ORIGINAL RESEARCH

Audit and Feedback-Focused approach to Evidence-based Care in Treating patients with pneumonia in hospital (AFFECT Study)

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ABSTRACT

Background: Pneumonia is the eighth leading cause of death in Canada. Use of guideline-concordant therapy tempers the development of resistance, decreases health care costs, and reduces morbidity and mortality.

Objectives: The purpose of this study was to optimize the treatment of patients with pneumonia under hospitalist care by focusing on best practice and local antibiogram data. The objectives were to collaborate with a hospitalist representative to optimize in-hospital treatment of patients with community-acquired, hospital-acquired, and health care–associated pneumonia; to complete a baseline audit to determine the proportion of antibiotic orders adhering to the strategy; to present the strategy and baseline audit findings to the hospitalists; to perform a post-intervention audit, with comparison to baseline, and to present results to the hospitalists; to expedite de-escalation to a narrower-spectrum antibiotic; to expedite parenteral-to-oral step-down therapy and promote appropriate duration of therapy; and to determine if a pneumonia scoring system was used.

Methods: An audit and feedback intervention focusing on pre- and post-intervention retrospective chart audits was completed. Review of pneumonia guidelines and the local antibiogram assisted in identifying the study strategy. A presentation to the hospitalists outlined antimicrobial stewardship principles and described the findings of the baseline audit. Pre- and post-intervention audit results were compared.

Results: Local best-practice treatment algorithms were developed for community-acquired pneumonia and for hospital-acquired and health care–associated pneumonia. The pre-intervention audit covered the period December 2011 to January 2012, with subsequent education and audit results presented to the hospitalists in November 2012. The post-intervention audit covered the period December 2012 to January 2013. Adherence to the treatment algorithms increased from 10% (2/21) in the pre-intervention audit to 38% (5/13) in the post-intervention audit. There was a trend to reduced duration of therapy in the post-intervention group.

Conclusion: An audit and feedback intervention related to hospitalists' prescribing for pneumonia increased adherence to local best practice.

Keywords: pneumonia, antimicrobial stewardship, audit and feedback

RÉSUMÉ

Contexte : La pneumonie est la huitième cause de mortalité au Canada. L'utilisation d'un traitement qui respecte les lignes directrices permet de freiner le développement de la résistance, de diminuer les coûts de soins de santé et de réduire la morbidité et la mortalité.

Objectifs : Le but de cette étude était d'optimiser le traitement des patients atteints de pneumonie qui sont suivis par des médecins hospitaliers en mettant l'accent sur les meilleures pratiques et les données locales d'antibiogrammes. Les objectifs étaient de collaborer avec un représentant des médecins hospitaliers afin d'optimiser les traitements à l'hôpital de patients atteints d'une pneumonie extra-hospitalière, nosocomiale ou associée aux soins de santé; d'effectuer une vérification initiale afin d'établir la proportion d'ordonnances d'antibiotiques qui respectent la stratégie; de présenter la stratégie et les conclusions de la vérification initiale aux médecins hospitaliers; d'effectuer une vérification post-intervention ainsi qu'une comparaison de cette dernière à la vérification initiale et de présenter les résultats aux médecins hospitaliers; d'accélérer le passage à un antibiotique à spectre plus étroit; de hâter le passage d'un traitement parentéral à un traitement oral et de favoriser le respect de la durée recommandée de la thérapie; et de déterminer si un système de notation pour la pneumonie a été utilisé.

Méthodes : Une vérification et une intervention de rétroaction portant sur les vérifications rétrospectives de dossiers médicaux pré- et post-intervention ont été réalisées. Un examen des lignes directrices de traitement de la pneumonie et des données locales d'antibiogrammes a aidé à définir la stratégie d'étude. Une présentation destinée aux médecins hospitaliers exposait les principes de gestion responsable des antimicrobiens et décrivait les conclusions de la vérification initiale. Les résultats des vérifications pré- et post-intervention ont été comparés.

