DATA SUPPLEMENT 1: Algorithm Scoring Criteria

1. Health care-associated pneumonia (HCAP) criteria[1]

The American Thoracic Society (ATS)/ Infectious Diseases Society of American (IDSA) pneumonia guidelines define HCAP as pneumonia in the presence of at least one of the six characteristics listed in Table 1.[1] Patients with at least one of these criteria meet the HCAP definition and are considered high-risk for resistant bacteria. The HCAP criteria were developed by expert interpretation of the literature by the IDSA/ATS pneumonia guideline committee.[1]

Table 1. Criteria for healthcare-associated pneumonia (HCAP) definition

1. Hospitalization for ≥ 2 days in preceding 90 days
2. Residence in a nursing home or extended care facility
3. Home infusion therapy (including antibiotics and chemotherapy) within 30 days
4. Chronic dialysis within 30 days
5. Home wound care within 30 days
6. Family member with multidrug resistant pathogen

2. Summit Criteria[2]

Kollef et al.[2] published a summary of the 2008 HCAP Summit, a meeting of pneumonia opinion leaders who evaluated and discussed the diagnosis and treatment of HCAP. Participants of the HCAP Summit suggested pneumonia patients who meet ≥ 2 of the following three criteria should be considered high-risk for resistant bacteria: severe illness, prior antibiotic therapy, and poor baseline functional status. A precise definition for each criterion was not provided in the original publication of this algorithm. Definitions for each criterion used in the current study are listed in Table 2.

Table 2. Definitions for Summit Criteria	
Variable	Definition
Severe illness	Variable fulfilled by either of the following: - ≥ 1 ATS major criterion for severe pneumonia in the ED, including: intubation; or vasopressor use[3] - ≥ 3 ATS minor criteria for severe pneumonia in the ED, including: respiratory rate ≥ 30; PaO_2 / FiO_2 ratio ≤ 250; multilobar infiltrates on chest x-ray or CT scan; confusion/disorientation; BUN ≥ 20 mg/dL; WBC < 4,000 cells/mm^3; platelet count < 100,000 cells/ mm^3; triage body temperature < 96.8ºF; or triage systolic blood pressure < 90 mm Hg[3]
Prior antibiotic therapy	Variable fulfilled by: - Systemic antibiotic use in the 90 days prior to ED presentation.
Poor baseline functional status	Variable fulfilled by: - Patient does not independently complete all domains of activities of daily living as defined by Katz et al.[4]: feeding; continence; transferring; going to toilet; dressing; bathing.

ATS = American Thoracic Society; PO_2, FiO_2, CT = computed tomography; BUN = blood urea nitrogen; WBC = white blood cell count

3. Brito and Niederman Strategy[5]

Brito and Niederman[5] devised a strategy for subdividing patients meeting the HCAP definition into those with high risk of resistant bacteria (similar to hospital-acquired pneumonia) and those with low risk of resistant bacteria (similar to community-acquired pneumonia). This strategy was developed based on expert interpretation of pneumonia literature published from 2004 to 2008, representing the five years following adoption of the HCAP concept by the ATS/IDSA pneumonia management guidelines.[5] It was designed to improve the specificity of the HCAP criteria by classifying more patients as low-risk for resistant bacteria. Patients without any HCAP

criteria are considered low-risk for resistant bacteria. Patients meeting the HCAP definition are further classified as high- or low-risk for resistant bacteria. Patients fulfilling both the HCAP definition and two or more of the following five criteria are considered high-risk: 1) severe illness leading to intensive care unit (ICU) admission or mechanical ventilation, 2) immune suppression, 3) hospitalization within the past 90 days, 4) poor functional status, and 5) antibiotic therapy within the past six months. HCAP patients not fulfilling at least two of these criteria are considered low-risk for resistant bacteria.[5] Maruyama et al.[6] recently used the Brito and Niederman strategy to select antibiotics in a prospective therapeutic study of 445 pneumonia patients in six Japanese hospitals.

In the original description of the Brito and Niederman strategy, [5] specific definitions for immune suppression and poor function status were not outlined. In the current study, we classified a patient as immunosuppressed if any of the following were present: active hematologic malignancy, active solid organ malignancy, organ transplantation, stem cell transplantation, immunosuppressive medications, chronic steroids at dose equivalent to prednisone > 25 mg/day for > 10 days, active chemotherapy, active radiotherapy, splenectomy, HIV infection, autoimmune disease. In the current study, we classified patients as having poor functional status if they were unable to independently perform any of the six activities of daily living defined by Katz et al.[4]: feeding, continence, transferring, going to toilet, dressing, bathing. This definition of functional status is similar to the definition used by El Solh et al.,[7] who found poor functional status to be an independent risk factor for infection with resistant bacteria. Maruyama et al.[6] used a slightly different classification system for functional status based on the Barthel Index.[8]

The criteria we used for the Brito and Niederman strategy are summarized in Table 3. Patients were classified as high risk for resistant bacteria if they met ≥ 1 HCAP criterion and ≥ 2 of these additional criteria listed in Table 3.

