Economic burden of ventilator-associated, hospital-acquired, healthcare-associated and community-acquired pneumonia in the hospital setting

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INTRODUCTION

- Ventilator-associated pneumonia (VAP), hospital-acquired pneumonia (HAP), healthcare-associated pneumonia (HCAP), and community-acquired pneumonia (CAP) are common pneumonia types observed in hospitals, and are associated with significant morbidity and mortality.[1,2]
- While several studies have separately reported the cost impact of VAP and CAP,[3–5] few have estimated the total hospital costs (direct and indirect) attributable to all types of pneumonia.

OBJECTIVE

- To evaluate the economic burden of VAP, HAP, HCAP and CAP on hospital costs and length of stay (LOS) in the US.

METHODS

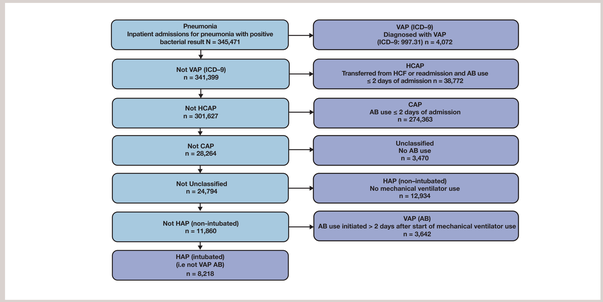
- A retrospective cohort study was conducted using the Premier database, which contains information from > 700 hospitals in the United States.[6]
- Patients with either a primary or secondary *International Classification Diagnosis* (ICD-9) code of pneumonia and a concomitant positive bacterial culture between January 1, 2008 and March 31, 2015 were included in this study.
- The pneumonia types (VAP, HAP, HCAP and CAP) were constructed in a stepwise approach.[7]
- Main outcome measures were hospital costs (2015 $US, inflation adjusted) and LOS, stratified by age and severity.
- Severity was defined based on the type of care received: "non-ICU" (not admitted to the Intensive Care Unit [ICU]) and "ICU" (admitted for ≥ 1 night to the ICU).

RESULTS

Patient characteristics

- We identified 345,471 patients with culture-positive pneumonia (Figure 1). Mean age was 66 years (SD ± 18), 49.2% were male, and 74.6% were white (Table 1). The majority of patients came from urban (90.5%) areas in the South (43.8%), and were admitted through emergency care (78.1%). Two-thirds (67.1%) of patients had Medicare, although 11.6% had Medicaid and 11.4% had managed care.
- Among these patients, 274,363 were classified as CAP (79.4%), 38,772 as HCAP (11.2%), 21,152 as HAP (6.1%) and 7,714 as VAP (2.2%) (Table 1); 3,470 patients were unclassified (1.0%) (data not shown).
- Gender distribution was consistent across the four pneumonia types. Mean (SD) age was highest in HCAP patients (68 [± 18] years) and lowest in VAP patients (60 [± 19] years). HCAP had a higher proportion of white patients than VAP (75.9% vs. 61.7%), but had a lower proportion of black patients (10.8%) compared with VAP (18.7%).
- Emergency admission was highest for CAP patients (83.1%) and lowest for HCAP patients (52.5%). Although Medicare was generally the most common payer, its use was lower in VAP (52.1%) than in other pneumonia types; 18.2% of VAP patients used Medicaid and 14.5% of VAP patients used managed care.
- The extreme categories of All Patient Refined Diagnosis Related Group (APR DRG) severity of illness and risk of mortality were highest in VAP patients (92.5% and 73.4%, respectively) and lowest in CAP patients (38.7% and 31.2%, respectively) (Table 1).

Figure 1. Cohort construction



AB = antibiotic; CAP = community-acquired pneumonia; HAP = hospital-acquired pneumonia; HCAP = healthcare-associated pneumonia; HCF = healthcare facility; VAP = ventilator-associated pneumonia;
ICD = *International Classification Diagnosis*; Pneumonia = VAP + HAP + HCAP + CAP + Unclassified; VAP = VAP (ICD-9) + VAP (antibiotic); HAP = HAP (intubated) + HAP (non-intubated). Unclassified, n = 3,470 (data not shown).

