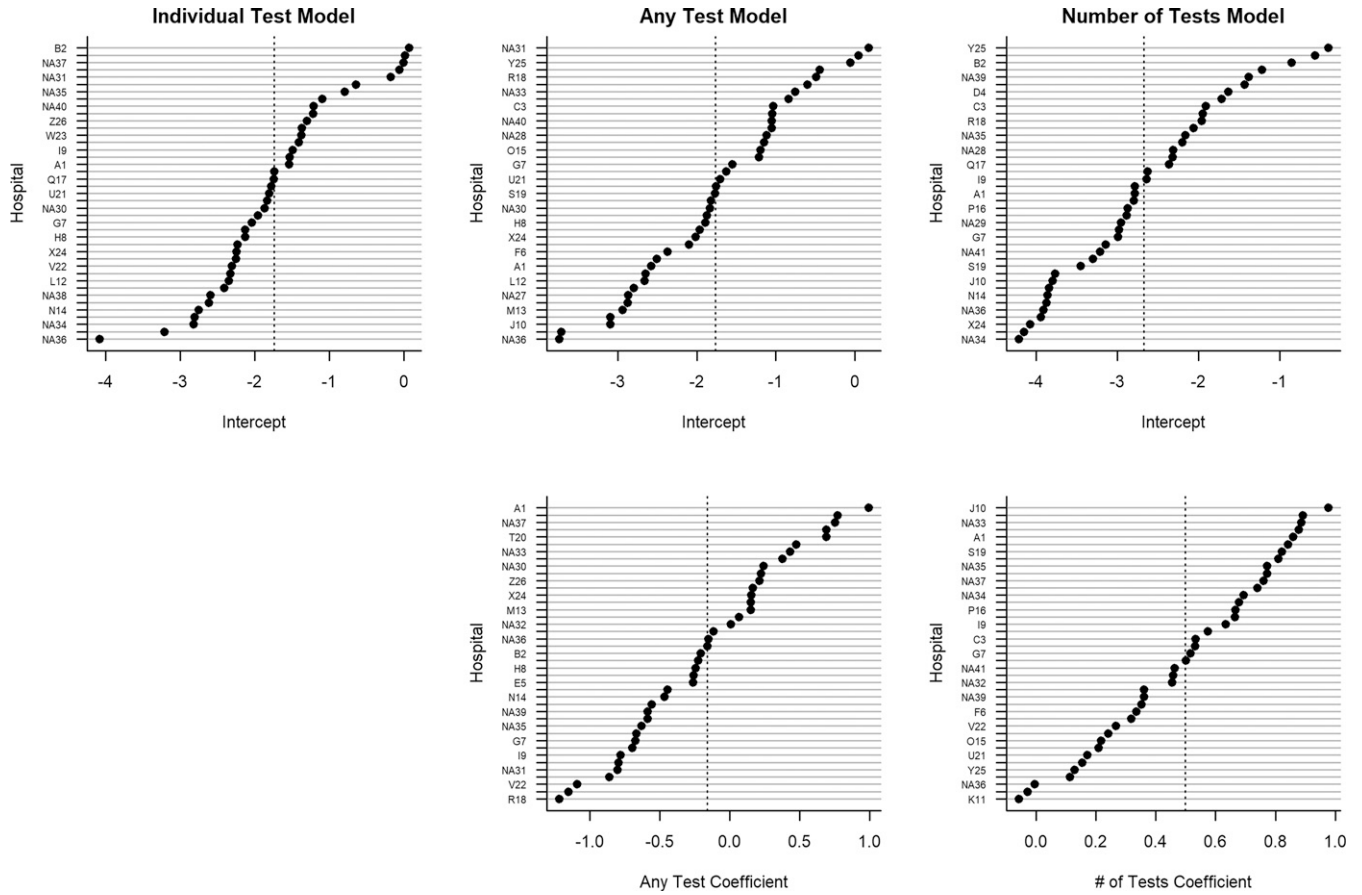


## Supplemental Information



**SUPPLEMENTAL FIGURE 4** Variation in random effects across the 3 studied models. Each hospital is represented along the y-axis as a random alphanumeric code. Estimated fixed effects are the vertical dotted lines. The any test model had random intercepts (top center plot) and a random coefficient for the binary any test covariate (bottom center plot). The “number of tests” model had random intercepts (top right plot) and a random coefficient for the number of tests covariate (bottom right plot).

