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# An audit of community-acquired pneumonia antimicrobial compliance using an intervention bundle in an Irish hospital



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## ABSTRACT

**Objectives:** Hospitalisations with community-acquired pneumonia (CAP) are often not managed in accordance with antimicrobial guidelines. This study aimed to assess whether guideline-driven antimicrobial prescribing for CAP can be improved using an intervention bundle. Secondary measures assessed were hospital length of stay (LOS), mortality, duration of intravenous antibiotics and total antibiotics, improved uptake of appropriate investigations, and documentation of CURB-65 score.

**Methods:** A retrospective cohort of hospitalised CAP patients from August–September 2018 was compared with a post-intervention prospective cohort from May–June 2019. The intervention bundle included a mobile audience response system, promotion of the antimicrobial app, development of a physical card with local guidelines, and incorporating CURB-65 into the unscheduled admission proforma. Local guidelines are in keeping with British Thoracic Society CAP guidelines.

**Results:** A total of 69 adult patients (aged >18 years) were included in the study (37 retrospective, 32 prospective). Overall compliance with local CAP guidelines improved from 21.6% to 62.5% ( $P < 0.001$ ). No difference in initial intravenous antibiotic duration was seen (median 4 days vs. 4 days;  $P = 0.70$ ) and total antibiotic duration was significantly shorter in the post-intervention group (median 9 days vs. 7 days;  $P = 0.01$ ). No difference in LOS or mortality was seen between the groups. Documentation of CURB-65 improved from 5.4% to 46.9% ( $P < 0.001$ ). Uptake of streptococcal urinary antigen testing improved from 18.9% to 40.6% ( $P = 0.024$ ).

**Conclusions:** A simple, low-cost quality improvement bundle can significantly increase appropriate antimicrobial prescribing and shorten the total antibiotic duration.

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## 1. Introduction

Lower respiratory tract infections are a major cause of morbidity and mortality, ranked third in the World Health Organization (WHO) global burden of disease rankings between 2000–2016 for impact on disability-adjusted life-years and fourth for deaths [1]. In Europe there are approximately 1 million community-acquired pneumonia (CAP) admissions per year [2]. Admission rates per country vary widely. Ireland has the highest rate of admissions with 227.24 per 100 000, which accounts for 4.5% of unscheduled hospitalisations annually. A cost analysis in a

single tertiary centre has shown that the mean cost per stay was €14 802 in 2017 [3].

The decision to admit and the antimicrobial choice for CAP have been highly protocolised based on well-validated scoring systems, including CURB-65 for patients presenting to hospital [4,5]. Despite this, documentation of severity scores for unscheduled admissions has been poor [6–10]. Patients with low CURB-65 scores are admitted unnecessarily [11]. Admitted patients tend to be under-investigated [12,13]. Similarly, antimicrobial use is poorly compliant with British Thoracic Society (BTS) guidelines and has been overly broad in spectrum of activity [14,15]. Hospital length of stay (LOS) and overall duration of antibiotics have been shown to be prolonged in some cases [3].

The aim of this audit was to assess whether an intervention bundle featuring a single interactive teaching session using a mobile audience response system (MARS) with the adjunctive

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measures of promoting the antimicrobial mobile app, providing a physical card containing guidelines and integrating the CURB-65 score into the medical admission proforma could improve antimicrobial stewardship of in-hospital CAP. Secondary outcomes reviewed were LOS, uptake of appropriate investigations, and time to antibiotics in the prospective group.

## 2. Methods

### 2.1. Study outline

This audit was an initiative of the Sligo University Hospital (SUH) Antimicrobial Stewardship Committee in conjunction with the respiratory department. CAP management was identified as an area of particularly poor compliance. This was evident from preliminary data from a hospital-wide pharmacy audit of overall prescription within the hospital. SUH is a 359-bed hospital in Ireland with a 24-h emergency department (ED). Data collection for the retrospective part of the study was from 1 August 2018 to 30 September 2018. Prospective data collection occurred between 1 May and 30 June 2019.

### 2.2. Audit standard

Local antimicrobial guidelines for CAP, which are consistent with national Irish guidelines. Irish guidelines draw heavily on 2009 BTS CAP guidelines (Table 1)[16].

