Impact of a community-acquired pneumonia care bundle in North East England from 2014 to 2017—A quality improvement project

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Abstract

Objectives: To explore the impact of implementation of Community-Acquired Pneumonia (CAP) quality care bundle.

Setting: Eight acute hospitals in the North East of England and North Cumbria.

Participants: ICD-10 coded CAP aged ≥18 were identified. A total of 16 201 CAP patients were discharged 2016/2017 (15 707; 2015/2016 and 10 733; 2014/2015).

Outcome measures: Secondary User Service (SUS) data were collected monthly from April 2014 to 2017. Data were pseudonymised and data flows governed by Data Sharing Agreements. CAP measures were based on British Thoracic Society guidance and agreed following clinician consultation. CAP admissions and individual organisational compliance with and impact of, CAP quality bundle measures was explored.

Results: Average length of stay (LOS) was 10.4 days (median 6) 25% >13 days. Crude in-hospital mortality rate was 17.6%, significantly lower (95% CI) than 19.1% in 2015/2016 and 19.3% in 2014/2015. Emergency readmissions within 28 days were 19.7% (19.2%; 2015/2016, 17.9%; 2014/2015). A total of 39.5% of patients received all appropriate care measures. Compliance has improved over time, although not for all hospitals. Most quality measures have higher mortality for those passing measures compared to those failing (P < .05 95% CI). Giving oxygen, had a significantly higher emergency readmission rate, 3.3% higher (95% CI 1.1% to 5.5%). Appropriate antibiotics and recording CURB-65 scores reduced the emergency readmission rates (−2.7% (95% CI −4.5% to −0.8%) −2.6% (95% CI −3.8% to −1.4%), respectively, (P = ns)).

Conclusion: CAP accounts for significant bed days, mortality and readmissions. Although mortality was lower, LOS and readmission rates were not, despite improvements in compliance after implementation of the care bundle. Care bundle use remained sub-optimal.

Abbreviations: CAP, community-acquired pneumonia; HSMR, hospital standardised mortality ratio; ICD-10, International Classification of Diseases, version 10; NCI, not clinically indicated; NHS, National Health Service; ONS, Office for National Statistics; SHMI, summary hospital-level mortality indicator; SUS, secondary user services.
KEYWORDS
community-acquired pneumonia, ICD-10 code, standardised hospital mortality

1 | INTRODUCTION

Community-acquired pneumonia (CAP) is defined as pneumonia acquired outside hospital or health-care facilities. CAP tends to affect older people and is associated with significant morbidity and mortality. Current estimates describe pneumonia as affecting 29,000 people per annum in the United Kingdom with 5%-15% of those hospitalised dying within 30 days of admission. Pneumonia is responsible for more hospital admissions and bed days than any other respiratory condition.\(^1,\)\(^2\)

The supposition is that CAP care bundles improve the outcomes from pneumonia if widely and systematically implemented.\(^3,\)\(^4\) In this study, we explore the implementation of CAP quality measures as a mechanism for assessing use and impact of care bundle implementation in acute hospital settings across the whole of the United Kingdom North East and North Cumbria (NENC) geographical region.

The report focuses on process and outcomes, comparing the outcomes for patients over time, against the regional outcomes and based on the type of treatment received, specifically, whether patients passed, failed or were excluded from the pneumonia measures.

2 | METHODOLOGY

2.1 | Setting

This study was conducted across ICD-10 coded CAP patients (Appendix Table A1) over the age of 18 in eight acute hospitals in the North East of England using a unified database. Secondary User Service (SUS) data were collected by Clarity Informatics Limited from each hospital monthly from April 2014 to 2017. Data were pseudonymised at source and all data flows were governed by Data Sharing Agreements with each trust to ensure appropriate Information Governance.

2.2 | Community-acquired pneumonia quality measures

The seven CAP measures are based on the widely accepted British Thoracic Society guidance\(^3,\)\(^4\) with details of operational definitions of the measures agreed across all hospitals following consultation with clinicians and nurses from the hospitals via a series of workshops and meetings are as follows:

- CAP-1: Chest X-ray or CT scan of thorax within 4hrs of hospital arrival
- CAP-2: Oxygen assessed within 1hr of hospital arrival
- CAP-3: Oxygen given within 1hr of hospital arrival
- CAP-4: Initial antibiotic received within 4hrs of hospital arrival
- CAP-5: Appropriate initial antibiotic regimen received
- CAP-6: Defines whether a clinical prediction tool (CURB-65 or CRB-65 Score) is recorded
- CAP-7: Critical care advice given if CURB-65 score = 4 or 5 or CRB-65 score = 3 or 4

