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Impact of an antimicrobial stewardship program on outcomes in patients with community-acquired pneumonia admitted to a tertiary community hospital

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Abstract

Purpose.—Results of a study evaluating the impact of an antimicrobial stewardship program (ASP) on clinical outcomes in patients hospitalized for community-acquired pneumonia (CAP) are reported.

Methods.—A retrospective records review was conducted at a 400-bed hospital to identify patients admitted over 3 years with CAP documented as a primary or secondary diagnosis. Clinical and medication-use outcomes during a 1-year baseline period and in the first and second years after ASP implementation (post-ASP years 1 and 2) were analyzed. A local CAP guideline was implemented around the beginning of post-ASP year 2.

Results.—The mean hospital length of stay declined from 7.24 days in the baseline period to 5.71 days in post-ASP year 1 ($p = 0.011$) and 5.52 days in post-ASP year 2 ($p = 0.008$). Mean inpatient antimicrobial days of therapy (DOT) declined from 5.68 days in the baseline period to 5.08 days ($p = 0.045$) and 4.99 days ($p = 0.030$) in post-ASP years 1 and 2, respectively. Mean DOT per 100 total days of antimicrobial therapy declined from 9.69 days in the baseline period to 8.85 days in post-ASP year 1 ($p = 0.019$) and 8.38 days in post-ASP year 2 ($p = 0.001$).

Conclusion.—ASP implementation was associated with specific clinical benefits in patients with CAP, including decreased length of stay, decreased durations of antimicrobial therapy, and a shift in utilization to a primary regimen shown to produce superior clinical outcomes.

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Disclosures

The authors have declared no potential conflicts of interest.

Additional information

The findings and conclusions expressed are the authors' and do not necessarily represent the official position of Providence Alaska Medical Center, Alaska Native Medical Center, or the Centers for Disease Control and Prevention.

Keywords

antimicrobial stewardship; duration of therapy; length of stay; pneumonia

According to a 2014 report from the Centers for Disease Control and Prevention, approximately 30–50% of antibiotics prescribed in hospitals in the United States are either inappropriate or unnecessary.[1] The problem is compounded by high utilization; admission data from a 2010 survey of 323 hospitals showed that 55.7% of patients received antibiotics during their hospital stay.[1]

The goals of a local antimicrobial stewardship program (ASP) should be to optimize clinical outcomes and minimize unintended consequences of both overuse and improper use of antimicrobials.[2] The Infectious Diseases Society of America (IDSA) and the Society for Healthcare Epidemiology of America established a consensus guideline in 2007 with the goal of helping acute care hospitals develop and implement evidence-based interprofessional ASPs. This guideline recommends the primary antimicrobial stewardship strategies of prospective audit with intervention and feedback, formulary restriction, and preauthorization, with secondary strategies including education, guideline and clinical pathway development, antimicrobial therapy de-escalation, dose optimization, and parenteral-to-oral conversion. While the 2007 guideline provides little guidance with regard to monitoring clinical outcomes of targeted antimicrobial stewardship interventions, a 2016 guideline update places increased emphasis on developing and implementing clinical practice guidelines for common infectious syndromes.[3] It also recommends measuring syndrome-specific clinical outcomes but indicates that selection of specific metrics must vary by syndrome and, to some extent, the capabilities of local ASPs.

With an obvious need for increased antimicrobial stewardship in inpatient care settings, increased evaluation of the impact of these programs is warranted. As an important step in the process of gauging the value of an ASP, evaluation should include thorough review of syndrome-specific clinical outcomes in addition to overall antimicrobial use. Involvement of an ASP or infectious diseases (ID) team in the care of patients with various clinical syndromes has been shown to yield clinical benefits such as reductions in mortality, length of stay, and readmission rates.[4–7] Furthermore, recent literature has emphasized the need to assess clinical outcomes and the quality of healthcare provided, including interventions pertaining to antimicrobial de-escalation, days of antimicrobial therapy, and hospital readmission rates.[8]

A tertiary care center with roughly 400 beds located in Anchorage, Alaska, initiated an ASP on August 26, 2013. The program structure includes 1 full-time ID clinical pharmacist, who is responsible for the primary stewardship strategy of daily prospective audit with intervention and feedback, and 1 ID physician functioning as the program medical director. The ASP also uses an interprofessional antimicrobial stewardship committee comprising pharmacy, infection prevention, microbiology, informatics, administration, and nursing personnel and several clinicians from various practice specialties. This committee performs various administrative functions, including vetting and approving locally developed guidelines and clinical pathways. While the program has positive impacts on overall

antimicrobial expenditures and utilization, clinical outcomes pertaining to a single ID diagnosis, such as mortality, 30-day readmission rates, and length of stay, had not been evaluated at the institution prior to the study described here.

