues (face validity, stakeholder acceptability). However, reducing avoidable ED attendance is a key focus for health services. Like readmissions, they have a financial cost and put pressure on individual hospitals. By not including ED attendance in the period following a discharge from an inpatient stay we may be missing an important quality of care metric.

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TABLES AND FIGURES

Table 1 Summary of emergency hospitalisations (readmissions) and ED attendances (which could end in discharge from the ED or hospitalisation) and a combined measure for each acute hospital in England following discharge form an index hospitalisation between April 2009 and March 2011. Numbers and proportions of patients discharged alive with specified outcomes. National proportions are shown for comparison purposes.

Table 2 Assessment of inter-hospital variation

Table 3 Relative contribution of patient and hospital characteristics to hospital outcomes (patient level) (ω).

Table 4 Summary of statistical properties of different hospital return to care metrics.

Figure 1a-1b Funnel plots showing the dispersion and number of outliers for standardised readmissions and emergency department attendances for COPD. Similar patterns are seen for HF.

Figure

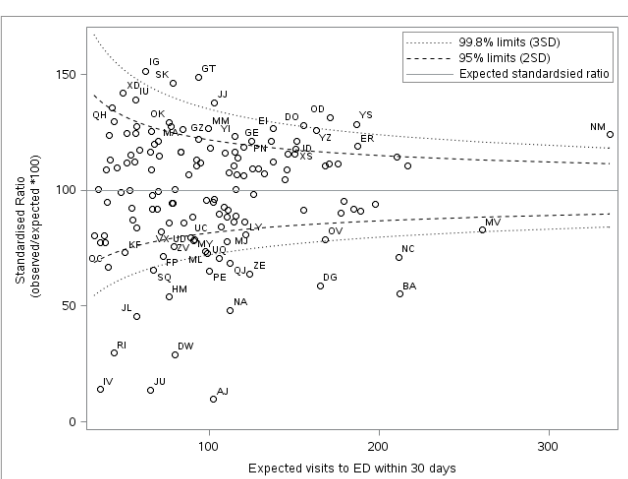


Figure 1a-1b Funnel plots showing the dispersion and number of outliers for standardised readmissions and emergency department attendances for COPD. Similar patterns are seen for HF.

	HF				COPD			
	Median (IQR)				Median (IQR)			
Discharged patients	428.5 (320, 582.5)				626.5 (435, 829.5)			
Time period	National proportion	Number	Percentage of discharged patients	CV ⁴	National proportion	Number	Percentage of discharged patients	CV ⁴
Readmission¹								
7-days	6.8%	28 (21, 40.5)	6.6 (5.7, 7.8)	0.32	5.7%	34.5 (22, 52)	5.6 (4.8, 6.2)	0.25
30-days	19.8%	85 (63.5, 121.5)	19.6 (18.1, 21.4)	0.17	16.5%	99 (68.5, 142)	16.5 (14.8, 17.9)	0.19
90-days	34.1%	145.5 (109.5, 212.5)	33.8 (32.2, 35.7)	0.10	28.6%	173 (119.5, 238.5)	28.5 (26.6, 30.3)	0.13
365-days	52.2%	225 (170.5, 320.5)	52.5 (49.8, 54.1)	0.08	47.4%	297 (198.5, 382)	47.2 (44.6, 49.1)	0.10
ED attendance²								
7-days	6.2%	26.5 (19, 36)	6.4 (4.7, 7.6)	0.73	5.3%	31 (20, 47)	5.2 (4.0, 6.5)	0.48
30-days	17.4%	76.5 (55, 103)	17.6 (14.6, 21.7)	0.40	15.5%	95 (63.5, 138)	15.5 (12.2, 18.7)	0.42
90-days	29.9%	130.5 (97, 167)	29.9 (25.6, 36.3)	0.36	27.0%	161 (111.5, 226)	27.8 (22.5, 31.9)	0.34
365-days	45.8%	199.5 (147.5, 264.5)	46.2 (40.3, 54.3)	0.09	45.0%	274 (189.5, 372)	46.2 (38.7, 52.7)	0.30
ED attendance OR readmission³								
7-days	8.0%	33 (25, 49.5)	8.0 (6.8, 9.2)	0.3	6.00%	39.5 (28, 61.5)	6.7 (5.7, 7.7)	0.3
30-days	22.7%	93.5 (71, 136.5)	22.9 (20.5, 24.5)	0.17	19.60 %	114.5 (82.5, 167.5)	19.2 (17.4, 21.3)	0.2
90-days	38.6%	167 (126, 236)	38.9 (36.2, 40.7)	0.12	33.80 %	206.5 (142.5, 281)	33.6 (31.2, 36.5)	0.16
365-days	58.3%	255 (194, 360)	58.2 (55.4, 60.8)	0.09	55.50 %	340 (237, 446)	55.4 (52.2, 58.2)	0.11
ED attendance: 7 days Readmission: 30 days ⁵	20.7%	87 (65.5, 127)	20.8 (18.7, 22.2)	0.17	17.40 %	103 (74, 149.5)	17.2 (15.4, 18.9)	0.2