**SUPPLEMENTAL TABLE 4** International Classification of Disease, 10th Revision Definitions

Code	Explanation
Community acquired pneumonia <sup>a</sup>	
A37.01	Whooping cough due to <i>Bordetella pertussis</i> with pneumonia
A37.11	Whooping cough due to <i>Bordetella parapertussis</i> with pneumonia
A37.81	Whooping cough due to other <i>Bordetella</i> species with pneumonia
A37.91	Whooping cough, unspecified species with pneumonia
J10.00	Influenza due to other identified influenza virus with unspecified type of pneumonia
J10.01	Influenza due to other identified influenza virus with the same other identified influenza virus pneumonia
J10.08	Influenza due to other identified influenza virus with other specified pneumonia
J11.00	Influenza due to unidentified influenza virus with unspecified type of pneumonia
J11.08	Influenza due to unidentified influenza virus with specified pneumonia
J12.0	Adenoviral pneumonia
J12.1	Respiratory syncytial virus pneumonia
J12.2	Parainfluenza virus pneumonia
J12.3	Human metapneumovirus pneumonia
J12.89	Other viral pneumonia
J12.9	Viral pneumonia, unspecified
J13	Pneumonia due to <i>Streptococcus pneumoniae</i>
J15.0	Pneumonia due to <i>Klebsiella pneumoniae</i>
J15.211	Pneumonia due to Methicillin susceptible <i>Staphylococcus aureus</i>
J15.212	Pneumonia due to Methicillin resistant <i>Staphylococcus aureus</i>
J15.4	Pneumonia due to other streptococci
J15.6	Pneumonia due to other aerobic Gram-negative bacteria
J15.8	Pneumonia due to other specified bacteria
J15.9	Unspecified bacterial pneumonia
J16.8	Pneumonia due to other specified infectious organisms
J18.0	Bronchopneumonia, unspecified organism
J18.1	Lobar pneumonia, unspecified organism
J18.8	Other pneumonia, unspecified organism
J18.9	Pneumonia, unspecified organism
Complicated pneumonia	
J90	Pleural effusion, not elsewhere classified
J85	Abscess of lung with pneumonia
J86	Pyothorax
J91.0	Malignant pleural effusion
J91.8	Pleural effusion in other conditions classified elsewhere
J94.1	Fibrothorax
J94.2	Hemothorax
J94.8	Other specified pleural conditions
J94.9	Pleural condition, unspecified
J96.00	Acute respiratory failure, unspecified whether with hypoxia or hypercapnia
J96.90	Respiratory failure, unspecified, unspecified whether with hypoxia or hypercapnia
R09.1	Pleurisy
R09.2	Respiratory arrest
R78.81	Bacteremia
SIRS or sepsis	
A02.1	<i>Salmonella</i> sepsis
A20.7	Septicemic plague