Methods

Study design and population.

A retrospective records review was performed to identify patients admitted to the hospital for treatment of community-acquired pneumonia (CAP) from August 26, 2012, through August 25, 2015. The period August 26, 2012–August 25, 2013, is referred to as the baseline period; the period August 26, 2013–August 25, 2014, is designated as year 1 after ASP initiation (post-ASP year 1); and the period August 26, 2014–August 25, 2015, is referred to as post-ASP year 2, with the latter 2 periods designated as the intervention periods. During post-ASP year 1, interventions were provided via prospective audit with intervention and feedback; however, the local ASP committee approved a facility-specific treatment guideline and clinical pathway for CAP in August 2014 (Figure 1). The approval of this guideline correlated with the post-ASP year 2 period. In both intervention periods, targeted interventions included antimicrobial selection, dose optimization, ensuring appropriate duration of therapy, i.v.-to-oral interchange, and appropriate de-escalation based on culture results. Patients were identified by reviewing records for documentation of either *International Classification of Diseases, 9th Revision (ICD-9)*, code 486.0 or *ICD-10* code J18.9 (both codes denote pneumonia due to an unspecified organism) as a primary and/or secondary diagnosis for the corresponding admission. Patients 18 years of age or older and admitted for more than 24 hours were included. Patients were excluded if they were incarcerated or pregnant; had an infection other than CAP that required antibiotic therapy; met criteria for healthcare-associated pneumonia, as defined in 2005 guidelines jointly issued by IDSA and the American Thoracic Society[9]; were transitioned to comfort or hospice care during treatment; were transferred from another facility; or had an overall length of stay greater than 60 days. Of 1,357 records reviewed, 528 met the inclusion criteria, with 9 exclusions for pregnancy, 127 for concurrent infections, 630 for healthcare-associated pneumonia, 7 due to transition to comfort or hospice care, 54 due to transfer from an outside facility, and 2 for an overall length of stay greater than 60 days.

In addition, we reviewed CAP-related ASP interventions provided during post-ASP years 1 and 2. However, the intervention was not evaluated according to the same exclusion criteria listed above; instead, all interventions made during the specified time period in any admitted patient 18 years or older who was diagnosed with CAP were analyzed. The intent was to capture the numbers and types of recommendations being made in order to evaluate the impact that implementation of a local guideline and clinical pathway for CAP may have had on the scope of interventions after implementation.

Study outcomes.

The study was granted exempt status by the Western Institutional Review Board. Primary outcomes analyzed included overall inpatient length of stay and measures of antimicrobial utilization such as the duration of inpatient antimicrobial therapy and duration of total

antimicrobial therapy, including inpatient duration plus prescribed duration of ambulatory care prescriptions, per electronic medical record discharge summary. Secondary outcomes included inpatient mortality, overall 30-day hospital readmission rate, rate of 30-day hospital readmission secondary to pneumonia or shortness of breath, acquisition of *Clostridium difficile* infection (CDI) during the index admission, the utilization rate for each specified antimicrobial agent (defined as the rate of total days of therapy [DOT] per 100 total DOT for all antimicrobials administered for CAP), and evaluation of ASP intervention rates and types during the prespecified study periods. Duration of therapy for inpatient antimicrobials and total duration of therapy were defined as receipt of at least 1 dose of any antimicrobial agent on a given day regardless of the total amount or number of doses administered.

Statistical analysis.

Primary and secondary outcomes were assessed by comparing data for the baseline period with data for each intervention period. Statistics were analyzed using Stata Statistical Software: Release 14 (StataCorp LLC, College Station, TX). Inpatient mortality, 30-day readmission rates, rates of 30-day readmission secondary to pneumonia or shortness of breath, acquisition of CDI during index admission, intervention variance, sex, and baseline comorbidities (hypertension, chronic obstructive pulmonary disease, diabetes mellitus, asthma, heart failure, atrial fibrillation, and tobacco use) were assessed using a chi-square test or Fisher's exact test, as appropriate. Age, weight, mean duration of inpatient antimicrobial use, mean duration of total antimicrobial use, and DOT of individual inpatient antimicrobials per 100 total antimicrobial DOT were assessed using a *t* test. Mean length of stay was assessed using rank sum methods given the nonnormal data distribution. A p value of <0.05 was considered to denote statistical significance. We estimated that a sample size of 120 patients in each group would be required to provide 80% power to detect a 15% reduction in length of stay and durations of antimicrobial therapy (both inpatient and total durations).