¹Readmission: hospitalisation following discharge from an inpatient stay. Either through the ED or other routes.

²ED attendance: any attendance at an ED which can result in hospitalisation or discharge from the ED.

³ED attendance or readmission: a combined measure which includes all hospitalisations either through the ED or other routes, and ED attendances from which the patient is discharged without hospitalisation.

⁴CV: coefficient of variation – IQR/median.

⁵Combined outcome - two different time points.

Table 1 Summary of emergency hospitalisations (readmissions) and ED attendances (which could end in discharge from the ED or hospitalisation) and a combined measure for each acute hospital in England following discharge from an index admission between April 2009 and March 2011. Numbers and proportions of patients discharged alive with specified outcomes. National proportions are shown for comparison purposes.

	Covariance parameter estimate	Standard error of the intercept	ICC ⁴ (%)	Covariance parameter estimate	Standard error of the intercept	ICC (%)
Outcome	HF			COPD		
Readmission ¹						
7 days	0.01144	0.00516	0.35	0.01246	0.00523	0.38
30 days	0.00525	0.00228	0.16	0.00806	0.00246	0.24
90 days	0.00278	0.00146	0.08	0.00663	0.00193	0.20
365 days	0.00414	0.00151	0.13	0.00585	0.00153	0.18
ED attendance ²						
7 days	0.07475	0.01526	2.22	0.10372	0.01831	3.06
30 days	0.11327	0.01741	3.33	0.13365	0.02006	3.90
90 days	0.14291	0.02018	4.16	0.14166	0.01920	4.13
365 days	0.16779	0.02165	4.85	0.17063	0.02220	4.93
ED attendance or readmission ³						
7 days	0.01088	0.00468	0.33	0.01356	0.00451	0.41
30 days	0.00635	0.00228	0.19	0.01028	0.00254	0.31
90 days	0.00488	0.00163	0.15	0.00916	0.00213	0.28
365 days	0.00775	0.00205	0.23	0.00953	0.00202	0.29
ED attendance: 7 days Readmission: 30 days ⁵	0.00548	0.00226	0.17	0.00781	0.00235	0.24

¹Readmission: hospitalisation following discharge from an inpatient stay. Either through the ED or other routes.

²ED attendance: any attendance at an ED which can result in hospitalisation or discharge from the ED.

³ED attendance or readmission: a combined measure which includes all hospitalisations either through the ED or other routes, and ED attendances from which the patient is discharged without hospitalisation.

⁴ICC – Intra-class correlation coefficient

⁵Combined outcome – two different time points.

Table 2 Assessment of inter-hospital variation derived from a random intercept, fixed slopes hierarchical model.

