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Predictors of 30-day readmission following hospitalisation with community-acquired pneumonia

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ABSTRACT

Background There is a paucity of UK data to aid healthcare professionals in predicting which patients hospitalised with community-acquired pneumonia (CAP) are at greatest risk of 30-day readmission and to determine which readmissions may occur soonest.

Methods An analysis of CAP cases admitted to nine UK hospitals participating in the Advancing Quality Pneumonia Programme.

Results An analysis was performed of 12 157 subjects hospitalised with CAP in the Advancing Quality Programme Database. 26% of those discharged were readmitted within 30 days with readmission predicted by comorbidity including non-metastatic cancer, diabetes with complications and chronic kidney disease. 41% and 66% of readmissions occurred within 7 and 14 days of discharge, respectively. Patients readmitted within 14 days were more likely to have metastatic cancer (6.6% vs 4.5%; p=0.03) compared with those readmitted at 15–30 days.

Conclusions A quarter of patients hospitalised for CAP are readmitted within 30 days; of those, two-thirds are readmitted within 2 weeks. Further research is required to determine whether such readmissions might be preventable through imple menting measures including in-hospital cross-specialty comorbidity management, convalescence in intermediate care, targeted rehabilitation and advanced care planning.

Key messages

- In the UK, little is known regarding predictors of 30-day readmission following hospitalisation with Community Acquired Pneumonia and at what time period these readmissions mostly occur?
- The 30-day readmission is observed in over a quarter of cases of community-acquired pneumonia requiring hospitalisation and often occurs within the first 2 weeks following discharge.
- This is a large UK -based study examining 30-day readmission where all cases of community-acquired pneumonia were diagnosed on the basis of a senior physician diagnosis and abnormal chest radiograph. Understanding factors linked with readmission may prompt changes to current patient pathways in the delivery of care in community-acquired pneumonia requiring hospitalisation.

BACKGROUND

In healthcare systems, the rate of emergency readmission to hospital is a key performance indicator reflecting the quality of care delivered at various time points during the patient pathway.[1] The literature reports that rates of readmission following an emergency hospital admission have remained relatively stable over the last 14 years, but that for some conditions, including community-acquired pneumonia (CAP), readmissions are increasing.[2] One factor that may explain this rise could be the burden of comorbidity present in the increasing elderly cohort of patients hospitalised with CAP. The presence of comorbidity has been associated with an elevated mortality in subjects aged over 65 years diagnosed with CAP and has also been linked to worse survival at 24 months.[3 4] While there have been UK-based studies highlighting the association between hospitalisation with a diagnosis of pneumonia and that of comorbidity, there is a relative paucity of UK data exploring which patients hospitalised with CAP are at greatest risk of readmission and the time frame where this readmission risk is highest.[5] Advancing Quality (AQ) is a National Health Service (NHS)-recognised initiative set in the northwest of England, which aims to improve standards of healthcare delivery in alignment with national guidelines and encompasses a variety of conditions, including CAP.[6] In contrast with many databases which rely solely on diagnostic coding, entry into the AQ CAP Programme requires that the diagnosis of CAP is specified in the medical records by a consultant physician and quality control processes exclude those patients admitted without a chest radiographic changes compatible with pneumonia. The aim of this study was to analyse readmission data within the AQ Database to determine the predictors and timing of readmission to hospital within 30 days of discharge following an admission with CAP.

