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Development of a Real Time Electronic Algorithm to Identify Hospitalized Patients with Community-Acquired Pneumonia (CAP)

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BACKGROUND

- Community-acquired pneumonia (CAP) is a major driver of antibiotic use in US hospitals[1].
- Interventions to improve antibiotic use in CAP have been successful; however, large-scale implementation of these interventions can be limited by difficulty in finding cases for evaluation.

OBJECTIVE

To develop an electronic extraction algorithm to prospectively identify patients with CAP.

METHODS

- **Patient population:** adults admitted to The Johns Hopkins Hospital from 12/2018 to 3/2019 who received CAP antibiotics for ≥48 hours and had a bacterial urinary antigen and chest imaging ordered within 48 hours of admission.
- **Exclusion criteria**: neutropenic patients, chest imaging to evaluate position of endotracheal tube or central line.
- **Data collection & definitions**: Charts were manually reviewed by 2 investigators to identify true cases of CAP (**Table 1**).
  - CAP was defined based on IDSA guidelines[2]
  - CAP antibiotics included: azithromycin or doxy+amp/sulbactam, cefdinir, ceftriaxone, cefepime, vanc+aztreonam, OR moxifloxacin
- **Development of an electronic algorithm:**
  - We explored potential indicators of CAP which included both objective data (vitals signs and laboratory data) as well as free text extracted via natural language processing (NLP) (**Table 2**) using cases identified in 12/2018 (n=111).
  - We evaluated combinations of indicators that identified patients treated for CAP who did have CAP (true CAP) and did not have CAP (false CAP) (Figure) using cases identified 1-3/2019 (n=173).
- **Statistical analysis:** The 1-3/2019 cohort was further divided in a training and a validation set (2/3 and 1/3, respectively). Predictive performance of composite indicators for true CAP were assessed using receiver-operating characteristics (ROC) curves. An AUC value of 0.5 indicates no discriminative ability and an AUC >0.8 indicates good to excellent prediction. The Hosmer-Lemeshow goodness fit test was used to test model fit and the Akaike Information Criteria to determine model selection.

RESULTS

True CAP was observed in 41% (71/173) of cases. Cohort characteristics between patients with true CAP and false CAP are shown in **Table 1** below.

	All Patients N=173	No CAP N= 102 (59%)	CAP N= 71 (41%)	P value
Male, n (%)	96 (55.5)	54 (52.9)	42 (59.2)	0.41
Age, median (IQR)	58 (46-67)	58 (41-67)	58 (48-67)	0.38
Fever, n (%)	61 (35.3)	29 (28.4)	32 (45.1)	0.02
Hypothermia, n (%)	84 (48.6)	48 (47.1)	36 (50.7)	0.63
Fever or Chills, n (%)	8 (4.6)	4 (3.9)	4 (5.6)	0.59
Tachypnea, n (%)	95 (54.9)	48 (47.1)	47 (66.2)	0.01
Hypoxemia, n (%)	121 (69.9)	67 (65.7)	54 (76.1)	0.14
Leukocytosis, n (%)	84 (48.6)	45 (44.1)	39 (54.9)	0.16
Leukopenia, n (%)	19 (11.0)	10 (9.8)	9 (12.7)	0.55
Pro-BNP normal, n (%)	109 (63.0)	71 (69.6)	38 (53.5)	0.03
Bacterial urine antigen, sputum or blood culture positive, n (%)	40 (23.1)	21 (20.6)	19 (26.8)	0.34
Consolidation, n (%)	73 (42.2)	16 (15.7)	57 (80.3)	<0.01
Infiltrate, n (%)	10 (5.8)	4 (3.9)	6 (8.5)	0.20
CXR Consolidation, n (%)	28 (16.2)	5 (4.9)	23 (32.4)	<0.01
CT Consolidation, n (%)	48 (27.8)	10 (9.8)	38 (53.5)	<0.01

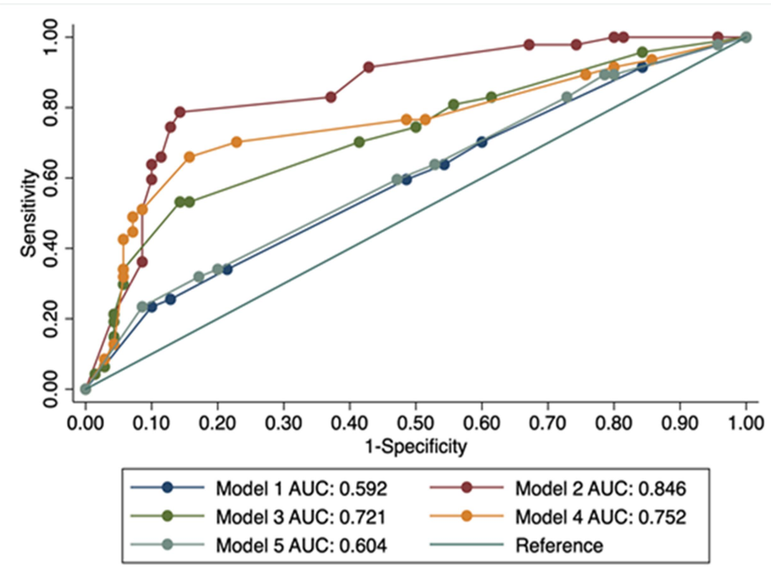
Table 2: CAP indicators

Free-text indicators	Vital signs indicators	Laboratory indicators
• Chief complaint of fever or chills • Radiographic report of consolidation • Radiographic report of infiltrate	• Temperature ≥38°C • Temperature ≤36°C • Respiratory rate ≥24r/min • Supplemental O_2 • Oxygen saturation <92%	• WBC >12,000 cells/mm^3 • WBC <4,000 cells/mm^3 • ProBNP=0-125pg/ml • *S. pneumoniae* or *L. pneumophila* urinary antigen • Sputum or blood culture positive for respiratory pathogen

These indicators were combined to make 45 potential composite indicators. ROC curves for selected composite indicators are shown in the **Figure**.

RESULTS, *continued*

Figure: ROC curves for composite indicators to identify CAP cases



- Selected models
  - Model 1 (No NLP): Temp. ≥38°C, hypoxemia (supplemental O2 or oxygen saturation <92%), WBC >12,000 cells/mm3.
  - **Model 2: model 1 plus "consolidation" on CXR or CT.**
  - Model 3: model 1 plus "consolidation" on CXR only.
  - Model 4: model 1 plus "consolidation" on CT only.
  - Model 5: model 1 plus "infiltrate" on CT.
- The best fitting model (Model 2) included fever, hypoxemia, leukocytosis, and "consolidation" on imaging with a positive predictive value 78.7% and a negative predictive value of 85.7%.

CONCLUSIONS & LIMITATIONS

- Patients with CAP can be identified using electronic data, use of NLP-derived radiographic criteria improves case-finding. These data can be linked with data on antibiotic use and duration to develop reports for clinicians regarding appropriate CAP diagnosis and treatment.
- The tool may not be generalizable to hospitals where bacterial urinary antigen is not ordered routinely.

References: 1) Baggs J, Fridkin SK, Pollack LA, Srinivasan A, Jernigan JA. Estimating National Trends in Inpatient Antibiotic Use Among US Hospitals From 2006 to 2012. *JAMA Intern Med.* 2016;176(11):1639–1648. doi:10.1001/jamainternmed.2016.5651, 2) Diagnosis and Treatment of Adults with Community-acquired Pneumonia. An Official Clinical Practice Guideline of the American Thoracic Society and Infectious Diseases Society of America. American Journal of Respiratory and Critical Care Medicine 2019.