Table 1. Patient characteristics (N = 345,471)

Variable	All pneumonia (n = 345,471)	CAP (n = 274,363)	HCAP (n = 38,772)	HAP (n = 21,152)	VAP (n = 7,714)
Age, mean years (SD)	66 (18)	66 (18)	68 (18)	67 (18)	60 (19)
Male, n (%)	170,121 (49.2)	133,755 (48.8)	18,865 (48.7)	11,076 (52.4)	4,615 (59.8)
Race, n (%)					
White	257,565 (74.6)	206,092 (75.1)	29,414 (75.9)	14,949 (70.7)	4,756 (61.7)
Black	46,719 (13.5)	37,837 (13.8)	4,184 (10.8)	2,998 (14.2)	1,440 (18.7)
Hispanic	4,553 (1.3)	3,858 (1.4)	331 (0.9)	231 (1.1)	111 (1.4)
Other / unknown	36,520 (10.6)	26,508 (9.7)	4,811 (12.4)	2,965 (14.0)	1,403 (18.2)
Admission type, n (%)					
Emergency	269,774 (78.1)	227,927 (83.1)	20,357 (52.5)	14,375 (68.0)	5,016 (65.0)
Urgent	49,348 (14.3)	29,090 (10.6)	13,840 (35.7)	4,073 (19.3)	1,474 (19.1)
Elective	23,161 (6.7)	15,361 (5.6)	4,407 (11.4)	2,366 (11.2)	649 (8.4)
Trauma center/other/ unknown	3,188 (0.9)	1,985 (0.7)	168 (0.4)	338 (1.6)	575 (7.5)
Discharge status, n (%)					
Discharged to home	133,776 (38.7)	118,665 (43.3)	7,353 (19.0)	5,304 (25.1)	922 (12.0)
Discharged to home health organization	51,434 (14.9)	43,671 (15.9)	3,505 (9.0)	3,181 (15.0)	724 (9.4)
Discharged to hospice	15,982 (4.6)	11,859 (4.3)	2,441 (6.3)	1,193 (5.6)	340 (4.4)
Discharged to intermediate-care facility	4,696 (1.4)	3,423 (1.2)	1,000 (2.6)	208 (1.0)	39 (0.5)
Discharged to long-term care hospital	10,460 (3.0)	6,646 (2.4)	1,882 (4.9)	928 (4.4)	978 (12.7)
Discharged to rehabilitation	10,242 (3.0)	6,642 (2.4)	1,185 (3.1)	1,254 (5.9)	1,041 (13.5)
Discharged to short-term hospital	7,985 (2.3)	5,879 (2.1)	1,047 (2.7)	692 (3.3)	247 (3.2)
Discharged to skilled nursing facility	69,061 (20.0)	48,629 (17.7)	13,643 (35.2)	4,831 (22.8)	1,538 (19.9)
In-hospital mortality	33,673 (9.7)	23,129 (8.4)	5,617 (14.5)	2,892 (13.7)	1,511 (19.6)
Other/unknown	8,162 (2.4)	5,820 (2.1)	1,099 (2.8)	669 (3.2)	374 (4.8)
APR DRG severity of illness					
Minor or moderate	60,449 (17.5)	55,273 (20.1)	3,412 (8.8)	1,173 (5.5)	22 (0.3)
Major	134,629 (39.0)	113,033 (41.2)	13,094 (33.8)	6,659 (31.5)	556 (7.2)
Extreme	150,391 (43.5)	106,055 (38.7)	22,266 (57.4)	13,320 (63.0)	7,136 (92.5)
APR DRG risk of mortality					
Minor or moderate	94,158 (27.3)	84,115 (30.7)	6,241 (16.1)	2,676 (12.7)	211 (2.7)
Major	130,614 (37.8)	104,538 (38.1)	14,552 (37.5)	8,372 (39.6)	1,842 (23.9)
Extreme	120,697 (34.9)	85,708 (31.2)	17,979 (46.4)	10,104 (47.8)	5,661 (73.4)
Geographic area, n (%)					
Northeast	62,624 (18.1)	48,654 (17.7)	7,454 (19.2)	4,099 (19.4)	1,994 (25.8)
Midwest	91,427 (26.5)	69,972 (25.5)	14,518 (37.4)	5,086 (24.0)	1,422 (18.4)
South	151,319 (43.8)	123,432 (45.0)	13,864 (35.8)	9,031 (42.7)	3,300 (42.8)
West	40,101 (11.6)	32,305 (11.8)	2,936 (7.6)	2,936 (13.9)	998 (12.9)
Urban	312,519 (90.5)	248,566 (90.6)	34,488 (89.0)	19,652 (92.9)	7,475 (96.9)
Primary payer, n (%)					
Medicare	231,685 (67.1)	182,884 (66.7)	28,578 (73.7)	14,174 (67.0)	4,016 (52.1)
Medicaid	40,218 (11.6)	31,647 (11.5)	4,283 (11.0)	2,522 (11.9)	1,405 (18.2)
Managed care	39,432 (11.4)	32,755 (11.9)	2,806 (7.2)	2,233 (10.6)	1,116 (14.5)
Commercial	13,420 (3.9)	10,182 (3.7)	1,363 (3.5)	942 (4.5)	518 (6.7)
Self-pay	10,709 (3.1)	8,976 (3.3)	823 (2.1)	610 (2.9)	237 (3.1)
Other/unknown	10,007 (2.9)	7,919 (2.9)	919 (2.4)	671 (3.2)	422 (5.5)