### 2.3. Retrospective analysis

Data were retrospectively collected on patients admitted with CAP in August–September 2018 in SUH. Patients with pneumonia were identified using ICD-10 codes for CAP from Hospital In-Patient Enquiry (HIPE) data, the national healthcare data collection system in Ireland, managed by the Health Service Executive (HSE). Inclusion criteria included patients with consolidation on chest radiography who were admitted through the ED or Acute Assessment Unit. Exclusion criteria included patients with hospital-acquired pneumonia, immunosuppression, on chemotherapy or with other pathologies incorrectly coded as CAP. Charts and prescription records for patients were reviewed. CURB-65 scores were retrospectively calculated for those not documented (CURB-65: confusion, urea >7 mmol/L, respiratory rate >30 breaths/min, systolic blood pressure ≤90 mmHg/diastolic blood pressure ≤60 mmHg, age >65 years old; a single point is attributed to each criterion fulfilled). Radiological imaging was reviewed on McKesson Radiological Imaging Service (RIS) software v.2.0. Laboratory results, urinary antigen tests and microbiological results were reviewed on VT400 Lab73 healthcare software.

Compliance with antimicrobial guidelines was defined as correct route, dose and frequency. If additional antibiotics were

given despite otherwise complete adherence the episode was deemed non-adherence. For example, for a patient with a CURB-65 score of 3, amoxicillin/clavulanic acid 1.2 g every 8 h intravenous (i.v.) + clarithromycin 500 mg every 12 h orally with additional gentamicin 5 mg/kg once daily i.v. would be deemed non-adherence due to the presence of gentamicin despite correct prescription otherwise.

### 2.4. Intervention

The 'intervention bundle' was undertaken at the beginning of non-consultant hospital doctor (NCHD) 'changeover', a period when junior doctors change roles within a hospital or between hospitals to gain experience in a new specialty in a period of training prior to subspecialisation, in early April 2019. Four low-cost measures were implemented in the bundle.

First, an interactive presentation was given during a 1-h medical grand rounds session using on-line Mentimeter® software, a MARS. This session was also given to the ED separately. Assessment of knowledge of correct antimicrobial choice based on CURB-65 score was assessed at the beginning and end of each presentation through collective voting using smartphones with real-time data projected onto the presentation. Data were also automatically collated in Microsoft® Excel format. Common pathogens, appropriate investigations, rationale for antimicrobial choice, antimicrobial resistance and results of retrospective audit were presented.

Second, the local SUH antimicrobial SHARx smartphone application for iOS and Android was also promoted. This app is password protected and was developed by MEG Support Tools with a grant from Pfizer Healthcare Ireland; the content of the app is solely an electronic extension of local antimicrobial guidelines, which are decided upon by the Antimicrobial Stewardship Committee.

Third, an 85 × 55 mm card with CURB-65 score, appropriate investigations and a table of local guidelines was given to all medical and ED faculty members present at the presentations (Appendix 1). The cards are the same size as a standard hospital swipe card and were intended to slide behind swipe cards on hospital lanyards. Cards were also left in the morning medical handover meeting room. Lastly, the CURB-65 criteria was also added to the admission proforma for unscheduled patients admitted through the ED.

### 2.5. Prospective analysis

Patients with CAP between May and June 2019 were identified using the same methodology and inclusion/exclusion criteria as the retrospective audit. Door to needle time for antibiotics was recorded at this time as a potential variable for future audit. NCHDs were not explicitly informed that their practice subsequent to the intervention would be audited as part of a re-audit.

**Table 1**

Current British Thoracic Society (BTS) guidelines for empirical treatment of community-acquired pneumonia.

CURB-65 score	First-line	Non-type 1 hypersensitivity reaction to penicillin	Type 1 hypersensitivity
0–1	Amoxicillin p.o. 1 g t.i.d.	Clarithromycin p.o. 500 mg b.i.d.	Clarithromycin p.o. 500 mg b.i.d.
2	Amoxicillin p.o./i.v. 1 g t.i.d. + clarithromycin 500 mg b.i.d. (i.v. if NPO)	Cefuroxime p.o. 500 mg b.i.d. or i.v. 1.5 g t.i.d. + clarithromycin 500 mg b.i.d. (i.v. if NPO)	Clarithromycin 500 mg b.i.d. (i.v. if NPO) or doxycycline 200 mg q.d.
3	Amoxicillin/clavulanic acid i.v. 1.2 g t.i.d. + clarithromycin 500 mg b.i.d.	Cefuroxime i.v. 1.5 g t.i.d. + clarithromycin 500 mg b.i.d. (i.v. if NPO)	Microbiology advice

p.o., oral; t.i.d., three times daily; b.i.d., twice daily; i.v., intravenous; NPO, nil by mouth; q.d., once daily.