Résultats : Des algorithmes de traitement stipulant les meilleures pratiques locales ont été élaborés pour la pneumonie extra-hospitalière et pour les pneumonies nosocomiale et associée aux soins de santé. La vérification pré-intervention a porté sur la période de décembre 2011 à janvier 2012 et elle a été suivie de la présentation des conclusions en découlant aux médecins hospitaliers ainsi que de la formation de ceux-ci en novembre 2012. La vérification post-intervention a porté sur la période de décembre 2012 à janvier 2013. L'observance des algorithmes de traitement est passée de 10 % (2/21) lors de la vérification pré-intervention à 38 % (5/13) lors de la vérification post-intervention. Une tendance à la réduction de la durée du traitement dans le groupe post-intervention a été observée.

Conclusion : Une vérification et une intervention de rétroaction portant sur les habitudes de prescription des médecins hospitaliers traitant les personnes atteintes de pneumonie ont permis d'améliorer l'observance des meilleures pratiques locales.

Mots clés : pneumonie, gestion responsable des antimicrobiens, vérification et rétroaction

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INTRODUCTION

Pneumonia is the eighth leading cause of death in Canada.[1] The incidence of pneumonia and death related to pneumonia has continued to escalate despite advances in health care and antimicrobial therapy.[2-5] The development of pneumonia in a hospital inpatient is associated with an estimated excess cost of about US$4947 per patient and extends the hospital stay by approximately 8 days.[3,5] Appropriate and timely antibiotic treatment of pneumonia reduces the risk of complications, helps curb the development of antibiotic resistance, decreases health care costs, and reduces morbidity and mortality.[6-10]

Inappropriate empiric antibiotic therapy is associated with an increased risk of death, prolonged length of hospital stay, higher rates of clinical failure, and more frequent readmission to hospital.[11-14] Changing therapy once culture results are available may not reduce this risk; therefore, appropriate empiric therapy is essential for an optimal outcome.[8,11-14]

Classification of Pneumonia

Pneumonia is classified based on the setting where it is acquired: hospital-acquired pneumonia (HAP), health care–associated pneumonia (HCAP), and community-acquired pneumonia (CAP).[2-4]

HAP, an inflammatory condition of the lungs that develops more than 48 h after hospital admission, is caused by infectious agents that were not present or incubating at the time of admission.[4] Late-onset HAP occurs 96 h after admission and commonly involves multidrug-resistant (MDR) pathogens.[3,4]

HCAP is diagnosed in patients with one or more of the following characteristics: hospitalized in an acute care institution for more than 1 day in the previous 3 months, received IV antibiotic therapy or chemotherapy, received wound care in the past 30 days, attended a hospital or hemodialysis clinic, or residence in a nursing home or long-term care facility.[4] The pathogens associated with HCAP vary depending on the specific type of facility and patient population.[15]

CAP is an acute infection of the lungs in a patient who does meet any of the HCAP criteria and who was not hospitalized at the time of symptom onset.[16] Determining the site of initial treatment is an important clinical decision in managing patients with CAP and is often based on severity.[2,16] Prognostic models such as the Pneumonia Severity Index (PSI) or the CURB-65 severity score (based on confusion, uremia, respiratory rate, blood pressure, and age) can be used as a guide, in conjunction with clinical judgment, to identify patients who are at low risk for adverse outcomes and who may be treated in an outpatient setting.[2,16-19] The PSI is time-consuming to use, as it requires the calculation of a score based on 20 variables; in contrast, the CURB-65 score is easier to use and relies on calculation of only 5 variables.[18,19]

Treatment of Pneumonia

A variety of pneumonia treatment guidelines have been published.[2-4,20-24] Differences between these guidelines complicate prescribing and may result in non-guideline–based treatment.[2] To provide effective treatment for a specific clinical setting, local microbiologic data should be used in conjunction with published evidence-based guidelines, as resistance patterns can vary markedly.[2,3]

Antimicrobial Stewardship and Audit and Feedback Programs

Antimicrobial stewardship refers to the appropriate selection, dosing, route, and duration of antimicrobial therapy.[25] Resistance to antimicrobial agents is increasing, and the development of novel antimicrobial agents is lacking, which places increased importance on antimicrobial stewardship.[26] Two core strategies providing the foundation for an antimicrobial stewardship program are prospective audit of antimicrobial use (with intervention and feedback to the prescribing physician) and formulary restriction.[25] The first of these core strategies formed the basis of the AFFECT study, reported here. Persuasive and restrictive interventions have been shown to be equally effective after 6 months.[27]