Results

Baseline demographic characteristics were similar in the 3 groups, with no significant differences (Table 1). A total of 528 patients were included in the review: 221 patients in the baseline period, 175 patients in the post-ASP year 1 period, and 132 patients in the post-ASP year 2 period. All patients had complete results, with the exception of a single patient in the post-ASP year 1 group for whom data on total duration of antibiotic use was missing.

The mean length of stay was 7.24 days at baseline, as compared with 5.71 days (95% confidence interval [CI], −1.54 to −0.14 days; $p = 0.011$) during post-ASP year 1 and 5.52 days (95% CI, −1.98 to −0.51 days; $p = 0.008$) during post-ASP year 2. When data for the baseline period were compared with data for both intervention periods, rates of inpatient mortality, overall 30-day readmission and 30-day readmission secondary to pneumonia or shortness of breath, and CDI acquisition during the index admission were not significantly different (Table 2). Over the 3-year study period, inpatient mortality rates were 5% during the baseline period, 3% during post-ASP year 1, and 2% during post-ASP year 2.

Evaluation of durations of inpatient antimicrobial therapy showed that the mean inpatient duration of antimicrobial therapy was 5.67 days during the baseline period, as compared with 5.08 days (95% CI, −1.19 to −0.01; $p = 0.045$) during post-ASP year 1 and 4.99 days (95% CI, −1.31 to −0.07 days; $p = 0.03$) during post-ASP year 2. There were similar decreases in total durations of antimicrobial therapy (Table 2).

With regard to utilization of specific antimicrobial regimens in the treatment of CAP, higher rates of prescribing of β-lactam– and azithromycin-based regimens, as opposed to levofloxacin-based regimens, were observed during both intervention periods. The primary β-lactam used was ceftriaxone, utilization of which increased from baseline to post-ASP year 1, representing an increase of 10 DOT per 100 total antimicrobial days (95% CI, 4.1–15.4 DOT; $p < 0.001$). During post-ASP year 2, ceftriaxone use increased to 19 DOT (95% CI, 12.1–25.4 DOT; $p < 0.001$) per 100 total antimicrobial days. Utilization of azithromycin increased by 9 DOT per 100 total antimicrobial days (95% CI, 3.4–14.9; $p = 0.002$) from baseline to post-ASP year 1 and by 15 DOT (95% CI, 9.3–21.4 DOT; $p < 0.001$) per 100 total antimicrobial days from baseline to post-ASP year 2. Levofloxacin utilization decreased by 7 DOT (95% CI, –12.6 to –1.4 DOT; $p = 0.016$) per 100 total antimicrobial days from baseline to post-ASP year 1 and by 24 DOT (95% CI, –28.5 to –17.9 DOT; $p < 0.001$) per 100 total antimicrobial days from baseline to post-ASP year 2. Utilization rates for the 3 primary inpatient CAP regimens are shown in Table 3.

During the first year of ASP activity, a total of 326 CAP-related interventions were performed across 230 days of program operation, for a rate of 1.42 interventions per day of operation; 267 interventions were direct-to-provider interventions provided telephonically or through the use of the electronic medical record, with a 91% acceptance rate. The remaining 59 interventions were performed automatically through the use of locally approved and available Pharmacy and Therapeutics (P&T) Committee protocols. In post-ASP year 2, a total of 429 CAP-related interventions were performed across 234 days of program operation, for a rate of 1.83 interventions per day of operation ($p < 0.001$ for comparison with the baseline period). Additionally, of these 429 interventions, 373 were direct-to-provider interventions, with an associated acceptance rate of 87%. In post-ASP year 2, there were 56 interventions performed per P&T committee protocol. Thus, the bulk of the increase in ASP interventions in the second year of program activity largely represented an increase in direct-to-provider recommendations.