Antimicrobial choice is directed by severity of infection measured by CURB-65 score. CURB-65: confusion, urea ≥7.0 mmol/L, respiratory rate >30 breaths/min, systolic blood pressure ≤90 mmHg/diastolic blood pressure ≤60 mmHg, age >65 years old; a single point is attributed to each criterion fulfilled.

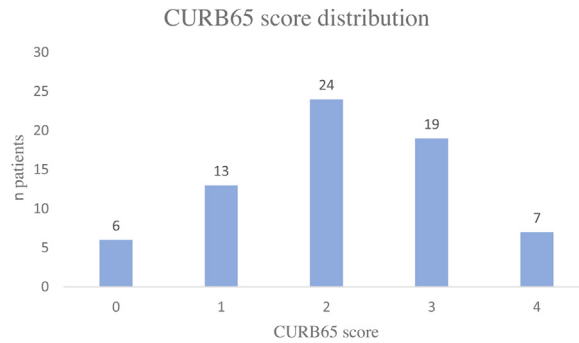


Fig. 1. Distribution of CURB-65 scores in unscheduled admissions with community-acquired pneumonia as the primary diagnosis.

## 2.6. Statistical analysis

Data were compiled in Microsoft Excel 2019<sup>®</sup> and statistical analysis was performed using IBM SPSS Statistics v.26.0 (IBM Corp., Armonk, NY). The  $\chi^2$  test was used for categorical data. The Mann–Whitney *U*-test was performed on non-normally distributed nominal data (LOS, duration of antibiotics), and the Kruskal–Wallis test was used for non-normally distributed ordinal/nominal data related to a scale (i.e. time to antibiotics for given CURB-65 score).

## 3. Results

A total of 69 patients were included in the final study (37 pre-intervention and 32 post-intervention). Twenty-six patients were excluded as they were either miscoded as CAP or had other

diagnoses, many of which were hospital-acquired pneumonia (15 pre-intervention, 11 post-intervention). Some patients had missing charts and thus incomplete data.

Of the 69 patients, 37 (53.6%) were female with a mean  $\pm$  standard deviation (S.D) age of  $74.8 \pm 16.08$  years. Eleven patients (15.9%) were nursing home residents. The mean  $\pm$  S.D. CURB-65 score was  $2.16 \pm 1.17$ , and 50 patients (72.5%) had a CURB-65 score of  $\geq 2$  (Fig. 1). Moreover, 28 patients (40.6%) had a previous respiratory diagnosis. Chronic obstructive pulmonary disease was the most common single co-morbidity (23.2%). The median white blood cell count and C-reactive protein (CRP) were  $11 \times 10^9$  cells/mL and 70 mg/L, respectively (Table 2).

The median LOS was 4 days in both groups [pre-intervention interquartile range (IQR) 3–11 days, post-intervention IQR 3–7 days], with no significant difference between the pre- and post-

**Table 2**  
Baseline demographics and results of baseline laboratory and chest radiography findings.

Characteristic	Total (n = 69)	Pre-intervention (n = 37)	Post-intervention (n = 32)	P-value
Female sex [n (%)]	37 (53.6)	20 (54)	17 (53)	0.93
Age (years) [median (IQR)]	78 (68.5–86)	80 (69.5–86)	76.5 (68.5–85)	0.43
NH resident (n)	11	7	4	0.46
CURB-65 score (mean $\pm$ S.D.)	2.16 $\pm$ 1.17	2.03 $\pm$ 1.22	2.21 $\pm$ 1.01	0.48
Co-morbidities (n)				
COPD	16	8	8	
Asthma	4	3	1	
Bronchiectasis	2	1	1	
ILD	1	0	1	
Alpha-1 antitrypsin deficiency	1	0	1	
Pulmonary sarcoid	1	1	0	
Pulmonary TB (treated)	1	1	0	
Farmer's lung	1	0	1	
Lobectomy	1	1	0	
HTN	15	6	9	
Atrial fibrillation	9	5	4	
IHD <sup>a</sup>	8	5	3	
CHF	5	3	2	
CKD (eGFR < 30 mL/min/1.73 m <sup>2</sup> )	4	2	2	
T2DM	8	4	4	
Dementia	8	5	3	
Prior malignancy <sup>b</sup>	10	6	4	
Stroke	4	3	1	
Epilepsy	3	2	1	
Investigations				
CRP (mg/L) [median (IQR)]	70 (27–127)	59 (20.5–169)	71 (35–115)	
WBC count $\times 10^9$ cells/L [median (IQR)]	11 (8.5–14.4)	11.1 (7.7–14.4)	11 (8.8–14.2)	
Consolidation on chest radiography (n)				
Right	36	19	17	
Left	20	11	9	
Bilateral	13	7	6	

IQR, interquartile range; NH, nursing home; S.D., standard deviation; COPD, chronic obstructive pulmonary disease; ILD, interstitial lung disease; TB, tuberculosis; HTN, hypertension; IHD, ischaemic heart disease; CHF, congestive heart failure, CKD, chronic kidney disease, eGFR, estimated glomerular filtration rate; T2DM, type 2 diabetes mellitus; CRP, C-reactive protein; WBC, white blood cell.