Clinically appropriate exclusions were applied to the patient population, for example, if a patient was designated as needing palliative care. The measures were agreed and collected initially with three trusts in 2014 with inclusion of a further five trusts in 2015. The care bundle itself was widely accepted as reflecting existing clinical practice, albeit, not consistently delivered quickly. The only measure which involved a change in practice (rather than just increasing the timeliness of existing care) was the routine calculation of a clinical risk prediction tool such as CURB-65 or CRB-65 Score. All the hospitals involved in the project participated in a series of bespoke workshops aimed at educating teams about the bundle and the evidence for its benefits. In addition, teams developed a sticker for the notes that acted as an aid memoire so that all elements of the bundle were completed. These efforts at improvement were shared through the workshops.

2.3 | Outcome measures

We examined three main outcome measures, average length of stay (LOS), crude mortality rate and rate of emergency readmissions within 28 days of discharge.

Length of stay for pneumonia patients is described in days and presented as both mean and median values.

Crude in-hospital mortality rate was determined as the number of patients coded with a discharge method (patient died) or a discharge destination (patient died) divided by the total number of patient spells.\(^5\)

An emergency readmission rate was defined as the number of patients who are readmitted as an emergency, within 28 days of discharge, divided by the total number of live discharges.

2.4 | Process

Initially we considered the overall CAP admissions and compliance with the CAP quality bundle measures as a
whole. We then went onto consider individual organisations and their compliance with the CAP quality bundle measures and then, the impact of the measures and the relationship with outcomes. We defined two scores. The appropriate care score (ACS) was the number of those patients who received all relevant elements of care defined in the bundle and composite process score (CPS) the number of those patients who receive any element of the care defined in the bundle.

2.5 | Patient and public involvement

Patients and members from regional patient support groups were involved in the education workshops. Patients and the public were not involved in the design of the study, its implementation or analysis.

3 | RESULTS

3.1 | CAP prevalence rates

We identified 16,201 pneumonia patients discharged during April-March 2016/2017 for NENC Hospital trusts, this compares to 15,707 and 10,733 patients for the same period for 2015/2016 and 2014/2015, respectively.

The average age for pneumonia patients at NENC Hospital Trusts in 2016/2017 was 73.9 years. Median age was 78 years. Half of all patients were between 67 and 85 years old at discharge with 25% of patients being 85 years or older. The age profile has remained relatively constant over time. The key parameters for pneumonia patients at NENC Hospital Trusts for the 3 years from April 2014 to March 2017 are shown in Figure 1.

The age profile varies across trusts, Newcastle Hospitals having the youngest pneumonia population with an average age of 71.1 years whilst South Tyneside Hospital have the oldest, average age 75.5 years.

3.2 | Outcome measures

Outcomes over time are shown in Table 1.

3.2.1 | Length of stay

The average LOS for pneumonia patients at NENC Hospital Trusts in 2016/2017 was 10.4 days. The median LOS was 6 days. Half of all patients stayed in hospital for between 3 and 13 days, 25% of patients were in hospital for 13 days or longer. The LOS profile for pneumonia patients at NENC Hospital Trusts has remained consistent for the most recent 2 years of the programme and slightly higher than in 2014/2015.

3.2.2 | Mortality

In April-March 2016/2017, the crude mortality rate for Pneumonia patients at NENC trusts was 17.6%, this is significantly lower (95% CI) than the 19.1% in April-March 2015/2016 and 19.3% in April-March 2014/2015.

3.2.3 | Emergency readmissions

In April-March 2016/2017, the rate of emergency readmissions within 28 days for Pneumonia patients at NENC trusts was 19.7%, compared to 19.2% in April-March 2015/2016 and 17.9% in April-March 2014/2015 (Table 1).

3.3 | Quality measures data

For NENC Hospital trusts, from April 2014 to March 2017 compliance with the bundle of quality measures has varied between measures, with lowest compliance for recording of a clinical risk prediction tool (CURB-65 score) at 47.5%, to highest compliance for oxygen assessment within 1 hour of

| Measure Completeness |
|-----------------------|
| Patients marked as Completed | 19,919 |
| % Complete | 48.8% |
hospital arrival at 85.5%. Only 39.5% of patients received all appropriate care measures, that is, they received all measures that they were eligible to receive. Overall, bundle measure compliance improved over time, although not for all trusts.

A patient is deemed to have ‘passed’ a measure if they are eligible for the measure activity and the activity was given within the specified time scales. Figure 2A shows the pass rates for individual NENC Hospital Trusts, for each measure, from April 2014 to March 2017 discharges with Figure 2B showing this over time.