METHODOLOGY

In the UK, the Advancing Quality Alliance (AQuA) works with the NHS in the field of quality improvement. The AQ Programme is designed to identify and address those factors responsible for variation in care delivery through the use of high-quality data collection. As described elsewhere, the AQ Pneumonia Programme requires participating hospitals to submit data for proven CAP admissions on a rolling monthly basis.[7] For this study, analysis of all the CAP cases submitted by the nine participating hospitals in the AQ Pneumonia Programme was undertaken during the study period 1 January 2017 and 31 March 2019. The AQ Pneumonia Programme uses the Secondary Uses Service Payment by Results (SUS PbR) data extract from NHS Digital to identify the cohort done using the International Classification of Diseases, Tenth Revision (ICD-10) coding for pneumonia. The SUS PbR data also contain detail about patient demographics (such as age and gender) and information about the hospital admission such as whether the patient was discharged alive or died at the end of the spell. Once the cohort has been identified, participating hospitals are required to review the patients and answer additional qualification questions to ensure that the admission was suitable for the AQ CAP measures. For example, entry into the AQ Pneumonia dataset requires that the diagnosis of CAP must have been made by a consultant physician within 24 hours of hospital admission and at the time of data entry, an independent administrator reviews the chest X-ray radiology report to ensure it was compatible with the diagnosis of CAP. Patients who were not actively treated for CAP, but were palliated from admission, are also excluded, as are patients with hospital-acquired pneumonia. The hospital then submits the additional performance data for the validated patient set. Each hospital participating in the AQ Pneumonia Programme complies with regular independent NHS audits in order to ensure accuracy of data entry. Readmission within 30 days is defined as a subsequent admission recorded in SUS data commencing within 30 days of discharge. The reason for readmission is defined as the primary ICD-10 diagnosis of this second admission. The Charlson Comorbidity Index (CCI) was used to classify comorbidity as defined in the Standardized Hospital Mortality Guide.[8] The analysis was performed by a group comprising respiratory physicians, a senior business intelligence analyst, a medical statistician and two healthcare managers.

Patient and public involvement

The AQuA works with the NHS in the field of quality improvement. The AQ Programme is designed to identify and address those factors responsible for variation in care delivery through the use of high-quality data collection. AQuA has a panel of lived experience affiliates to support and challenge AQuA's programme of work: from developing the ideas, designing the programmes, their delivery and evaluation. The lived experience panel work to ensure that co-production and person centredness are incorporated into the design of programmes through use of their experience and stories. The panel work together to develop a measurement for co-production across AQuA activity, to maintain a person-centred perspective, continuously add value and provide deep patient insight to the programmes offered.

STATISTICAL ANALYSIS

Demographic information was summarised using means and SDs for continuous data, unless the data were not normally distributed. When this occurred, the median and IQR were used to describe the average and variability of the data. Categorical data are presented using counts and percentages. The data were stratified depending on whether patients had been readmitted to hospital within 30 days following the index admission with CAP. Following this, formal hypothesis tests (using Pearson's X^2 test) were undertaken to investigate possible differences between comorbidities and 30-day readmission. Logistic regression was used to construct a multivariate model, which combined demographic variables and comorbidities to determine the major predictors of 30-day readmission. In all analyses, results were considered significant if $p<0.05$. All analyses were undertaken using SPSS V.22 and were performed by a medical statistician (SL).

RESULTS

A total of 12 157 adults (mean age 73 (SD 16) years; mean CCI 9.47 (SD 8.81); 47% men) admitted with CAP were submitted to the AQ Database during the study period with an in-hospital mortality of 14.7% (1791 of 12 157). A total of 10 366 cases were discharged from hospital and 71 subsequently died outside of hospital within 30 days. Of the remaining patients who survived to 30 days, 26% (2691) were readmitted within 30 days of discharge. The mean level of comorbidity in the cohort, as measured by CCI, was high at 9.47 (SD 8.81). No correlation was observed between increasing age and CCI ($r^2=0.103$). The mean CCI was higher in the 30-day readmission group compared with the group who were not readmitted during this period (median 7 (IQR 11) vs 4 (IQR 14); Mann-Whitney U test; $p<0.001$). Of the 2691 who were readmitted within 30 days, 23.9% (644 of 2691) of readmissions had a principal readmission diagnosis of pneumonia.