<sup>a</sup> Includes percutaneous coronary intervention, coronary artery bypass grafting and myocardial infarction.

<sup>b</sup> Includes prostate cancer, Mantle cell lymphoma, colorectal cancer, oesophageal cancer, breast cancer, renal cell carcinoma and lung cancer.

**Table 3**  
Results of primary and secondary outcomes.

	Total (n = 69)	Pre-intervention (n = 37)	Post-intervention (n = 32)	P-value
Compliance with antimicrobial guideline		8 (21.6%)	20 (62.5%)	<0.001
β-Lactam/β-lactamase inhibitor		11/34 (32.4%)	21/30 (70.0%)	0.002
Clarithromycin		15/29 (51.7%)	19/25 (76.0%)	0.065
Investigations				
Streptococcal urinary antigen	20	7 (18.9%)	13 (40.6%)	0.024
Legionella antigen	17	7 (18.9%)	10 (31.3%)	0.14
Sputum culture	17	7 (18.9%)	10 (31.3%)	0.14
Blood cultures	47	27 (84.4%)	20 (62.5%)	0.35
CURB-65 documentation <sup>a</sup>	17	2 (5.4%)	15 (46.9%)	<0.001
SIRS documentation <sup>b</sup>	10	4 (10.8%)	6 (18.8%)	0.35
Antibiotic duration (days) [median (IQR)]				
i.v. antibiotics		4 (2–4.5)	4 (2–5)	0.70
Total antibiotics		9 (7–11)	7 (6.5–9)	0.01
Time to antibiotics (mean)		–	142 min	
Deaths	5	2 (5.4%)	3 (9.3%)	0.53
Length of stay (days) [median (IQR)]	4	4 (3–11)	4 (3–7)	0.85

NOTE: Data are n (%) unless otherwise stated.

SIRS, systemic inflammatory response syndrome; IQR, interquartile range; i.v., intravenous.

<sup>a</sup> CURB65: confusion, urea  $\geq 7.0$  mmol/L, respiratory rate  $>30$  breaths/min, systolic blood pressure  $\leq 90$  mmHg/diastolic blood pressure  $\leq 60$  mmHg, age  $>65$  years old; a single point is attributed to each criterion fulfilled.<sup>b</sup> Temperature  $>38$  or  $<36$  °C, heart rate  $>90$  beats/min, tachypnoea  $>22$  breaths/min, white blood cell count  $>12$  or  $<4 \times 10^9$  cells/L; any criterion fulfilled scores 1 point, and  $\geq 2$  points indicate possible sepsis.

intervention groups. Two deaths occurred in the pre-intervention group and three in the post-intervention group (5.4% vs. 9.3%;  $P = 0.53$ ). All patients who died had a CURB-65 score of  $\geq 3$  and documented respiratory sepsis (Table 3).

Regarding the interactive medical grand rounds teaching session, 25 NCHDs engaged on the day of the intervention. Amoxicillin and clarithromycin were correctly identified as the antibiotic of choice for a patient with a CURB-65 score of 2 at the start of the session by 15/25 (60.0%). In the independent teaching session with ED doctors, of seven present on the day of the session, three (42.9%) correctly identified the appropriate antimicrobial choice for a CURB-65 of 2. At the end of session re-assessment this increased to 21/25 (84%) medical doctors and 7/7 (100%) ED doctors. Medical doctors rated their perceived diagnostic accuracy of chest radiography findings for pneumonia compared with a consultant radiologist at 68%, whereas ED doctors rated their accuracy at 64%. On review of admission notes, there was 81% concordance of documented findings with official radiology reporting. *Streptococcus pneumoniae* was known to be the most common cause of CAP by 84% of medical doctors and 100% of ED doctors.

*Streptococcus pneumoniae* was the most common causative organism identified ( $n = 4$ ) (Table 4).