The breakdown of intervention types across post-ASP years 1 and 2 can be seen in Table 4. Notably, significant reductions in interventions pertaining to duration of therapy ($p = 0.003$) and duplication of therapy ($p = 0.034$) were observed. Conversely, significant increases in interventions intended to de-escalate therapy ($p = 0.024$) were observed in the post-ASP year 2 group.

Discussion

This retrospective review indicated that after the implementation of an ASP at a 400-bed tertiary care center, reductions in hospital length of stay and both inpatient and total antimicrobial durations of therapy were observed without associated increases in

inpatient mortality, the overall 30-day hospital readmission rate, the rate of 30-day hospital readmission secondary to pneumonia or shortness of breath, and acquisition of CDI during the index admission. Furthermore, the activity of this ASP appeared to have substantially shifted antimicrobial prescribing from fluoroquinolone-based regimens to β-lactam– and azithromycin-based regimens. These findings demonstrate the potential clinical benefits of an ASP functioning through the primary antimicrobial stewardship strategy of prospective audit with intervention and feedback coupled with utilization of a local guideline and clinical pathway. Additionally, implementation of a local guideline and clinical pathway led to a statistically significant increase in the rate of CAP-related interventions per day of operation. This increase was primarily driven by increases in direct-to-provider recommendations rather than interventions performed by the ASP pharmacist per P&T committee–approved protocols, such as i.v.-to-oral conversion for azithromycin and levofloxacin or renal dosing protocols for levofloxacin. Implementation of the local guideline and clinical pathway also changed the distribution of intervention types, as evidenced by the decrease in interventions pertaining to duration or duplication of therapy and an increase in interventions pertaining to de-escalation.

Other studies evaluating the impact of an ASP on outcomes such as length of stay and total antibiotic therapy duration have demonstrated outcomes similar to those seen in our review. The Connecticut Pneumonia Pathway Project, a statewide initiative conducted to decrease hospital length of stay among patients hospitalized for CAP, found a decrease in the mean length of stay (from 7 to 5 days) after guideline implementation.[10] This overall reduction in length of stay was similar to the reduction noted in our review; also, as in our review, no significant changes were found in 30-day mortality and readmission rates. Benenson et al.[11] analyzed length of stay, inpatient mortality, and time to first antimicrobial dose in patients with CAP. Those researchers compared groups of patients seen 3 months prior to CAP pathway implementation, 10–12 months after implementation of the pathway, and 34–36 months after implementation of the pathway. They found a statistically significant decrease in length of stay (from 9.7 to 6.4 days) without corresponding significant changes in the rate of in-hospital mortality. Carratala et al.[12] evaluated the implementation of a 3-step critical pathway for CAP and demonstrated a decrease in length of stay, from 6 days in a usual care group to 3.9 days in a postimplementation group. They also demonstrated a 2-day decrease in the mean duration of i.v. antibiotic therapy in the postimplementation group.

The clinical impacts of ASPs have also been evaluated in other studies, which had findings similar to those observed in this review. A systematic review of research reports published from 2000 through 2013 found that 17 of the 37 studies that evaluated patient outcomes showed no significant differences in any patient outcomes, including mortality, length of stay, readmission, and occurrence of CDI.[13] The evaluated ASPs operated via a variety of methods, including audit and feedback, guideline implementation, decision support, formulary restriction or preauthorization, and procalcitonin monitoring to guide antimicrobial therapy. A variety of infectious conditions were targeted, and patients came from a variety of inpatient settings, including intensive care units, surgical units, and medical wards. Likewise, our study included patients admitted to any hospital unit and with CAP of any severity, and we evaluated multiple antimicrobial stewardship strategies, including

prospective audit with intervention and feedback and local guideline and clinical pathway implementation.

This review did not demonstrate a statistically significant difference in overall 30-day readmission rates. Pneumonia readmission rates were previously reported as a part of Medicare's quality measures reporting.[14] The reported national mean for pneumonia 30-day readmission during the period July 2012–June 2015 was 17.1%. The same report estimated the national average rate of CAP-related mortality at 16.3%, with a reported rate at our facility of 14% (based on reported data from 447 patients).[14] In our study, the highest rate of mortality was 4.98%, reported in the baseline period; rates declined to 3% in post-ASP year 1 and 2% in post-ASP year 2. The lower rates of mortality and 30-day readmission seen in this review, as compared with the Medicare quality measures data cited above, are likely explained by the stringency of the inclusion and exclusion criteria defined in this study; thus, direct comparison of this institution's mortality rates to those reported nationally may not be appropriate.