When taking the index admission with CAP, 85.30% of those 7675 patients not readmitted within 30 days received appropriate antibiotics according to local guidelines compared with 85.28% of those 2691 patients readmitted within 30 days. The median time to antibiotic administration during the index admission was 191 (SD 397) min in the cohort who were not readmitted within 30 days compared with 196 (SD 404) min with this difference being non-significant ($p=0.58$).

Those variables identified as being significant predictors of 30-day readmission in the univariate analysis were

carried forward for multivariate modelling (tables 1 and 2). Table 2 outlines those factors emerging as significant predictors of 30-day readmission following multivariate analysis.

A greater number of hospital admissions in the 12 months prior to the index admission predicted a greater likelihood of 30-day readmission. In terms of comorbidity, the conditions associated with readmission were non-metastatic cancer (adjusted OR (aOR)=1.72, 95% CI (1.35 to 1.77)), diabetes with complications (aOR=1.64, 95% CI (1.17 to 2.78)) and chronic kidney disease (CKD) (aOR=1.25, 95% CI (1.01 to 1.32)). A longer length of stay (LOS) during the index admission was associated with an increased likelihood of being readmitted (aOR=1.01, 95% CI (1.002 to 1.009)). Subjects with a diagnosis of dementia (aOR=0.78, 95% CI (0.64 to 0.96)) were approximately less likely to be readmitted within 30 days as were those who presented with severe CAP (aOR=0.68, 95% CI (0.68 to 0.94)) during the index admission.

Of those subjects where no comorbidity was recorded, none was readmitted within 30 days while one or more comorbidity was recorded in 100% of subjects who were readmitted. Forty-one per cent (1103 of 2691) were readmitted within 0–7 days post-discharge followed by 24.9% (670 of 2691) between days 8 and 14, 17.2% (464 of 2691) between days 15 and 21, and 16.9% (454 of 2691) between days 22 and 30. Table 3 shows associations with the timing of readmission post-discharge with the presence of metastatic cancer significantly associated with early readmission within the first 2 weeks post-discharge.

DISCUSSION

We report that among patients discharged from hospital following admission with CAP, a quarter were readmitted within 30 days of whom two-thirds were readmitted within 14 days of discharge. The likelihood of readmission was associated with the presence of underlying comorbidity with the highest OR for readmission associated with diabetes (with complications), cancer and CKD.

Others have investigated the rates and predictors of readmission following CAP.[9 10] The Pneumonia Patient Outcomes Research Team Study reported that among 1343 US patients, the 30-day rehospitalisation rate following CAP was 10.1%,[9] while a subsequent US study examining 45 134 patients recruited between 2001 and 2007 reported a 30-day hospitalisation rate following CAP of 13.2%.[10] One explanation for the higher readmission rates reported in our study may be the proportion of the patients with multiple comorbidities. The link between comorbidity and readmission has been demonstrated in a number of prior studies.[11–13] A study of patients aged >65 years recruited from 20 hospitals, covering 70% of the Spanish population, showed a 30-day readmission rate following CAP of 11.39%.[12] In that study, 91% of those who were readmitted had comorbidities, particularly chronic respiratory failure, heart failure and chronic liver disease, reflecting our finding that chronic organ failure predicts readmission. In a US study charting 1 168 624 hospitalisations due to CAP over a 2-year period, the 30-day readmission rate was 18.3% and 22% of those readmissions were due to pneumonia which is comparable with the 24% of readmissions due to pneumonia in our study.[11] In a US study of 7 hospitals following up 577 patients discharged with CAP, 12% were readmitted within 30 days with the authors reporting that 74% of readmissions were comorbidity related.[13] However, in the UK, Daniel *et al* conducted a study of 108 working-aged patients with CAP who were recruited from four hospitals.[14] They showed 4.6% were readmitted within 4 weeks of discharge and found no single factor to be predictive of healthcare reconsultation post-discharge. The key differences between that cohort and the patients presented here are age and the burden of comorbidity. We found that age alone was not predictive of readmission and our cohort (median age 73 years) had an average CCI of 9.5, whereas Daniel *et al* described a cohort of median age 50 years with median CCI of 0. A systematic review by Weinreich *et al* revealed a median 30-day readmission rate of 17.3% following hospitalisation. The authors concluded that, similar to our findings, the majority of readmissions were related to the impact of pneumonia on comorbidities.[15] Another systematic review reported a 30-day readmission rate of 12%–20% and highlighted the importance of cardiovascular and respiratory comorbidity as the readmission diagnosis and also reported that pneumonia itself accounted for 22%–29% of readmission diagnoses.[16] These data support our findings and support the hypothesis that pneumonia exacerbates frailty, leads to decompensation of underlying organ failure and that these factors provoke readmission.