SUPPLEMENTAL TABLE 4 Continued

Code	Explanation
A21.7	Generalized tularemia
A22.7	Anthrax sepsis
A24.1	Acute and fulminating melioidosis (melioidosis sepsis)
A26.7	Erysipelothrix sepsis
A32.7	Listerial sepsis
A39.2	Acute meningococemia
A39.3	Chronic meningococemia
A39.4	Meningococemia, unspecified
A40.0	Sepsis due to <i>Streptococcus</i> , group A
A40.1	Sepsis due to <i>Streptococcus</i> , group B
A40.3	Sepsis due to <i>Streptococcus pneumoniae</i>
A40.8	Other streptococcal sepsis
A40.9	Streptococcal sepsis, unspecified
A41.01	Sepsis due to Methicillin susceptible <i>Staphylococcus aureus</i>
A41.02	Sepsis due to Methicillin resistant <i>Staphylococcus aureus</i>
A41.1	Sepsis due to other specified <i>Staphylococcus</i>
A41.2	Sepsis due to unspecified <i>Staphylococcus</i>
A41.3	Sepsis due to <i>Hemophilus influenzae</i>
A41.4	Sepsis due to anaerobes
A41.50	Gram-negative sepsis, unspecified
A41.51	Sepsis due to <i>Escherichia coli</i> [ <i>E. coli</i> ]
A41.9	Sepsis, unspecified organism
A418.9	Other specified sepsis
R65.10	SIRS of noninfectious origin without acute organ dysfunction.
R65.11	SIRS of noninfectious origin (without organ dysfunction)
Severe sepsis	
R65.20	Severe sepsis without septic shock
R65.21	Severe sepsis with septic shock

SIRS, systemic inflammatory response syndrome.

<sup>a</sup> Derived from ICD-9 codes for community-acquired pneumonia described in Williams, et al.<sup>30</sup>

**SUPPLEMENTAL TABLE 5** Definitions Used for Interventions. Codes Are Either International Classification of Disease, 10<sup>th</sup> Revision Clinical Modification Diagnosis or Procedure Codes, or Clinical Transaction Classification Codes Used by the Children's Hospital Association.

Code	Type of code	Explanation
Chest drainage		
0B9	ICD-10-CM	Drainage of respiratory system
0H95	ICD-10-CM	Drainage of chest skin
0J96	ICD-10-CM	Drainage of subcutaneous tissue and fascia of chest
0W98	ICD-10-CM	Drainage of chest wall
0W99	ICD-10-CM	Drainage of pleural cavity, right
0W9B	ICD-10-CM	Drainage of pleural cavity, left
0W9C	ICD-10-CM	Drainage of mediastinum
0W9D	ICD-10-CM	Drainage of pericardium
Oxygen		
521171	CTC	Oxygen therapy
Intravenous fluids		
146461	CTC	Dextrose and electrolytes
146000	CTC	Electrolyte and replenishment agents unspecified
146040	CTC	Hyperalimentation solutions unspecified
146435	CTC	Multiple electrolyte solutions
146451	CTC	Dextrose and sodium chloride
146218	CTC	Sodium chloride
146441	CTC	Sodium chloride and potassium chloride
146041	CTC	Hyperalimentation solution and electrolyte combinations
Antibiotics		
121225	CTC	Ampicillin (anhydrous) (sodium) (trihydrate)
122231	CTC	Ceftriaxone sodium
121231	CTC	Ampicillin sodium and sulbactam sodium
122421	CTC	Azithromycin (dihydrate)
122211	CTC	Cefotaxime sodium
124143	CTC	Clindamycin (HCl) (palmitate) (phosphate)
124133	CTC	Vancomycin (HCl)
124164	CTC	Metronidazole (HCl)
123215	CTC	Levofloxacin
122252	CTC	Cefepime HCl
122221	CTC	Ceftazidime
121265	CTC	Piperacillin sodium and tazobactam sodium
121105	CTC	Gentamicin (sulfate)
121135	CTC	Tobramycin sulfate
122177	CTC	Cefuroxime (axetil) (sodium)
124118	CTC	Meropenem
123115	CTC	Doxycycline (calcium) (hyclate) (monohydrate)
123131	CTC	Minocycline (HCl)
121101	CTC	Amikacin sulfate
123201	CTC	Ciprofloxacin (HCl)
124451	CTC	Sulfamethoxazole and trimethoprim (cotrimoxazole)
121217	CTC	Amoxicillin trihydrate
125303	CTC	Posaconazole