Intravenous antibiotics were received by 92% of patients. Amoxicillin/clavulanic acid was the most common antibiotic used ( $n = 41$ ; 59.4%). Clarithromycin was the second most common ( $n = 34$ ; 49.3%) (Table 5).

The systemic inflammatory response syndrome (SIRS) score was  $\geq 2$  in 34 patients, indicating possible respiratory sepsis

(temperature  $>38$  or  $<36$  °C, heart rate  $>90$  beats/min, tachypnoea  $>22$  breaths/min, white blood cell count  $>12$  or  $<4 \times 10^9$  cells/L; any criterion fulfilled scored 1 point, with  $\geq 2$  points indicating possible sepsis). Documentation of SIRS score was done in 10 (14.5%) of 69 patients.

### 3.1. Retrospective audit

Overall compliance with guidelines was 21.6%. The largest contributing factors for this were overuse of amoxicillin/clavulanic acid and use of unnecessary antibiotics for CAP such as piperacillin/tazobactam (TZP) and gentamicin (Table 5).

### 3.2. Prospective audit

A statistically significant increased uptake of pneumococcal urinary antigen testing was seen, from 18.9% in the pre-intervention group to 40.6% in the post-intervention group ( $P = 0.024$ ). No difference was seen for other investigations (blood cultures, legionella antigen detection, sputum cultures). An increase in documentation was seen for CURB-65 (5.4% vs. 46.9%;  $P < 0.001$ ). Overall compliance improved to 62.5% ( $P < 0.001$ ) [ $\beta$ -lactam/ $\beta$ -lactamase compliance 21/30 (70.0%); clarithromycin compliance 19/25 (76.0%)] (Table 3). One dose of TZP was administered in the ED prior to switch to appropriate antimicrobials, which was included as an episode of non-adherence to guidelines. Appropriate use of amoxicillin increased

**Table 4**  
Organisms identified and proportion of positive investigations.

Organism	Streptococcal urinary antigen	Legionella urinary antigen	Sputum cultures	Blood cultures	n
Positive [n/N (%)]	3/20 (15%)	0/17 (0%)	4/17 (23.5%)	4/27 (14.8%)	11/69 (16%)
<i>Streptococcus pneumoniae</i>	3			1	4
Alpha-haemolytic <i>Streptococcus</i>				1	1
<i>Streptococcus pyogenes</i>				1	1
<i>Pseudomonas aeruginosa</i>			1		1
<i>Haemophilus influenzae</i>			1		1
<i>Moraxella catarrhalis</i>			2		2
<i>Escherichia coli</i> <sup>a</sup>				1	1

<sup>a</sup> Although *E. coli* is not a typical cause of community-acquired pneumonia (CAP) and secondary bacteraemia, no other source of infection was identified. The patient had no pyuria or bacteriuria and no intra-abdominal focus was seen on computed tomography (CT) of the abdomen and pelvis. The presence of unilateral consolidation on presentation and symptoms of lower respiratory tract infection lead to the diagnosis of CAP.



**Table 5**  
Number of antibiotic prescription pre- and post-intervention.

Antibiotic	Pre-intervention	Post-intervention	Total
Clarithromycin	15	19	34
Amoxicillin	1	6	7
Amoxicillin/clavulanic acid	22	19	41
Piperacillin/tazobactam	7	1	8
Cefuroxime	4	3	7
Ceftriaxone	0	1	1
Gentamicin	3	0	3
Metronidazole	1	0	1
Levofloxacin	0	1	1

A significant reduction in the use of piperacillin/tazobactam and gentamicin was seen as well as an increase in the use of amoxicillin.

from a single patient who received i.v. therapy in the retrospective part of the audit to six patients in the prospective part, with four receiving oral amoxicillin and two i.v., one of whom had documented sepsis and another with a SIRS score of 2.

No difference was seen in the total duration of i.v. antibiotics [median 4 (IQR 2–4.5) days vs. 4 (IQR 2–5) days;  $P = 0.70$ ]. A difference was seen in total antibiotic duration pre-intervention versus post-intervention [median 9 (IQR 7–11) days vs. 7 (IQR 6.5–9) days;  $P = 0.01$ ].

The mean time to antibiotics in the prospective audit was 142 min. Kruskal–Wallis analysis showed a statistically significant association between time to antibiotics and CURB-65 score ( $P = 0.021$ ) (Fig. 2).