APR-DGR = All Patient Refined Diagnosis Related Group; CAP = community-acquired pneumonia; HAP = hospital-acquired pneumonia; HCAP = healthcare-associated pneumonia; VAP = ventilator-associated pneumonia;
Pneumonia = VAP + HAP + HCAP + CAP + Unclassified; SD = standard deviation; Unclassified, n = 3,470 (data not shown).

Hospital costs and LOS

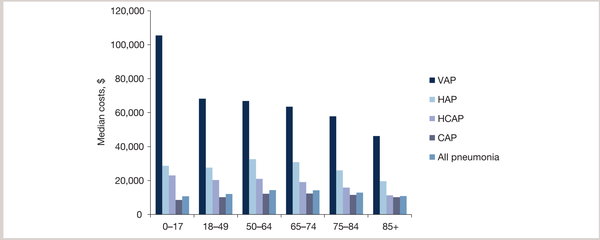
- The average cost for patients hospitalized with any type of pneumonia was $25,263 (SD ± $40,306), and the average hospital stay was 11 days (SD ± 15 days) (Table 2).
- VAP patients incurred the highest hospital costs (median: $63,899, IQR: $36,958–$108,366) and the longest LOS (median: 21 days, interquartile range [IQR]: 13–32 days). CAP patients incurred the lowest hospital costs (median: $11,384, IQR: $6,310–$23,209) and the shortest LOS (median: 7 days, IQR: 5–12 days) (Table 2).
- HAP patients had a median cost of $27,161 (IQR: $14,951–$52,196) and a median LOS of 14 days (IQR: 9–22 days). HCAP patients had a median cost of $16,531 (IQR: $8,712–$32,825) and a median LOS of 9 days (IQR: 6–15 days) (Table 2).
- Regardless of age and severity, patients with VAP had the highest utilization of hospital resources, followed by HAP, HCAP and CAP (Figures 2–5).
  - Highest hospital costs were seen in VAP patients 0–17 years old (median: $105,376, IQR: $46,284–$206,785, Figure 2). VAP patients 0–17 years old also had the longest LOS (median: 32 days, IQR: 16–91 days, Figure 3).
  - VAP patients admitted to the ICU had the highest hospital costs (median: $65,838, IQR: $39,365–$110,292, Figure 4). VAP patients admitted to ICU also had the highest LOS (median: 21 days, IQR: 14–33 days, Figure 5).