Our study demonstrated that two-thirds of readmissions occurred within the first 2 weeks following discharge with 41% occurring within 7 days. In a US study analysing claims-based data from over 1 million hospitalisations due to pneumonia, Dharmarajan *et al* reported that, consistent with our findings, 62.6% of these readmissions occurred during days 0–15 following discharge with a median time to readmission being 12 days.[11] A cohort study of 3996 subjects hospitalised with CAP in Sydney, Australia reported a readmission rate of 14.1% with a median time to readmission being 7 days with CAP responsible for 17.8% of all readmissions.[17] The authors reported a relationship between 30-day readmission and factors such as comorbidity, LOS and prior healthcare utilisation in the form of an index. In an earlier study of 270 patients hospitalised with CAP, a 30-day readmission rate of 23% was observed with readmission predicted by the Yale New Haven Readmission Risk Score which included certain comorbidity such as diabetes mellitus and congestive cardiac failure.[18] While a convincing argument already exists for inpatient respiratory specialist review of those with CAP, our data support a more holistic approach to CAP care if readmissions are to be reduced.[19 20] It may be that the ideal inpatient pathway for CAP includes respiratory specialist review during the acute phase of

Table 1 Univariate analysis

Variable	Discharged and not readmitted to hospital within 30 days (n=7675)	Readmitted to hospital within 30 days (n=2691)	Significance
Gender			p=0.03*
Male (%)	3548 (46.25)	1308 (48.64)	
Female (%) (available in 10 360)	4123 (53.75)	1381 (51.63)	
LOS			
Median (IQR)	5 (9)	6 (10)	p<0.001*
Age			
Median (IQR)	75 (21)	75 (18)	p>0.999*
CURB-65 score 3–5	1405 (18.30)	414 (15.38)	p=0.0007*
Chronic kidney disease			
Absent	6680 (87.04)	2263 (84.10)	p=0.0002*
Present	995 (12.96)	428 (15.90)	
Dementia			
Absent	7185 (93.62)	2558 (95.06)	p=0.008*
Present	490 (6.38)	133 (4.84)	
Liver disease			
Absent	7615 (98.22)	2666 (99.07)	p=0.54*
Present	60 (0.78)	25 (0.93)	
Cardiac failure			
Absent	6610 (86.13)	2241 (83.28)	p=0.0004*
Present	1065 (13.87)	450 (16.72)	
Non-metastatic.cancer			
Absent	6932 (90.32)	2253 (83.72)	p<0.0001*
Present	743 (9.68)	438 (16.28)	
COPD			
Absent	5219 (68.1)	1725 (64.10)	p=0.0002*
Present	2456 (31.9)	966 (35.90)	
Ischaemic heart disease			
Absent	6842 (89.15)	2347 (87.22)	p=0.007*
Present	833 (10. 85)	344 (12.78)	
Mental health			
Absent	6958 (90.66)	2421 (89.97)	p=0.31*
Present	717 (9.34)	270 (10.03)	
Severe liver disease			
Absent	7657 (9977)	2681 (99.63)	p=0.06*
Present	18 (0.23)	10 (0.37)	
Stroke			
Absent	7397 (96.38)	2588 (96.17)	p=0.32*
Present	278 (3.62)	103 (3.83)	
Pulmonary disease			
Absent	6177 (80.48)	2135 (79.34)	p=0.21*
Present	1498 (19.52)	556 (20.66)	
Diabetes mellitus			
Absent	6243 (81.34)	2130 (79.15)	p=.0.01*
Present	1432 (18.66)	561 (20. 85)	