#### 4. Discussion

In this study, we observed an improvement in antimicrobial stewardship practices for patients with CAP in association with a combination of interventions that included an interactive teaching session, reminder cards, promotion of a prescribing app and addition of CURB-65 score to the admission proforma. Use of an educational session while improving access to guidelines using a pocket book has also been shown to significantly de-escalate antimicrobials and to decrease LOS in a cohort of post-operative patients in the Netherlands [17]. Learning using MARS is a rising and viable pedagogical technique in the undergraduate medical domain [18]. Audience response systems have extended into teaching in clinical practice in small studies with some positive impact [19,20].

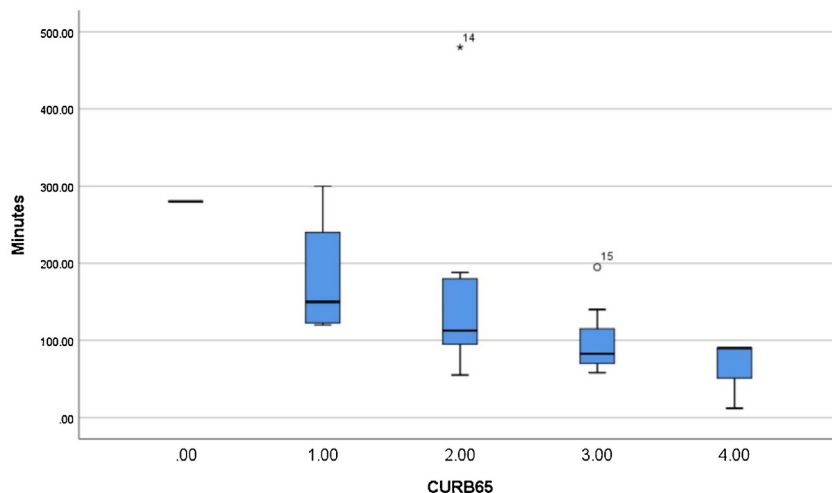
Other strategies within the bundle focused on increasing ease of access to the guidelines; the SHARx mobile app was promoted, which has recommendations on investigations, CURB-65 and

antimicrobials. The hardcopy card was designed to slide into a hospital card holder on a lanyard to give those that do not have a smartphone or choose not to use the app the same level of access to CAP guidelines when assessing CAP patients.

Our study showed that at baseline, hospital doctors had some understanding of antimicrobial choice for CURB-65 (60.0% medicine, 42.9% ED) but this was not reflected in antimicrobial choice in practice (21.6% compliance). Reasons for this may be manifold and give rise to questions about doctor's belief in effectiveness of scoring systems to dictate management of CAP, mismatches between perceived effectiveness of guideline-based treatment and perceived unwellness of their patients, or complex behavioural factors around prescribing antibiotics. Studies examining the behavioural practices of healthcare professionals around antibiotic prescribing have been done. Thematic analysis of qualitative interviewing of healthcare professionals has shown prescribing can be dominated by culture rules that dictate a 'prescribing etiquette'. In essence, senior decision-makers are more likely to prescribe based on personal experience than on policy, junior members are unlikely to challenge these decisions, and overall members within the group are less likely to interfere with antimicrobial decisions of their peers [21]. Effective antimicrobial stewardship quality improvement strategies should take these factors into consideration and adopt previously validated, evidence-based methods of behavioural and social sciences to implement behaviour change to foster true sustainability of stewardship strategies [22]. The recognition of the importance of this issue is gaining traction and an international working group of the Joint Programming Initiative on Antimicrobial Resistance (JPIAMR) has released a consensus paper defining key research areas where behavioural science can optimise antimicrobial stewardship programmes [23].

In this study, the most problematic areas were overprescription of amoxicillin/clavulanic acid where amoxicillin would have been adequate, and unnecessary use of gentamicin and the antipseudomonal penicillin combination TZP. This directly correlated with CURB-65 score. All four patients pre-intervention with a CURB-65 score of four received TZP (Table 6). High levels of TZP overuse have been described in another Irish study [6].

Documentation of CURB-65 was poor at just 5.4%, and low levels of investigations (18.9% pneumococcal urinary antigen, 18.9% sputum cultures) were also seen in the retrospective audit and have been described elsewhere [12,13]. In the prospective study, overall compliance increased to 62.5%. Although individual compliance with  $\beta$ -lactams and clarithromycin improved to higher percentages (70.0% and 76.0%, respectively), the combined



**Fig. 2.** Time to antibiotics relative to CURB-65 score in the prospective study. Kruskal–Wallis testing reached significance ( $P = 0.021$ ).