Recent literature has encouraged the use of β-lactam and macrolide-based regimens over fluoroquinolone-based regimens in patients with CAP because the former have been associated with decreased mortality and length of stay in patients with moderate-to-severe CAP.[15–18] Upon program initiation in 2013, the ASP at our facility began strongly recommending the use of β-lactams and macrolide-based regimens over fluoroquinolone-based regimens. Furthermore, this recommendation was formally documented in a facility-specific treatment guideline and clinical pathway developed by the local ASP pharmacist and Antimicrobial Stewardship Committee in August 2014. Implementation of this clinical guideline, as compared with preimplementation use of prospective audit with intervention and feedback alone, may have been responsible for the further reductions in fluoroquinolone-based regimens and increased use of β-lactam– and macrolide-containing regimens observed in post-ASP year 2. Additionally, it appears that the local guideline may have effectively aided in clarifying local antimicrobial preferences for duration of therapy and reduced cases of unnecessary therapeutic duplication; this may have allowed increased focus on other interventions involving changes to the patient's regimen based on available culture results and clinical status, such as de-escalation of therapy.

This review had several noteworthy limitations. First, the retrospective study design limited our ability to control for major confounders that may have influenced outcomes either favorably or unfavorably. Likewise, many of our primary and secondary outcomes were influenced by multiple uncontrolled factors. It should be noted that correlation does not necessarily prove causation, and differences in outcomes between the baseline and intervention groups may not necessarily be entirely attributable to initiation of an ASP and subsequent implementation of a local guideline and clinical pathway. Second, we did not identify statistically significant variance in many of the secondary outcomes; however, this review was not powered to detect differences in mortality or 30-day readmission rates. Another potential limitation in the evaluation of total duration of therapy pertains to the observed shift in antimicrobial regimen utilization. Utilization of respiratory fluoroquinolones may allow for a 5-day duration of therapy for CAP; however, recent literature suggests that the appropriate duration of therapy with use of a β-lactam–based

regimen may vary from 5 to 14 days, depending on the patient's underlying comorbidities and clinical response to therapy.[19–21] While the 2007 IDSA and American Thoracic Society guideline on CAP management support a minimum 5-day duration of therapy for β-lactam–containing regimens in patients with a rapid response to therapy, patients should also be afebrile for 48–72 hours prior to discontinuation of antibiotics.[22] This guideline also recommends that antibiotics be continued as long as patients exhibit at least 2 of the following: a temperature of ≥37.8 C, a heart rate of ≥100 beats per minute, a respiratory rate of ≥24 breaths per minute, systolic blood pressure of ≤90 mm Hg, arterial oxygen saturation of ≤90%, inability to maintain oral intake, and altered mental status.[22] Therefore, it is possible that in our review, a shift to a primary regimen of a β-lactam and a macrolide may have actually prolonged the overall duration of therapy. Lastly, it might be expected that implementation of a local guideline and clinical pathway for CAP would reduce the rate of ASP intervention due to provision of clearer, streamlined workflows and more readily available recommendations. We identified the opposite effect and suspect that this finding may have been due to the relative newness of the ASP during its first year and increasing ASP pharmacist competency and confidence in providing interventions during the second year after program implementation. Also, the guideline and clinical pathway for CAP in the study institution represented the first guideline and clinical pathway produced by the ASP. This guideline may have initially generated more interventions for the ASP pharmacist immediately after implementation, with a decline in required interventions anticipated... as the local guideline becomes more widely distributed and local therapeutic preferences are better delineated.

Conclusion

ASP implementation was associated with specific clinical benefits in patients with CAP, including decreased length of stay, decreased durations of antimicrobial therapy, and a shift in utilization to a primary regimen shown to produce superior clinical outcomes, with no corresponding increases in mortality, readmissions, and acquisition of CDI. As the scope of antimicrobial stewardship changes within the United States, further information regarding benefits of ASPs on the global, local, and patient levels is needed in order help drive the practice of antimicrobial stewardship forward in a meaningful fashion that truly optimizes patient outcomes and minimizes unintended consequences of antimicrobial therapy.