### 3.4 | Relationship between compliance with CAP quality measures and outcomes

#### 3.4.1 | Length of stay

Length of stay is a difficult outcome to monitor. Average LOS is heavily influenced by just one or two long stay patients, median LOS is more consistent but rarely identifies differences. We found no statistical difference for LOS across time or with adherence to the CAP measure bundle.

#### 3.4.2 | Mortality

Figure 3 below shows crude mortality rates plotted on a funnel plot for NENC Hospital Trusts, for eligible patients for each pneumonia measure, by pass status, for April 2014 to March 2017 discharges.

The data presented visualises the impact of pass or fail for each measure. Above the mean line represents increased numbers of deaths associated with a measure, below the line represents decreased numbers of deaths. Ideally, passing a measure (green circle) would always be found below the mean and failing a measure (red diamond) would be associated with a figure above the mean. In addition, the data labels are coloured green when the crude mortality rate for patients who pass a measure is lower than for those who fail and where one of those patient groups is significantly (99.8%) different than the mean for all eligible patients. Conversely, the data labels are coloured red when the crude mortality rate for patients who pass is higher than those who fail and one of those patient groups is significantly (99.8%) different than the mean for all eligible patients.

Table 2 below shows the above data in tabular form, showing the difference in the crude mortality rate between eligible patients who pass a measure compared to those who fail, 95% confidence intervals for the differences are included along with Fisher’s exact $P$ value from a 2-proportion test.

Overall, most measures have higher mortality rates for eligible patients who pass measures compared to those who fail and these differences are statistically significant (95% CI). The exceptions are patients who have CURB-65 or CRB-65
score recorded. Mortality is 17.5% for those who fail this measure, mortality is 14.1% for those who pass, therefore, the difference is 3.4% lower (95% CI −4.7% to −2.2%). Eligible patients who receive appropriate antibiotics also show a reduced crude mortality rate but not significantly so.

### 3.4.3 Emergency readmissions within 28 days

In order to visualise, by pass status, for April 2014 to March 2017 discharges emergency readmission rates were plotted on a funnel plot for North East trusts, for eligible patients for each pneumonia measure.

For emergency readmissions, oxygen given, has a significantly higher emergency readmission rate for patients who pass the measure compared to those who fail that is, is visualised with the funnel plot as an outlier, 3.3% higher (95% CI 1.1% to 5.5%). Two measures, appropriate antibiotics and CURB-65 score recorded show significantly reduced emergency readmission rates, these are −2.7% (95% CI −4.5% to −0.8%) and −2.6% (95% CI −3.8% to −1.4%), respectively. For all other measures, the differences in readmission rates are not statistically significant.

### 4 DISCUSSION

CAP is common and in our study prevalence rose during the period. CAP is also seasonal (with higher rates in winter) and with considerable variation between years dependent on the epidemiology of microbes circulating in the population. In this study, identification was based on clinical coding in administrative data from a number of different
FIGURE 3  Funnel plots by pass status for North East trusts, from April 2014 to March 2017. The data presented visualises the impact of pass or fail for each measure. Above the mean line represents increased numbers of deaths associated with a measure, below the line represents decreased numbers of deaths. Ideally, passing a measure (green circle) would always be found below the mean and failing a measure (red diamond) would be associated with a figure above the mean. In addition, the data labels are coloured green when the crude mortality rate for patients who pass a measure is lower than for those who fail and where one of those patient groups is significantly (99.8%) different than the mean for all eligible patients. In contrast, the data labels are coloured red when the crude mortality rate for patients who pass is higher than those who fail and one of those patient groups is significantly (99.8%) different than the mean for all eligible patients. A, Crude mortality rate; B, Emergency Readmission Rates
## Table 2
Mortality and readmissions rates according to whether individual components of the CAP quality bundle were passed or failed