**Table 6**  
Individual  $\beta$ -lactam antimicrobial prescriptions pre- and post-intervention.

		Pre intervention				
GUIDELINE	CURB65	Amoxicillin	Co-amoxiclav	Piperacillin-tazobactam	Cefuroxime	Ceftriaxone
Amoxicillin	0		2			
Amoxicillin	1		5		1	
Amoxicillin	2	1	8	1	2	
Co-amoxiclav	3		7	2	1	
Co-amoxiclav	4			4		
		Post intervention				
GUIDELINE	CURB65	Amoxicillin	Co-amoxiclav	Piperacillin-tazobactam	Cefuroxime	Ceftriaxone
Amoxicillin	0		1			
Amoxicillin	1	2	1		2	
Amoxicillin	2	4	6	1		1
Co-amoxiclav	3		9			
Co-amoxiclav	4		2		1	

NOTE: Blue boxes indicate non-compliance with the guidelines. Ceftriaxone was used in one case with community-acquired pneumonia as a secondary diagnosis with intra-abdominal infection as the primary diagnosis; this was deemed appropriate in that setting. No other episodes had apparent underlying factors that accounted for deviation from guidelines.

Co-amoxiclav, amoxicillin/clavulanic acid; TZP, piperacillin/tazobactam.

compliance was necessary to qualify as a compliant episode (Table 3). Increasing compliance of antibiotics in CAP with care bundles has had mixed results. A national UK BTS audit improved compliance from 25% to 29.4% [24]. A smaller study implementing a bundle over 18 months had more success, with documentation of CURB-65 increasing from 32% to 94% and antibiotic prescribing improving from 48% to 87%. High levels of success were attributed to the perseverance of the multidisciplinary team who had weekly meetings and used a weekly compliance surveillance tool [25]. Areas of improvement in our bundle were the near elimination of TZP from use except for one dose in the ED, elimination of gentamicin, and a rise in use of amoxicillin for CURB-65 score of 0–2, although this remained the single largest problem area with eight patients in the prospective group receiving amoxicillin/clavulanic acid in place of amoxicillin for a CURB-65 of 0–2 (Table 6).

No impact on duration of i.v. antibiotics was seen (median 4 days vs. 4 days), which may reflect the ongoing necessity for i.v. antibiotics in the early phase of treatment in both groups, as 49.3% of patients had markers for sepsis (SIRS  $\geq 2$ ). A decrease in total antibiotic duration was seen owing to shortened periods of oral antibiotics both in hospital and prescribed at discharge (median total antibiotics duration 9 days vs. 7 days;  $P = 0.01$ ) (Table 3).

An organism was identified in 15.9% of patients. CAP has traditionally been poorly differentiated in terms of causative organism [26]. As PCR of respiratory samples was not performed, the profile of organisms identified in the study is unlikely to be fully representative of causes of CAP. *Streptococcus pneumoniae* was the most common organism identified, which is unsurprising as it is the single most prevalent bacterial pathogen representing 17.7% of all CAP internationally [27]. Gram-negative organisms (*Pseudomonas aeruginosa*, *Haemophilus influenzae*, *Moraxella catarrhalis* and *Escherichia coli*) were the largest group identified (Table 4). As a significant proportion of patients had chronic respiratory diagnoses, cognisance of the profile of possible organisms that can cause pneumonia in this patient group is important to direct therapy should initial CAP therapy fail, which has been described elsewhere [28].

Time to antibiotics in the prospective study showed a significant reduction in time for each CURB-65 score; as <50% of

CURB-65 scores were documented, and less so for SIRS and sepsis, time to antibiotics was likely driven by identification of these markers without their documentation (Fig. 2).

This study has significant limitations. Sample size is small given the frequency of presentation of unscheduled CAP admissions. Seasonality influences the rate of CAP hospitalisations, with more admissions occurring during the winter season [29,30]. Although both retrospective and prospective parts of the study were outside of the winter season, they were not at the same time of year (August/September for retrospective versus May/June for prospective). Consultants and registrars were the same throughout both periods, but more junior firm members, interns and senior house officers, which may have been different due to the rotation cycles of trainees. The prospective audit was performed just after the April 'changeover' so all NCHDs in the hospital would be the same for the duration of the prospective period. Also, having only two time points of assessment, i.e. before and after the interventional teaching session, means confounders may be present and it is difficult to confirm to what extent the improvements were due to the intervention bundle. Assessment on a continuous basis, as seen with quality improvement design, would have aided in differentiating the relative advantages from the individual aspects of the bundle. It would also have indicated the sustainability of the intervention bundle.