SUPPLEMENTAL TABLE 5 Continued

Code	Type of code	Explanation
121221	CTC	Amoxicillin trihydrate and potassium clavulanate
122202	CTC	Cefdinir
122271	CTC	Ceftaroline fosamil
124147	CTC	Colistimethate sodium
124137	CTC	Linezolid
124169	CTC	Rifaximin
122217	CTC	Cefpodoxime proxetil
122401	CTC	Erythromycin
126105	CTC	Hydroxychloroquine sulfate
121215	CTC	Penicillin V potassium
126221	CTC	Isoniazid (INH) (isonicotinic acid hydrazide)
122173	CTC	Cefprozil (anhydrous)
122115	CTC	Cephalexin (HCl) (monohydrate)
122207	CTC	Cefixime
122425	CTC	Clarithromycin
121247	CTC	Nafcillin sodium
122275	CTC	Ceftazidime and avibactam
125225	CTC	Fluconazole
129121	CTC	Pentamidine isethionate
122109	CTC	Cefazolin sodium
129105	CTC	Dapsone (DDS)
125215	CTC	Caspofungin acetate
126245	CTC	Rifampin
123225	CTC	Moxifloxacin HCl
125216	CTC	Micafungin sodium
121251	CTC	Oxacillin sodium
122171	CTC	Cefoxitin sodium
126211	CTC	Ethambutol HCl
126235	CTC	Pyrazinamide
129111	CTC	Atovaquone
121115	CTC	Neomycin sulfate
124405	CTC	Sulfadiazine
125217	CTC	Voriconazole
121201	CTC	Penicillin G (aqueous) (potassium) (sodium)
125201	CTC	Amphotericin B
124121	CTC	Aztreonam
124138	CTC	Tedizolid phosphate
129117	CTC	Nitazoxanide
126141	CTC	Atovaquone and proguanil HCl
124145	CTC	Tigecycline
124123	CTC	Chloramphenicol (palmitate) (sodium succinate)
122241	CTC	Ceftolozane and tazobactam
124105	CTC	Imipenem-cilastatin
124113	CTC	Ertapenem sodium
124431	CTC	Sulfasalazine
125118	CTC	Methylene blue

**SUPPLEMENTAL TABLE 5** Continued

Code	Type of code	Explanation
126251	CTC	Isoniazid and rifampin
122163	CTC	Cefotetan disodium
126101	CTC	Chloroquine
126241	CTC	Rifabutin
124129	CTC	Daptomycin
121207	CTC	Penicillin G benzathine
126115	CTC	Primaquine phosphate
124185	CTC	Antibiotic combinations
122227	CTC	Ceftizoxime sodium
124131	CTC	Quinupristin/dalfopristin
122112	CTC	Cephradine
121241	CTC	Dicloxacillin sodium
124103	CTC	Doripenem
129113	CTC	Tinidazole
Vasoactive infusion		
131321	CTC	Epinephrine
131111	CTC	Milrinone lactate
131351	CTC	Norepinephrine bitartrate (levarterenol)
131355	CTC	Phenylephrine HCl
131311	CTC	Dopamine HCl
131315	CTC	Ephedrine (sulfate)
131305	CTC	Dobutamine HCl
Positive pressure ventilation and intubation		
0BH17EZ	ICD-10	Insertion of endotracheal airway into trachea, via natural or artificial opening
0BH18EZ	ICD-10	Insertion of endotracheal airway into trachea, via natural or artificial opening endoscopic
Z9911	ICD-10	Dependence on respirator [ventilator] status
521162	CTC	Continuous positive airway pressure
521164	CTC	Bilevel positive airway pressure
High Flow nasal cannula		
521172	CTC	High Flow nasal cannula supportive therapy

CTC, Clinical Transaction Classification.

**SUPPLEMENTAL TABLE 6** Definitions Used for Diagnostic Testing. Codes Are Clinical Transaction Classification (CTC) Codes Used by the Children's Hospital Association.