Table 3. Criteria used for the Brito and Niederman Strategy.

1. Intensive care unit admission or mechanical ventilation
2. Immunosuppression
3. Hospitalization for ≥ 2 days in the past 90 days
4. Systemic antibiotic therapy in the prior 6 month
5. Inability to perform ≥ 1 of the following independently: feeding, continence, transferring, going to toilet, dressing, bathing

4. Shorr Model[9,10]

Shorr et al. derived[9] and externally evaluated[10] a clinical prediction model for resistant bacteria in pneumonia patients who presented to an ED in St Louis, Missouri. These studies were limited to pneumonia patients with proven bacterial etiologies based on positive culture or urinary antigen testing, not all patients presenting from the community with pneumonia as in the current study. The scoring system for the Shorr model is outlined in Table 4, with scores ≥ 1 denoting high risk for resistant bacteria.

Table 4. Scoring system for Shorr Model

Variable	**Points**
Hospitalization for ≥ 2 days in preceding 90 days	4
Presentation from a long term care facility	3
Chronic hemodialysis	2
Intensive care unit admission within 24 hours of ED evaluation	1
Total score = sum of points	

5. Aliberti Model[11]

Aliberti et al. developed a clinical prediction model to estimate the risk of resistant bacteria in 935 adult pneumonia patients presenting from the community and hospitalized at a single center in Milan, Italy. Similar to the current study, the population used for the Aliberti model derivation included pneumonia patients with an identified pathogen and those with unknown etiology (i.e. culture-negative pneumonia). Scoring criteria for the Aliberti model is shown in Table 5. Scores ≥ 3 are classified as high risk for resistant bacteria.

Table 5. Scoring system for Aliberti Risk Score.

Variable	Points
≥ 1 of the following: cerebrovascular disease, diabetes, COPD, antimicrobial therapy in preceding 90 days, immunosuppression, home wound care, home infusion therapy (including antibiotics)	0.5
Residence in a nursing home or extended-care facility	3
Hospitalization for ≥ 2 days in the preceding 90 days	4
Chronic renal failure (not limited to patients on hemodialysis)	5
Total score = sum of points	

6. Shindo Model[12]

Shindo et al. developed a clinical prediction model for resistant bacteria among patients hospitalized with pneumonia at 10 Japanese hospitals. Similar to the current study, Shindo et al.[12] evaluated pneumonia patients with established pathogens and those with unknown etiology. They found six independent predictors of resistant bacteria. Each of these criteria had approximately the same odds ratio associated with resistant bacteria; therefore, the model consists of simply counting the number of criterion present without different weighting for each criterion. The Shindo model criteria are listed in Table 6. In the current study, we used the same definition for

immunosuppression for both the Shindo model and Brito and Niederman strategy; patients were considered immunosuppressed if they met any of the following: active hematologic malignancy, active solid organ malignancy, organ transplantation, stem cell transplantation, immunosuppressive medications, chronic steroids at dose equivalent to prednisone > 25 mg/day for > 10 days, active chemotherapy, active radiotherapy, splenectomy, HIV infection, autoimmune disease.

In the simplest Shindo model, patients with ≥ 3 Shindo criteria are classified as high-risk for resistant bacteria, including resistant gram negative bacteria and methicillin-resistant *Staphylococcus aureus* (MRSA).

Table 6. Shindo Model Criteria

1. Hospitalization for ≥ 2 days in preceding 90 days
2. Immunosuppression
3. Systemic antibiotic use in the prior 90 days
4. Gastric acid suppressive agents (proton pump inhibitors, H2 blockers)
5. Tube feeding
6. Non-ambulatory status

Shindo et al.[12] also described a two-step algorithm that separately considered resistant gram negative bacteria and MRSA. In this algorithm, patients with ≥ 3 Shindo criteria were considered high-risk for all resistant bacteria (resistant gram negative bacteria and MRSA). Additionally, patients with two Shindo criteria plus ≥ 1 MRSA-specific risk factor were considered high-risk for MRSA, but not resistant gram negative bacteria.[12,13] The MRSA-specific Shindo risk factors are listed in Table 7.

Table 7. MRSA-specific Shindo risk factors
1. Chronic hemodialysis 2. Positive MRSA history (history of a positive culture for MRSA in the past) 3. Congestive heart failure