As mentioned in the methodology section, local guidelines at SUH are in line with BTS CAP guidelines first published in 2010 [14]. With the release of the National Institute for Health and Care Excellence (NICE) CAP guidelines in 2014, the BTS released annotated guidelines mostly highlighting high levels of overlap between NICE and BTS, including the use of amoxicillin for low-severity pneumonia, amoxicillin plus a macrolide for moderate severity, and a  $\beta$ -lactam/ $\beta$ -lactamase inhibitor plus a macrolide for patients with severe disease (all in patients without penicillin hypersensitivity) [31]. Antimicrobial choice for CAP has not changed significantly over time. One reason for this is the modest increase in antimicrobial resistance of common CAP organisms. The SENTRY Antimicrobial Surveillance Program identified 19 123 isolates of *S. pneumoniae* in Europe between 1997–2016 and found isolates were generally susceptible to penicillins and had a small rise in resistance over that timeframe [32]. Similarly, invasive pneumococcal disease) with

penicillin-non-susceptibility in the UK reported to the European Centre of Disease Control (ECDC) in 2010 was 3.1% [95% confidence interval (CI) 2–4%] but rose to 5.6% (95% CI 5.6%) by 2018 [33,34]. In essence, CAP guidelines have not needed to change significantly.

In the context of the current coronavirus disease 2019 (COVID-19) pandemic, the cause of infection in patients presenting to EDs with acute respiratory illnesses is obscured. Management of these patients can be more difficult to navigate for physicians as CAP and COVID-19 have many of the same features, such as cough, fever, hypoxia, infiltrates on chest radiography and raised CRP. Commencing antimicrobials can be the reflex action and clinical cohorts of hospitalised COVID-19 patients show antimicrobial use can be as high as 95% [35]. Recently, NICE published guidelines for antimicrobial prescribing of CAP during the COVID-19 pandemic and offer guidance on investigations to differentiate bacterial pneumonia and COVID-19 [36]. Amoxicillin/clavulanic acid, doxycycline and levofloxacin are first-line antimicrobials for moderate to severe disease as per these guidelines. The authors of this manuscript caution the use of antimicrobials and recommend continuously reviewing the decision to continue antibiotics in patients who have COVID-19. Huttner et al. offer guidance on this issue, recommending antibiotics only in severely unwell patients with hypoxia with a diagnosis of COVID-19 [37].

## 5. Conclusion

In this study, we have shown that a simple, low-cost intervention bundle using a MARS and improving ease of access to CAP guidelines is associated with a significant improvement in antimicrobial stewardship

tions, correct antibiotic choice and reduction in total length of antibiotics was seen. There was no impact on hospital LOS, duration of i.v. antibiotics or mortality. Elements of this intervention bundle should be considered in larger, better-resourced quality improvement strategies for the management of CAP.

## Funding

None.

## Conflict of interests

None declared.

## Ethical approval

Ethical approval was not sought as this study was performed in audit format and used standard clinical data. The audit was registered with the local Clinical Audit Office in Sligo University Hospital (SUH) and was in line with local clinical audit and data protection requirements.

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## Appendix A

Community Acquired Pneumonia Management			
CURB65: Confusion ①, Urea >7mmol/L ①, Resp Rate>30 ①, SBP<90 or DBP<60 ①, Age >65 ①			
Investigations: Streptococcal urinary antigen, Legionella urinary antigen, Sputum C/S			
Respiratory sepsis: ≥2 SIRS Criteria: Temp >38/<36C ①, HR>90 ①, RR>20 or PaCO2 <4.3kPa ①, WCC >12/<4 x10 <sup>9</sup> /L ①			
Add: Blood c/s, lactate, sepsis form			
CURB65	1 <sup>st</sup> line	Non-type 1 hypersensitivity reaction to penicillin	Type 1 hypersensitivity reaction to penicillin
0-1	AMOXICILLIN PO 1g TDS	CLARITHROMYCIN PO 500mg BD	CLARITHROMYCIN PO 500mg BD
2	AMOXICILLIN PO/IV 1g TDS + CLARITHROMYCIN 500mg BD (IV if NPO)	CEFUROXIME PO 500mg BD or 1.5g TDS IV + CLARITHROMYCIN 500mg BD (IV if NPO)	CLARITHROMYCIN 500mg BD (IV if NPO) or DOXYCYCLINE 200mg OD
3	CO-AMOXICLAV 1.2g IV TDS + CLARITHROMYCIN 500mg BD	CEFUROXIME 1.5g TDS IV + CLARITHROMYCIN 500mg BD (IV if NPO)	Microbiology advice (Vancomycin/Quinolone/aztreon am)



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