CTC code	Name
Chest radiography	
433311	Chest PA and lateral radiograph
433211	Chest anterior posterior (AP) radiograph
433411	Chest AP and lateral radiograph
433011	Chest radiograph
433911	Other specified chest radiograph
433111	Chest posterior anterior (PA) radiograph
Chest computerized tomography	
433051	Chest CT scan
473051	Chest arteriography CT scan
Chest ultrasonography	
433041	Chest ultrasound real-time
433042	Chest ultrasound B-mode
433241	Chest anterior posterior (AP) ultrasound real-time
433040	Chest ultrasound
Blood culture	
361110	Aerobic cultures
361120	Anaerobic cultures
361130	Aerobic and anaerobic cultures
Complete blood count	
322220	CBC without differential
322200	CBC unspecified
322210	CBC with differential
C-reactive protein	
344010	C-reactive protein
344011	hs-CRP
Procalcitonin	
316210	Calcitonin
Viral testing	
364151	Influenza A and B antibody
364241	Respiratory syncytial virus antibody
382237	Influenza virus PCR
382317	Respiratory syncytial virus PCR
382318	Respiratory syncytial virus RT-PCR
364150	Influenza virus unspecified
364242	Respiratory syncytial virus antigen
364152	Influenza A and B antigen
382240	Influenza virus DNA probe
382238	Influenza virus RT-PCR
Respiratory culture	
361110	Aerobic cultures

CRP, C-reactive protein; CBC, complete blood count; CT, computed tomography; PCR, polymerase chain reaction; RT-PCR, reverse transcription polymerase chain reaction.

**SUPPLEMENTAL TABLE 7** Use of Antibiotics by Primary Diagnosis Among Patients Admitted on Their Index Visit (*n* = 37 154)

Principal Diagnosis	No Antibiotics <i>N</i> (%)	Antibiotics <i>N</i> (%)
<i>N</i>	5303	34 223
Overall	3990 (10.7)	33 164 (89.3)
Viral pneumonia	3511	6665
Viral pneumonia, unspecified	2458 (54.4)	2058 (45.6)
Respiratory syncytial virus pneumonia	366 (26.7)	1003 (73.3)
Influenza due to other identified influenza virus with other specified pneumonia	65 (7.1)	848 (92.9)
Human metapneumovirus pneumonia	185 (20.5)	718 (79.5)
Influenza due to other identified influenza virus with unspecified type of pneumonia	51 (6.6)	722 (93.4)
Other viral pneumonia	198 (39.8)	300 (60.2)
Influenza due to unidentified influenza virus with unspecified type of pneumonia	24 (7)	319 (93)
Influenza due to unidentified influenza virus with specified pneumonia	22 (8.4)	241 (91.6)
Parainfluenza virus pneumonia	54 (23.8)	173 (76.2)
Adenoviral pneumonia	44 (19.8)	178 (80.2)
Influenza due to other identified influenza virus with the same other identified influenza virus pneumonia	44 (29.5)	105 (70.5)
Likely bacterial pneumonia	44 (0.6)	7290 (99.4)
Unspecified bacterial pneumonia	38 (0.6)	6430 (99.4)
Pneumonia due to <i>Streptococcus pneumoniae</i>	3 (0.7)	407 (99.3)
Pneumonia due to other streptococci	0 (0)	158 (100)
Pneumonia due to other specified bacteria	3 (2.5)	119 (97.5)
Pneumonia due to Methicillin resistant <i>Staphylococcus aureus</i>	0 (0)	72 (100)
Pneumonia due to Methicillin susceptible <i>Staphylococcus aureus</i>	0 (0)	56 (100)
Pneumonia due to other Gram-negative bacteria	0 (0)	27 (100)
Whooping cough due to <i>Bordetella pertussis</i> with pneumonia	0 (0)	10 (100)
Whooping cough, unspecified species with pneumonia	0 (0)	5 (100)
Pneumonia due to <i>Klebsiella pneumoniae</i>	0 (0)	2 (100)
Whooping cough due to <i>Bordetella parapertussis</i> with pneumonia	0 (0)	2 (100)
Whooping cough due to other <i>Bordetella</i> species with pneumonia	0 (0)	2 (100)
Pneumonia of indeterminate etiology	435 (2.2)	19 209 (97.8)
Pneumonia, unspecified organism	375 (2.4)	15 275 (97.6)
Lobar pneumonia, unspecified organism	48 (1.5)	3177 (98.5)
Other pneumonia, unspecified organism	5 (1.2)	417 (98.8)
Pneumonia due to other specified infectious organisms	5 (1.9)	255 (98.1)
Bronchopneumonia, unspecified organism	2 (2.3)	85 (97.7)