Outcomes	Hospital variables included in the model.		Hospitals included as a fixed effect.	
	ω (95%CI)		ω (95%CI)	
	HF	COPD	HF	COPD
Readmission				
7 days	18.2 (7.5, 44.4)	48.3 (16.5, 140.7)	1.8 (1.3, 2.6)	3.0 (2.2, 4.2)
30 days	32.7 (15.4, 69.7)	57.2 (30.6, 107.1)	4.4 (3.2, 6.0)	9.2 (7.1, 12.0)
90 days	89.7 (37.6, 214.0)	103.0 (56.1, 189.1)	10.2 (7.6, 13.8)	16.1 (12.5, 20.6)
365 days	141.4 (55.5, 324.7)	136.4 (75.9, 245.6)	15.5 (11.7, 20.6)	23.1 (18.2, 29.5)
ED attendance				
7 days	22.8 (8.8, 59.3)	11.2 (6.2, 23.9)	0.6 (0.4, 0.9)	0.8 (0.6, 1.1)
30 days	14.3 (8.5, 23.7)	16.9 (11.2, 25.4)	0.5 (0.4, 0.7)	0.8 (0.7, 1.0)
90 days	12.9 (8.9, 18.6)	22.3 (15.7, 31.6)	0.8 (0.6, 0.9)	1.2 (1.0, 1.3)
365 days	11.8 (8.9, 15.8)	14.2 (10.8, 18.7)	0.9 (0.8, 1.1)	1.0 (0.9, 1.1)
ED attendance or readmission				
7 days	31.5 (10.7, 92.5)	38.0 (15.0, 96.2)	2.0 (1.4, 2.8)	3.2 (2.3, 4.3)
30 days	44.9 (19.4, 104.0)	49.4 (27.5, 89.3)	4.3 (3.2, 5.9)	7.5 (5.9, 9.7)
90 days	89.7 (37.7, 213.5)	83.7 (47.5, 147.9)	8.6 (6.4, 11.4)	12.4 (9.9, 15.6)
365 days	219.6 (76.6, 629.5)	122.8 (65.3, 230.7)	11.4 (8.8, 14.7)	14.2 (11.4, 17.7)
ED attendance: 7 days Readmission: 30 days¹	36.0 (16.3, 79.4)	55.1 (29.5, 102.8)	4.4 (3.2, 5.9)	8.9 (6.9, 11.7)

¹Combined outcome – two different time points.

Table 3 Relative contribution of patient and hospital characteristics to hospital outcomes (patient level) (ω).

Outcome \ Metric	Variability between hospitals (assessed using the ICC – proportion of variation attributed to hospitals)	Relative contribution of patient and non-patient factors (assessed using the Omega statistic)	Statistical power to detect performance differences from the average
Readmission within 7 days	Very low (<1%)	Patient factors dominate	Low
ED attendance within 7 days	Low (2-3%) ¹	Hospital factors are contributing more than patient factors (evidence is stronger for HF than COPD)	Low
Readmission and/or ED attendance within 7 days	Very low (<1%)	Patient factors dominate	Moderate for HF Low for COPD
Readmission within 30 days	Very low (<1%)	Patient factors dominate	High
ED attendance within 30 days	Low (3-4%) ¹	Hospital factors are contributing more than patient factors (evidence is stronger for HF than COPD)	High
Readmission and/or ED attendance within 30 days	Very low (<1%)	Patient factors dominate	High
Readmission within 90 days	Very low (<1%)	Patient factors dominate	High
ED attendance within 90 days	Low (≈4%)	Patient and hospital factors are equally important.	High
Readmission and/or ED attendance within 90 days	Very low (<1%)	Patient factors dominate	High
Readmission within 365 days	Very low (<1%)	Patient factors dominate	High
ED attendance within 365 days	Low (≈5%)	Patient and hospital factors are equally important.	High
Readmission and/or ED attendance within 365 days	Very low (<1%)	Patient factors dominate	High

¹A range is given to account for slightly lower percentages for heart failure metrics.

Table 4: Summary of statistical properties of different hospital return to care metrics.