Biography

Katie Gordon, Pharm.D., BCPS, is the infectious diseases clinical pharmacist at Alaska Native Medical Center in Anchorage, Alaska. She received a doctor of pharmacy degree from Butler University in 2014. After completion of a postgraduate year 1 pharmacy

residency at Providence Alaska Medical Center, she worked as a clinical pharmacist with an interest in infectious diseases.

References

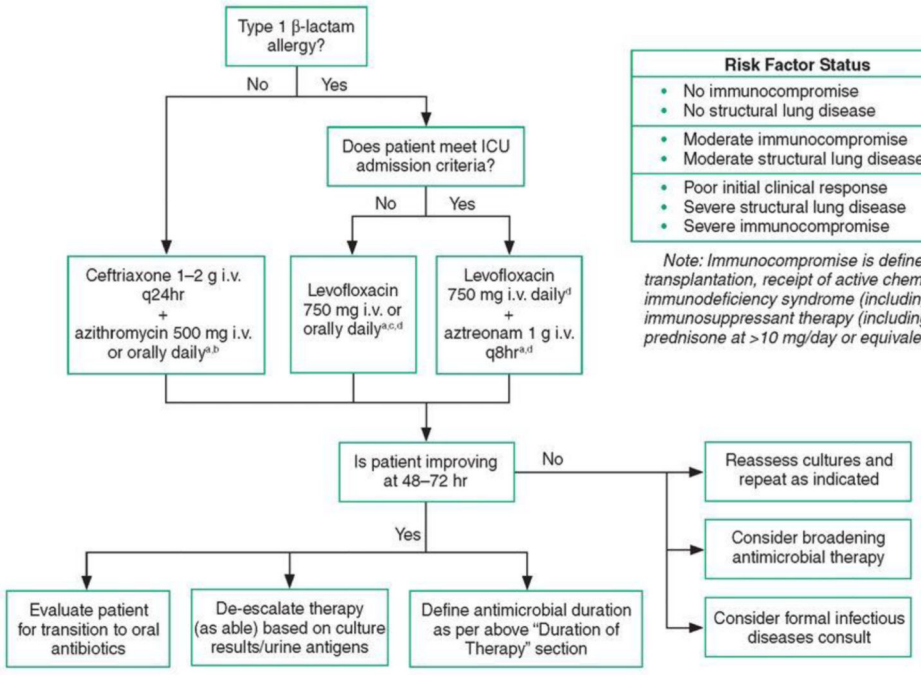
1. Centers for Disease Control and Prevention. Vital signs: improving antibiotic use among hospitalized patients. MMWR Morb Mortal Wkly Rep. 2014; 63(9):194–200. [PubMed: 24598596]
2. Dellit TH, Owens RC, McGowan JE et al. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. Clin Infect Dis. 2007; 44:159–177. [PubMed: 17173212]
3. Barlam TF, Cosgrove SE, Abbo LM et al. Implementing an antibiotic stewardship program: guidelines by the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America. Clin Infect Dis. 2016; 62:e51–77. [PubMed: 27080992]
4. Schmitt S, McQuillen DP, Nahass R et al. Infectious diseases specialty intervention is associated with decreased mortality and lower healthcare costs. Clin Infect Dis. 2014; 58:22–8. [PubMed: 24072931]
5. Malani AN, Richards PG, Kapila S et al. Clinical and economic outcomes from a community hospital's antimicrobial stewardship program. Am J Infect Control. 2013; 52:145–8.
6. Karanika S, Paudel S, Grigoras C et al. Systematic review and meta-analysis of clinical and economic outcomes from the implementation of hospital-based antimicrobial stewardship programs. Antimicrob Agents Chemother. 2016; 60:4840–52. [PubMed: 27246783]
7. Bohan JG, Remington R, Jones M et al. Outcomes associated with antimicrobial de-escalation of treatment for pneumonia within the Veterans Healthcare Administration. Open Forum Infect Dis. 2017; 4:1–4.
8. Ibrahim OM, Polk RE. Antimicrobial use metrics and benchmarking to improve stewardship outcomes. Infect Dis Clin North Am. 2014; 28:195–214. [PubMed: 24857388]
9. American Thoracic Society and Infectious Diseases Society of America. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. Am J Respir Crit Care Med. 2005; 171:388–416. [PubMed: 15699079]
10. Meehan TP, Weingarten SR, Holmboe ES et al. A statewide initiative to improve the care of hospitalized pneumonia patients: the Connecticut Pneumonia Pathway Project. Am J Med. 2001; 111:203–10. [PubMed: 11530031]
11. Benenson R, Magalski A, Cavanaugh S, Williams E. Effects of a pneumonia clinical pathway on time to antibiotic treatment, length of stay, and mortality. Acad Emerg Med. 1999; 6:1243–8. [PubMed: 10609926]
12. Carratala J, Garcia-Vidal C, Ortega L et al. Effect of a 3-step critical pathway to reduce duration of intravenous antibiotic therapy and length of stay in community-acquired pneumonia: a randomized controlled trial. Arch Intern Med. 2012; 172:922–8. [PubMed: 22732747]
13. Wagner B, Filice GA, Drekonja D et al. Antimicrobial stewardship programs in inpatient hospital settings. Infect Control Hosp Epidemiol. 2014; 35:1209–28. [PubMed: 25203174]
14. Medicare.gov. Hospital Compare. www.medicare.gov/hospitalcompare/Data/About.html (accessed 2016 Nov 20).
15. Sligl WI, Asadi L, Eurich DT et al. Macrolides and mortality in critically ill patients with community-acquired pneumonia: a systematic review and meta-analysis. Crit Care Med. 2014; 42:420–32. [PubMed: 24158175]
16. Restrepo MI, Mortensen EM, Waterer GW et al. Impact of macrolide therapy on mortality for patients with severe sepsis due to pneumonia. Eur Respir J. 2009; 33:153–9. [PubMed: 18768577]
17. Metersky MI, Ma A, Houck PM, Bratzler DW. Antibiotics for bacteremic pneumonia improved outcomes with macrolides but not fluoroquinolones. CHEST. 2007; 131:466–73. [PubMed: 17296649]
18. Baddour LM, Yu VL, Klugman KP et al. Combination antibiotic therapy lowers mortality among severely ill patients with pneumococcal bacteremia. Am J Respir Crit Care Med. 2004; 170:440–4. [PubMed: 15184200]