MRSA = Methicillin-resistant Staphylococcus aureus

References

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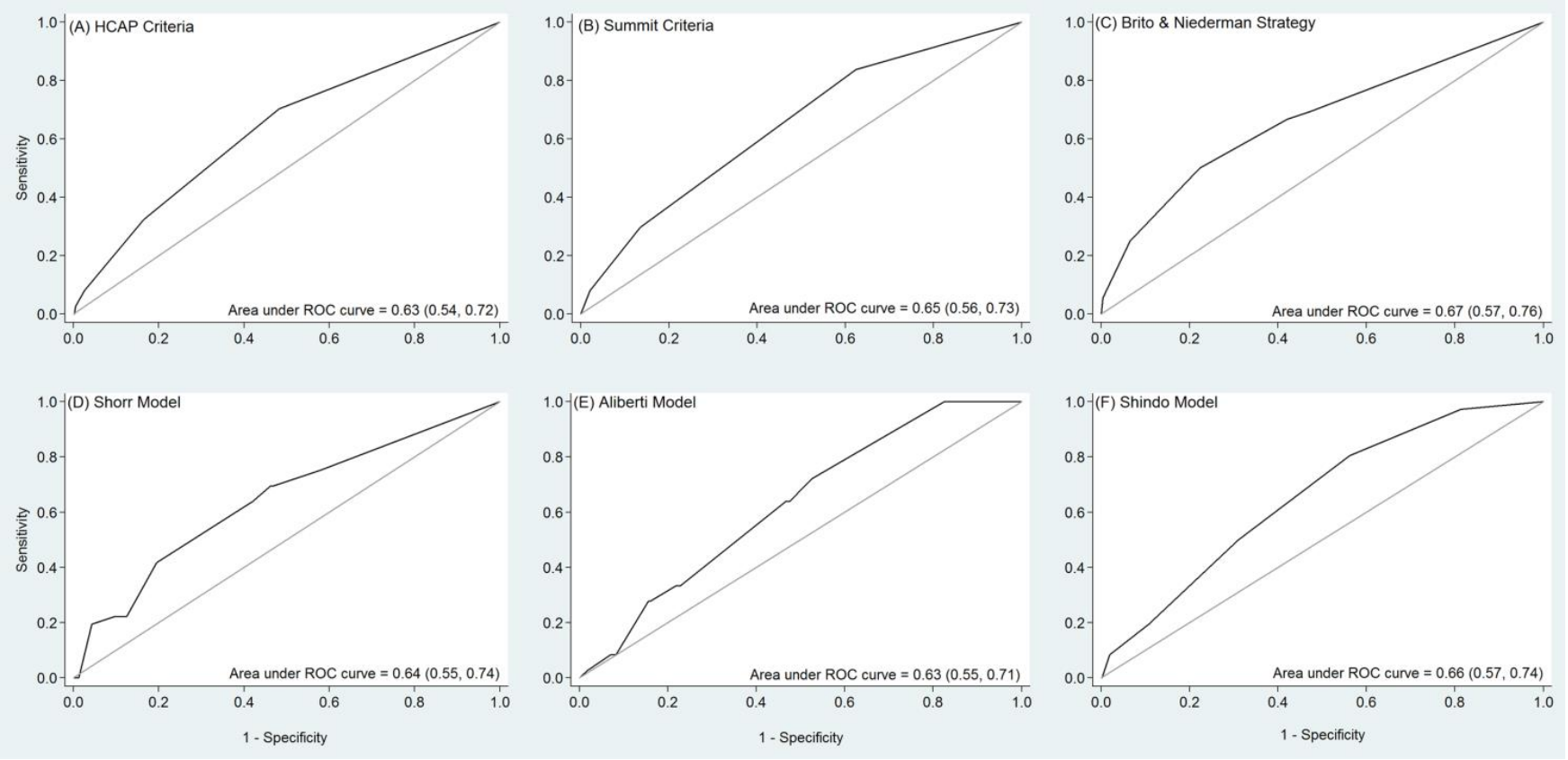
12. Shindo Y, Ryota I, Kobayashi D, et al. Risk factors for drug-resistant pathogens in community-acquired and healthcare-associated pneumonia. Am J Respir Crit Care Med 2013;188:985-95.
13. Wunderink RG. Community-acquired pneumonia versus healthcare-associated pneumonia: the returning pendulum. Am J Respir Crit Care Med 2013;188:896-8.

DATA SUPPLEMENT 2: Receiver operating characteristic (ROC) curves for six algorithms designed to identify community-onset pneumonia patients with resistant bacteria: (A) HCAP criteria,[1] (B) Summit criteria,[2] (C) Brito & Niederman strategy,[3] (D) Shorr model,[4,5] (E) Aliberti model,[6] (F) Shindo model.[7] Area under the ROC curve (95% confidence interval) is reported within each plot.



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DATA SUPPLEMENT 3: Cross-tabulation of resistant bacteria detected and results of the two-step Shindo algorithm using MRSA-specific risk factors.[1,2] Patients who would be treated with antibiotics not active against detected bacteria using this algorithm are denoted with shaded cells.

	No Resistant Bacteria Detected	MRSA Detected	Resistant Gram Negative Bacteria Detected	**Total**
Traditional CAP antibiotics (0-1 Shindo criteria, or 2 Shindo criteria and no MRSA risk factors)	353	5	7	**365**
Traditional CAP + MRSA antibiotics (2 Shindo criteria and MRSA risk factor)	46	3	3	**52**
Broad spectrum antibiotics against resistant gram negative bacteria and MRSA (≥ 3 Shindo criteria)	179	7	11	**197**
Total	**578**	**15**	**21**	**614**

References

1. Shindo Y, Ryota I, Kobayashi D, et al. Risk factors for drug-resistant pathogens in community-acquired and healthcare-associated pneumonia. Am J Respir Crit Care Med 2013;188:985-95.
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