Table 2. Hospital costs* and length of stay

Variable	All pneumonia (n = 345,471)	CAP (n = 274,363)	HCAP (n = 38,772)	HAP (n = 21,152)	VAP (n = 7,714)
Costs, $ Median (IQR)	12,883 (6,856–27,464)	11,384 (6,310–23,209)	16,531 (8,712–32,825)	27,161 (14,951–52,195)	63,899 (36,958–108,366)
LOS, days Median (IQR)	8 (5–13)	7 (5–12)	9 (6–15)	14 (9–22)	21 (13–32)

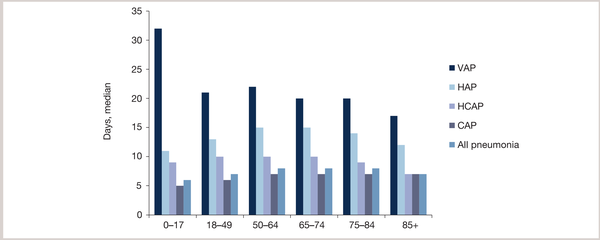
* 2015 $, inflation adjusted. CAP = community-acquired pneumonia; HAP = hospital-acquired pneumonia; HCAP = healthcare-associated pneumonia; VAP = ventilator-associated pneumonia; Pneumonia = VAP + HAP + HCAP + CAP + Unclassified; IQR = interquartile range; SD = standard deviation; Unclassified, n = 3,470 (data not shown).

Figure 2. Hospital costs* by age group



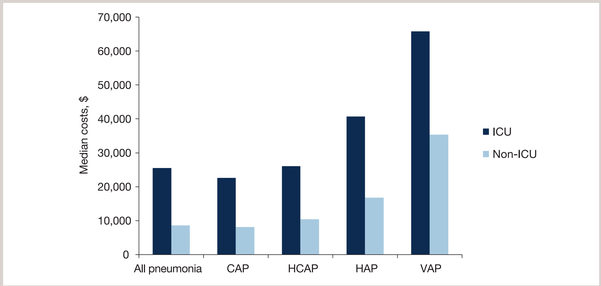
* 2015 $, inflation adjusted. CAP = community-acquired pneumonia; HAP = hospital-acquired pneumonia; HCAP = healthcare-associated pneumonia; VAP = ventilator-associated pneumonia; Pneumonia = VAP + HAP + HCAP + CAP + Unclassified; Unclassified, n = 3,470 (data not shown).

Figure 3. Hospital length of stay by age group



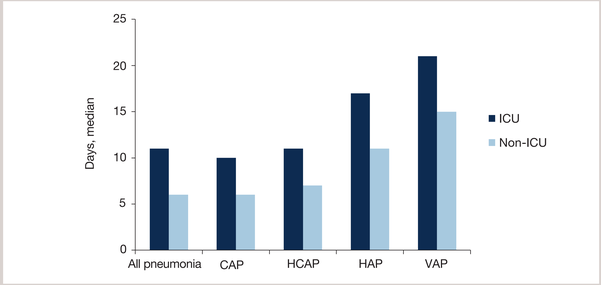
CAP = community-acquired pneumonia; HAP = hospital-acquired pneumonia; HCAP = healthcare-associated pneumonia; VAP = ventilator-associated pneumonia; Pneumonia = VAP + HAP + HCAP + CAP + Unclassified;
Unclassified, n = 3,470 (data not shown).

Figure 4. Hospital costs* by severity



* 2015 $, inflation adjusted. CAP = community-acquired pneumonia; HAP = hospital-acquired pneumonia; HCAP = healthcare-associated pneumonia; VAP = ventilator-associated pneumonia; ICU = Intensive Care Unit; Pneumonia = VAP + HAP + HCAP + CAP + Unclassified; Unclassified, n = 3,470 (data not shown).

Figure 5. Hospital length of stay by severity



CAP = community-acquired pneumonia; HAP = hospital-acquired pneumonia; HCAP = healthcare-associated pneumonia; VAP = ventilator-associated pneumonia; ICU = Intensive Care Unit; Pneumonia = VAP + HAP + HCAP + CAP + Unclassified; Unclassified, n = 3,470 (data not shown).

CONCLUSION

- The economic burden of pneumonia in the hospital setting is substantial. According to the Centers for Disease Control, pneumonia is a leading cause of hospitalization and death among adults in the US and its medical costs were reported to exceed $10 billion in 2011.[8]
- Although VAP was associated with the highest hospital costs and the longest LOS, HAP and HCAP also had an impact on hospital resources. Interventions targeting treatment and prevention of VAP, HAP and HCAP may result in significant cost savings.

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