Continued

Table 1 Continued

Variable	Discharged and not readmitted to hospital within 30 days (n=7675)	Readmitted to hospital within 30 days (n=2691)	Significance
Myocardial infarction			
Absent	7611 (99.17)	2668 (99.15)	p=0.92*
Present	64 (0.83)	23 (0.85)	
Diabetes complications			
Absent	7607 (99.11)	2652 (98.55)	p=0.02*
Present	68 (0.89)	39 (1.45)	
Renal disease			
Absent	7658 (99.78)	2688 (99.89)	p=0.39*
Present	17 (0.22)	3 (0.11)	
Metastatic cancer			
Absent	7417 (96.64)	2533 (94.13)	p=0.0001*
Present	258 (3.36)	158 (5.87)	
Learning disability			
Absent	7573 (98.67)	2651 (98.51)	p=0.59*
Present	102 (1.33)	40 (1.49)	
Previous admissions in 12 months prior to index admission; median (IQR)	2 (4)	1 (2)	p<0.0001†

*Independent samples t-test.
†Mann-Whitney U test.
COPD, chronic obstructive pulmonary disease; LOS, length of stay.

the admission followed by a multidisciplinary assessment later in the admission, incorporating identification and optimisation of comorbidities. The strong association observed in our study between metastatic cancer and early readmission would support an increased emphasis on community palliative care liaison, advanced care planning and a greater emphasis on review of social circumstances during discharge planning following CAP. To reduce readmission, in addition to a targeted focus on comorbidities, multidisciplinary pre-discharge evaluation should identify candidates for intermediate care along with directing the implementation of specific interventions for optimising mobility, reducing frailty and addressing social circumstances. With two-thirds of readmissions occurring within 14 days of discharge, intermediate care and supported discharge schemes are likely to be more successful than early outpatient clinic follow-up, but further studies are required to determine the effectiveness of implementing such pathways.[21]

A strength of this study lies in the accuracy of the diagnosis of CAP. AQ is a nationally recognised quality improvement initiative in the UK where data entry is strictly monitored and data quality audited. Furthermore, as described earlier, the diagnosis of CAP for entry into the AQ Programme is robust as opposed to simply labelling the patient with a diagnosis of CAP based on coding alone. However, certain limitations exist in our study. Our analysis did not measure an index of frailty in the study population nor did our study record details of social circumstances including nursing home residential status (although surrogates of comorbidity) or a history of cigarette smoking which may have been relevant in

Table 2 Multivariate analysis regarding predictors of 30-day readmission: logistic regression

	Beta	Exp (beta) adjusted OR	Exp (beta) 95% CI	Significance
Length of stay (index admission)	0.01	1.01	1.002 to 1.009	p<0.001
Chronic kidney disease	0.14	1.15	1.01 to 1.32	p=0.04
Cancer (non-metastatic)	0.44	1.55	1.35 to 1.77	p<0.001
Diabetes with complications	0.59	1.80	1.17 to 2.78	p<0.001
Dementia	−0.25	0.78	0.64 to 0.96	p=0.02
CURB 3–5	−0.22	0.80	0.68 to 0.94	p<0.001
Previous admissions	0.17	1.18	1.16 to 1.20	p<0.001

Table 3 Comparison between patients readmitted between days 0–14 and days 15–30 post-discharge