**SUPPLEMENTAL TABLE 8** Demographics and Clinical Characteristics of Study Cohort by Severity Type.

Variable	Mild-Discharged	Mild-Admitted	Moderate	Severe
<i>N</i>	85 488	8321	25 781	5590
Demographics				
Age, years	4.00 (2.00–7.00)	3.00 (1.00–5.00)	3.00 (1.00–5.00)	2.00 (1.00–5.00)
Male sex	44 876 (52.5)	4344 (52.2)	13 163 (51.1)	3019 (54.0)
Race and ethnicity				
Non-Hispanic White	27 372 (32.0)	3229 (38.8)	11 137 (43.2)	2432 (43.5)
Non-Hispanic Black	17 599 (20.6)	1849 (22.2)	4341 (16.8)	1303 (23.3)
Hispanic	26 324 (30.8)	1714 (20.6)	6427 (24.9)	1012 (18.1)
All others	11 924 (13.9)	1286 (15.5)	3332 (12.9)	729 (13.0)
Missing	2269 (2.7)	243 (2.9)	544 (2.1)	114 (2.0)
Geographic region				
Midwest	20 556 (24.0)	1857 (22.3)	5893 (22.9)	1452 (26.0)
Northeast	9493 (11.1)	1858 (22.3)	2244 (8.7)	671 (12.0)
South	32 065 (37.5)	3045 (36.6)	11 276 (43.7)	2424 (43.4)
West	23 374 (27.3)	1561 (18.8)	6368 (24.7)	1043 (18.7)
Primary source of payment				
Public	53 189 (62.2)	4493 (54.0)	13 841 (53.7)	3016 (54.0)
Private	25 498 (29.8)	3392 (40.8)	10 627 (41.2)	2317 (41.4)
Other or unknown	6801 (8.0)	436 (5.2)	1313 (5.1)	257 (4.6)
Weekend encounter	23 020 (26.9)	2282 (27.4)	7045 (27.3)	1525 (27.3)
Diagnostic testing				
Chest radiography	70 571 (82.6)	6419 (77.1)	20 910 (81.1)	4975 (89.0)
Chest computerized tomography	188 (0.2)	109 (1.3)	352 (1.4)	434 (7.8)
Chest ultrasound	118 (0.1)	74 (0.9)	746 (2.9)	679 (12.1)
Blood culture	6688 (7.8)	2437 (29.3)	11 424 (44.3)	2909 (52.0)
Complete blood count	10 683 (12.5)	3730 (44.8)	15 569 (60.4)	4221 (75.5)
C-reactive protein	5567 (6.5)	1851 (22.2)	8610 (33.4)	2547 (45.6)
Procalcitonin	559 (0.7)	254 (3.1)	1694 (6.6)	671 (12.0)
Viral testing	10 454 (12.2)	2066 (24.8)	6927 (26.9)	1943 (34.8)
Respiratory culture	113 (0.1)	33 (0.4)	110 (0.4)	234 (4.2)
Treatment				
Given antibiotics <sup>a</sup>	30 485 (35.7)	6673 (80.2)	22895 (88.8)	5009 (89.6)
Encounter length of stay, days <sup>b</sup>	1 (1–1)	1 (1–2)	2 (1–3)	4 (2–6)

Numbers in parenthesis represent percent or interquartile range.

<sup>a</sup> Defined as ordering of oral or intravenous antibiotics at any time during encounter, not including antibiotics prescribed at discharge.

<sup>b</sup> Among admitted patients, taking the longer admission from the index or revisit (where applicable) per encounter.