| Component                        | Pass | Fail | % Deaths | Diff. pass—Fail | 95% LL for Diff. | 95% UL for Diff. | Fisher’s P value | Live discharges | % Readmits | Diff. pass—Fail | 95% LL for Diff. | 95% UL for Diff. | Fisher’s P value |
|----------------------------------|------|------|----------|-----------------|-----------------|-----------------|-----------------|----------------|-------------|-----------------|-----------------|-----------------|-----------------|
| **CAP-1: Chest X-ray or CT scan**|      |      |          |                 |                 |                 |                 |                |             |                 |                 |                 |                 |
| Pass                            | 15244| 3868 | 17.5%    | 2.9%            | 1.6%            | 4.1%            | .000            | 12574          | 2390        | 19.0%           | 0.5%            | −1.0%           | 2.0%            | .500            |
| Fail                            | 566  |      | 14.6%    |                 |                 |                 |                 | 3302           | 610         | 18.5%           |                 |                 |                 |                 |
| **CAP-2: Oxygen Assessed**       |      |      |          |                 |                 |                 |                 |                |             |                 |                 |                 |                 |
| Pass                            | 11561| 1930 | 16.7%    |                 |                 |                 |                 | 9631           | 1742        | 18.1%           |                 |                 |                 |                 |
| Fail                            | 244  |      | 12.4%    | 4.3%            | 2.7%            | 5.9%            | .000            | 1723           | 304         | 17.6%           | 0.4%            | −1.5%           | 2.4%            | .683            |
| **CAP-3: Oxygen Given**          |      |      |          |                 |                 |                 |                 |                |             |                 |                 |                 |                 |
| Pass                            | 5208 | 3080 | 21.5%    |                 |                 |                 |                 | 4088           | 820         | 20.1%           |                 |                 |                 |                 |
| Fail                            | 1120 |      | 15.7%    |                 |                 |                 |                 | 1670           | 280         | 16.8%           | 3.3%            | 1.1%            | 5.5%            | .004            |
| **CAP-4: Initial Antibiotic Received** |      |      |          |                 |                 |                 |                 |                |             |                 |                 |                 |                 |
| Pass                            | 4734 | 1916 | 14.8%    |                 |                 |                 |                 | 4414           | 715         | 16.2%           |                 |                 |                 |                 |
| Fail                            | 2473 |      | 11.3%    |                 |                 |                 |                 | 2194           | 348         | 15.9%           | 0.3%            | −1.5%           | 2.2%            | .749            |
| **CAP-5: Appropriate Antibiotic Received** |      |      |          |                 |                 |                 |                 |                |             |                 |                 |                 |                 |
| Pass                            | 4734 | 2911 | 13.5%    |                 |                 |                 |                 | 4095           | 616         | 15.0%           |                 |                 |                 |                 |
| Fail                            | 639  |      | 14.0%    | −0.5%           | −2.1%           | 1.1%            | .538            | 2503           | 443         | 17.7%           | −2.7%           | −4.5%           | −0.8%           | .005            |
| **CAP-6: CURB-65 Score Recorded** |      |      |          |                 |                 |                 |                 |                |             |                 |                 |                 |                 |
| Pass                            | 6216 | 6871 | 14.1%    | −3.4%           | −4.7%           | −2.2%           | .000            | 5342           | 860         | 16.1%           |                 |                 |                 |                 |
| Fail                            | 874  |      | 17.5%    |                 |                 |                 |                 | 5669           | 1128        | 19.9%           |                 |                 | −3.8%           |                 |
| **CAP-7: Critical Care Advice Given** |      |      |          |                 |                 |                 |                 |                |             |                 |                 |                 |                 |
| Pass                            | 701  | 1697 | 31.2%    |                 |                 |                 |                 | 482            | 84          | 17.4%           |                 |                 |                 |                 |
| Fail                            | 219  |      | 17.7%    | 13.6%           | 9.7%            | 17.4%           | .000            | 1397           | 301         | 21.5%           | −4.1%           | −8.1%           | −0.1%           | .058            |
| **ACS: Appropriate Care Score**  |      |      |          |                 |                 |                 |                 |                |             |                 |                 |                 |                 |
| Pass                            | 8083 | 12366| 17.9%    |                 |                 |                 |                 | 6639           | 1270        | 19.1%           |                 |                 |                 |                 |
| Fail                            | 1444 |      | 16.6%    | 1.3%            | 0.2%            | 2.3%            | .020            | 10312          | 1966        | 19.1%           | 0.1%            |                 |                 |                 |
NHS organisations from across a large geographical area in the North of England. Whilst this process is stable variation in identification, documentation and coding are all subject to some variation. CAP is the diagnosis responsible for the highest volume of deaths in the hospital mortality Summary Hospital-level Mortality Indicator (SHMI), it accounts for very significant numbers of bed days, in our study had a 17% readmission rate and is one of the most significant sources of cost and unplanned activity for any NHS hospital. It is, therefore, important that service improvement strategies aim to target this condition to reduce LOS, readmission and mortality rates.

Although mortality was lower in the final year of the project, LOS and readmission rates were not despite improvements in compliance with the care bundle. Use of the care bundle remained suboptimal despite 3 years of effort and whilst some of this may be related to accuracy of documentation and auditing it is likely that the complexity of hospital care systems make it difficult for staff to consistently identify and treat patients with CAP in a timely manner.