Variable	Readmission 0–14 days (n=1773, 66%)	Readmission 15–30 days (n=918, 34%)	Significance
Age			
Mean (SD)	72.25 (14.72)	70.74 (14.08)	p=0.01
Range	19–102	19–101	
LOS			
Median (IQR)	6 (10)	6 (9)	NS
Range	0–178	0–153	
Gender			
Male, n (%)	854 (48.2)	454 (49.5)	NS
Female	919 (51.8)	464 (50.5)	
Chronic kidney disease (n=428)	297 (16.75%)	131 (14.27%)	p=0.09*
Dementia (n=134)	96 (5.41%)	38 (4.14%)	p=0.15*
Liver disease (n=25)	17 (0.01%)	8 (0.009%)	p=0.82
Congestive cardiac failure (n=450)	297 (16.75%)	153 (16.67%)	p=0.55*
Non-metastatic cancer (n=438)	292 (16.47%)	146 (15.90%)	p=0.60*
COPD (n=968)	615 (34.69%)	353 (38.45%)	p=0.054*
Ischaemic heart disease (n=344)	229 (12.92%)	115 (12.53%)	p=0.74*
Mental health (n=270)	173 (9.76%)	97 (10.57%)	p=0.51*
Severe liver disease (n=10)	5 (0.28%)	5 (0.54%)	p=0.32†
Stroke (n=105)	66 (3.72%)	39 (4.25%)	p=0.50*
Pulmonary disease (n=556)	349 (19.68%)	207 (22.55%)	p=0.59*
Diabetes mellitus (n=563)	363 (20.47%)	200 (21.79%)	p=0.96*
Myocardial infarction (n=23)	14 (0.79%)	9 (0.98%)	p=0.66*
Diabetes with complications (n=39)	26 (1.47%)	13 (1.42%)	p=0.92*
Metastatic cancer (n=158)	117 (6.60%)	41 (4.47%)	p=0.02*
Learning disability (n=40)	21 (1.18%)	19 (2.07%)	p=0.07*

*X^2.
†Fisher's exact test.
COPD, chronic obstructive pulmonary disease; LOS, length of stay; NS, not significant.

predicting readmission.[10 22–25] Our analysis was limited in focusing on emergency hospital readmission rates which represent only one aspect of healthcare utilisation. Interestingly, while the overall hospital readmission rate was low in the study by Daniel *et al*, some form of healthcare utilisation was noted in 66% of the cohort in the 4-week period post-hospital discharge with just over 90% of these being general practice consultations.[14] It is possible that these differences in hospital versus primary care consultation represent regional differences in healthcare provision. The northwest of the UK has the highest rates of socioeconomic deprivation in the country and relatively poor access to primary care in comparison with other areas and this may account for the apparent differences in how patients access healthcare.[26] Furthermore, our analysis did not take into account the effects of medications on readmission rate, for example, recording a history of oral corticosteroid use and the cardiovascular drug count, both of which have been associated with readmission, and this effect would have been useful to measure in our cohort.[10] In terms of the index admission, our dataset did not measure the time to clinical stability which has been shown to be predictive of 30-day outcomes nor did our study take into account differences in terms of microbiological aetiology.[27 28]

CONCLUSIONS

In the UK, a quarter of patients who survive to discharge following a hospital admission for CAP are readmitted to hospital within 30 days with two-thirds being readmitted within 2 weeks. Readmission can be predicted by the burden of comorbidity, in particular the presence of chronic organ failure, cancer or diabetic complications.

Contributors The analysis was performed by BC, DW, TJ, SL, JH, MA and EK. BC, DW, SL, MA and TJ designed and wrote the manuscript. All authors read and approved the final manuscript.

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Competing interests The National Health Service employer of BC was reimbursed for the time spent performing clinical advisor roles for the Advancing Quality Pneumonia Programme.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not required.

Ethics approval Formal approval to conduct the study was granted by the Health Research Authority (reference: 286356) which reviewed the application and deemed that a formal Research Ethics Committee review was not required as the study involved analysis of anonymised data from a recognised National Health Service improvement project.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. The data are available for Advancing Quality via https://www.aquanw.nhs.uk/

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