19. Zhao X, Wu JF, Xiu QY et al. A randomized controlled clinical trial of levofloxacin 750 mg versus 500 mg intravenous infusion in the treatment of community-acquired pneumonia. Diagn Microbiol Infect Dis. 2014; 80:141–7. [PubMed: 25130297]

20. Hurst JM, Bosso JA. Antimicrobial stewardship in the management of community-acquired pneumonia. Curr Opin Infect Dis. 2013; 26:184–8. [PubMed: 23434896]

21. Avdic E, Cushinotto LA, Hughes AH et al. Impact of an antimicrobial stewardship intervention on shortening the duration of therapy for community-acquired pneumonia. Clin Infect Dis. 2012; 54:1581–7. [PubMed: 22495073]

22. Mandell LA, Wunderink RG, Anzueto A et al. Infectious Diseases Society of America/American Thoracic Society consensus guideline on the management of community-acquired pneumonia in adults. Clin Infect Dis. 2007; 44:S27–72. [PubMed: 17278083]



Risk Factor Status	Duration of Therapy
• No immunocompromise • No structural lung disease	5 days
• Moderate immunocompromise • Moderate structural lung disease	7 days
• Poor initial clinical response • Severe structural lung disease • Severe immunocompromise	10–14 days

Note: Immunocompromise is defined as history of solid organ transplantation, receipt of active chemotherapy for cancer, immunodeficiency syndrome (including HIV infection), receipt of active immunosuppressant therapy (including long-term steroid therapy with prednisone at >10 mg/day or equivalent)

[a]Consider addition of vancomycin to regimen in patients with risk factors for MRSA pneumonia (i.e., chronic hemodialysis, intravenous drug use, recent influenza, and antibiotic therapy in preceding 90 days).
[b]Doxycycline 100 mg i.v. or orally b.i.d. may be substituted for azithromycin if concerns for QT prolongation exist.
[c]Not recommended for use during pregnancy.
[d]Antimicrobial doses listed above assume normal renal function (CL_{cr} of >50 mL/min).

Figure 1.

Treatment guideline and clinical pathway for management of community-acquired pneumonia at the study site. ICU = intensive care unit, HIV = human immunodeficiency virus, MRSA = methicillin-resistant Staphylococcus aureus, CLcr = creatinine clearance.