A major aim of the programme was to demonstrate that patients have improved outcomes (reduced LOS, mortality and emergency readmissions within 28 days) when they receive appropriate CAP quality care measures. We have looked for variations in outcomes between eligible patients who pass a measure and those who fail.

Overall, most measures have higher mortality rates for eligible patients who pass measures compared to those who fail and these differences are statistically significant (95% CI).

This seems counterintuitive, but could suggest that those with more severe CAP might be recognised and the care bundle complied with whilst less severe CAP is less recognised.

The exceptions are patients who have clinical prediction risk score (CURB-65 or CRB-65) recorded. For patients who pass this measure the crude mortality rate is 3.4% (95% CI −4.7% to −2.2%) lower than for patients who fail the measure and those who fail.

For average LOS, no statistical significance was found.

In conclusion, our study has shown that CAP is common and accounts for significant numbers of bed days, mortality and readmissions. Although mortality was lower in the final year of the project, LOS and readmission rates were not, despite improvements in compliance with the care bundle. Care bundle use remained sub-optimal, which may be related to accuracy of documentation. It is likely that the complexity of hospital care systems make it difficult for staff to consistently identify and treat patients with CAP in a timely manner.

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**CONFLICT OF INTERESTS**

The authors declare that they have no competing interests.

**AUTHORS’ CONTRIBUTIONS**

GM was responsible for the original study idea. All authors contributed to the design of the study. LF and MW conducted statistical analysis. AR carried out the thematic coding. All authors contributed to data interpretation. GM, JN and AR drafted the manuscript and all authors read and approved the final manuscript.

**DATA AVAILABILITY STATEMENT**

The data sets used and/or analysed during the current study are available from the corresponding author on reasonable request.
ETHICS APPROVAL AND CONSENT TO PARTICIPATE
Not applicable. Ethics approval was not sought as the data were collected under normal NHS Clinical Audit arrangements. Only case records were used to obtain data.

CONSENT FOR PUBLICATION
Not applicable.

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## APPENDIX

| Code | Definition |
|------|------------|
| CAP  | Pneumonia due to *Streptococcus pneumonia* |
| J13  | Pneumonia due to *Haemophilus influenza* |
| J150 | Pneumonia due to *Klebsiella pneumonia* |
| J151 | Pneumonia due to *Pseudomonas* |
| J152 | Pneumonia due to staphylococcus |
| J153 | Pneumonia due to streptococcus, group B |
| J154 | Pneumonia due to other streptococci |
| J155 | Pneumonia due to *Escherichia coli* |
| J156 | Pneumonia due to other aerobic Gram-negative bacteria |
| J157 | Pneumonia due to *Mycoplasma pneumonia* |
| J158 | Other bacterial pneumonia |
| J159 | *Bacterial pneumonia*, unspecified |
| J160 | *Chlamydial pneumonia* |
| J168 | Pneumonia due to other specified infectious organisms |
| J180 | Bronchopneumonia, unspecified |
| J181 | *Lobar pneumonia*, unspecified |
| J182 | *Hypostatic pneumonia*, unspecified |
| J188 | Other pneumonia, organism unspecified |
| J189 | Pneumonia, unspecified |

### Septicaemia

| Code | Definition |
|------|------------|
| A400 | Septicaemia due to streptococcus, group A |
| A401 | Septicaemia due to streptococcus, group B |
| A402 | Septicaemia due to streptococcus, group D |
| A403 | Septicaemia due to *Streptococcus pneumonia* |
| A408 | Other streptococcal septicaemia |
| A409 | Streptococcal septicaemia, unspecified |
| A410 | Septicaemia due to *Staphylococcus aureus* |
| A411 | Septicaemia due to other specified staphylococcus |
| A412 | Septicaemia due to unspecified staphylococcus |
| A413 | Septicaemia due to *Haemophilus influenza* |
| A414 | Septicaemia due to anaerobes |
| A415 | Septicaemia due to other Gram-negative organisms |
| A418 | Other specified septicaemia |
| A419 | Septicaemia, unspecified |

### Respiratory failure

| Code | Definition |
|------|------------|
| J960 | Acute respiratory failure |
| J962 | Acute and chronic respiratory failure |

### Cystic fibrosis

| Code | Definition |
|------|------------|
| E84.0 | Cystic fibrosis with pulmonary manifestations |
| E84.1 | Cystic fibrosis with intestinal manifestations |
| E84.8 | Cystic fibrosis with other manifestations (including combined manifestations) |
| E84.9 | Cystic fibrosis, unspecified |