Table 1

Patient Demographics by Study Period[a]

Variable	Baseline (*n* = 221)	Post-ASP Year 1 (*n* = 175)	Post ASP Year 2 (*n* = 132)	*P*	
				Baseline vs. Post-ASP Year 1	Baseline vs. Post-ASP Year 2
Mean age, yr	68.62	66.84	66.45	0.269	0.208
Mean weight, kg	83.31	84.74	88.75	0.601	0.089
Sex, no. (%) female	118 (53.4)	88 (50.3)	64 (48.5)	0.539	0.372
Comorbidities, no. (%)					
Hypertension	131 (59.3)	94 (53.7)	66 (50.0)	0.247	0.090
COPD	81 (36.7)	55 (31.4)	54 (40.9)	0.277	0.426
Diabetes	72 (32.6)	59 (33.7)	50 (37.9)	0.812	0.311
Heart failure	54 (24.4)	38 (21.7)	28 (21.2)	0.524	0.488
Atrial fibrillation	49 (22.2)	44 (25.1)	20 (15.2)	0.489	0.108
Asthma	41 (18.6)	25 (14.3)	23 (17.4)	0.258	0.790
Tobacco use	27 (12.2)	17 (9.7)	21 (15.9)	0.431	0.328

[a]ASP = antimicrobial stewardship program, COPD = chronic obstructive pulmonary disease.

Table 2

Comparative Data on Antimicrobial Stewardship Program Outcomes by Study Period[a]

Outcome	Baseline (*n* = 221)	Post-ASP Year 1 (*n* = 175)	Post-ASP Year 2 (*n* = 132)	*P*	
				Baseline vs. Post-ASP Year 1	Baseline vs. Post-ASP Year 2
Inpatient mortality, no. (%)	11 (5.0)	5(2.9)	2(1.5)	0.318	0.143
30-Day all-cause readmission, no. (%)	15 (6.8)	14 (8.0)	12 (9.1)	0.646	0.431
30-Day readmission due to pneumonia or shortness of breath, no. (%)	8 (3.6)	8 (4.6)	6(4.6)	0.633	0.666
CDI acquisition, no. (%)	2 (0.9)	1 (0.6)	1 (0.8)	1.000	1.000
Mean ± S.D. LOS, days	7.24 ±6.80	5.71 ±4.33	5.52 ±3.57	0.011	0.008
Mean ± S.D. duration of inpatient antimicrobial therapy, days	5.68 ±3.25	5.08 ± 2.47	4.99 ± 2.02	0.045	0.030
Mean ± S.D. total duration of antimicrobial therapy, days	9.69 ±3.76	8.85 ±3.07	8.38 ±2.49	0.019	0.001

[a]CDI = Clostridium difficile infection, LOS = length of stay.

Table 3

Days of Inpatient Therapy With Selected Drugs per 100 Total Days of Antimicrobial Use, by Study Period[a]

Drug	Baseline (Total Days = 1,238)	Post-ASP Year 1 (Total Days = 873)	Post-ASP Year 2 (Total Days = 659)	*P*	
				Baseline vs. Post-ASP Year 1	Baseline vs. Post-ASP Year 2
Azithromycin	38	47	53	0.002	<0.001
Ceftriaxone	37	47	56	<0.001	<0.001
Levofloxacin	47	40	23	0.016	<0.001

[a]ASP = antimicrobial stewardship program.

Table 4

Comparative Data on Interventions Related to Community-Acquired Pneumonia, by Study Period[a]

Variable	Post-ASP Year 1	Post-ASP Year 2	*P*
No. days of ASP operation	230	234	…[b]
Accepted direct-to-provider interventions (%)	90.64	86.60	0.117
Interventions per day	1.42	1.83	<0.001
Total no. interventions	326	429	…
No. direct-to-provider interventions	267	373	…
No. auto-substitution interventions	59	56	…
Rate of i.v.-to-oral conversion (%)	18.10	15.15	0.279
Rates of interventions, by type (%)			
Drug information	2.15	3.03	0.454
Renal dosing	2.76	1.86	0.437
Laboratory test or drug level ordered	0	0.47	0.509
Escalation of therapy	3.07	4.66	0.267
De-escalation of therapy	27.91	35.66	0.024
Duration of therapy	33.74	23.78	0.003
Duplication of therapy	1.23	0	0.034
Drug-organism mismatch	1.23	0.93	0.732
Dose optimization	9.82	8.86	0.653
Miscellaneous	0	5.59	<0.001

[a] ASP = antimicrobial stewardship program.

[b] Not calculated.