Audit and feedback constitute an approach that is used to improve practice, involving measurement of an individual's or group's practice and comparison with standards or targets.[28] The feedback component includes dissemination of the results in relation to a standard, with the belief that health care professionals are compelled to adjust their practice when their performance is inconsistent with the group or desired target.[28,29] Audit and feedback generally lead to small but potentially important improvements in professional practice.[5,28]

Barriers to the implementation of antimicrobial stewardship include the need to obtain adequate administrative support and potential antagonism from prescribers.[30,31] Including prescribers in the development of a program before implementation can effectively overcome these barriers.[32]

A previous audit and feedback pilot study of antimicrobial stewardship in the critical care setting demonstrated that a formal, prospective audit and feedback program led to more appropriate use of broad-spectrum antimicrobial agents and illustrated that pharmacists can play a pivotal role in promoting appropriate antimicrobial utilization.[32,33]

Goal 3, objective 3.9 of the Canadian Society of Hospital Pharmacy 2015 initiative—"…pharmacists will be actively involved in medication- and vaccination-related infection control programs"—further supports the proposition that pharmacists should actively apply evidence-based methods to the improvement of antimicrobial treatment.[34]

Prescriber Practice

Individual prescribing practices may differ depending on professional practice area or training. Hospitalists are distinct from other physicians in that they practise medicine full-time within an institutional setting.[35] Increasing evidence supports hospitalists' ability to better manage hospital resources, shorten average length of stay, reduce health care expenditures, and potentially improve patient outcomes.[35,36] As stated by Rosenberg of the North Shore University Hospital in Long Island, New York, "hospitalists are positioned as excellent champions of the principles and practices of antimicrobial stewardship".[37]

Hospitalists at the authors' institution expressed interest in partnering with hospital pharmacists to evaluate their antimicrobial prescribing practice. This set the stage for an antimicrobial stewardship study to effect practice change.

Purpose and Objectives

The overall purpose of this study was to optimize the antibiotic treatment of pneumonia for patients under hospitalist care according to antimicrobial stewardship principles focusing on best practice and local antibiogram data.

The specific objectives were to collaborate with a hospitalist representative to optimize in-hospital treatment of patients with HAP, HCAP, or CAP; to complete a baseline audit to determine the proportion of antibiotic orders adhering to the strategy; to present the strategy and baseline audit findings to the hospitalists; to perform a post-intervention audit, with comparison to baseline, and to present results to the hospitalists; to expedite de-escalation to a narrower-spectrum antibiotic; to expedite parenteral-to-oral step-down therapy and promote appropriate duration of therapy; and to determine if a pneumonia scoring system was used.

METHODS

The study consisted of 3 phases: a baseline chart audit, an educational intervention, and a post-intervention chart audit. The study methods were developed in collaboration with a hospitalist representative (R.T.). Eight local hospitalists served the study population in both the pre- and post- intervention phases. The study was approved by the Regina Qu'Appelle Health Region Research Ethics Board.

Identifying Best Practice

The initial steps to devise the study strategy included a review of the literature and collaboration with the hospitalist representative. These steps were followed by review of the health region's current antibiogram and consultation with the local infectious disease specialists and medical microbiologist.

Study Population and Timelines

Patients at least 13 years of age admitted to hospital with pneumonia were identified for inclusion in the study. The pre-intervention audit covered the period from December 1, 2011, to January 31, 2012, and the post-intervention audit from December 1, 2012, to January 31, 2013. The audit periods were limited to 2 months each, because of time constraints on the primary investigator (K.H.) to complete the project during a 1-year hospital pharmacy practice residency. Patients with active tuberculosis and patients undergoing mechanical ventilation were excluded, as the treatment options did not apply to these groups.

Pre-Intervention Chart Audit

A retrospective chart audit, covering the period December 1, 2011, to January 31, 2012, was performed to identify the antibiotics prescribed by local hospitalists. Data collection was completed using Fluid Surveys (http://fluidsurveys.com), a Canadian software system for online survey and data collection.

Patient characteristics were collected for comparison between groups. Outpatient medication profiles were reviewed to identify antibiotic use during the 3 months before hospital admission. Data to calculate both the PSI and CURB-65 scores were collected for group comparison purposes. Adherence to best practice was evaluated using the study strategy described above (Figure 1).

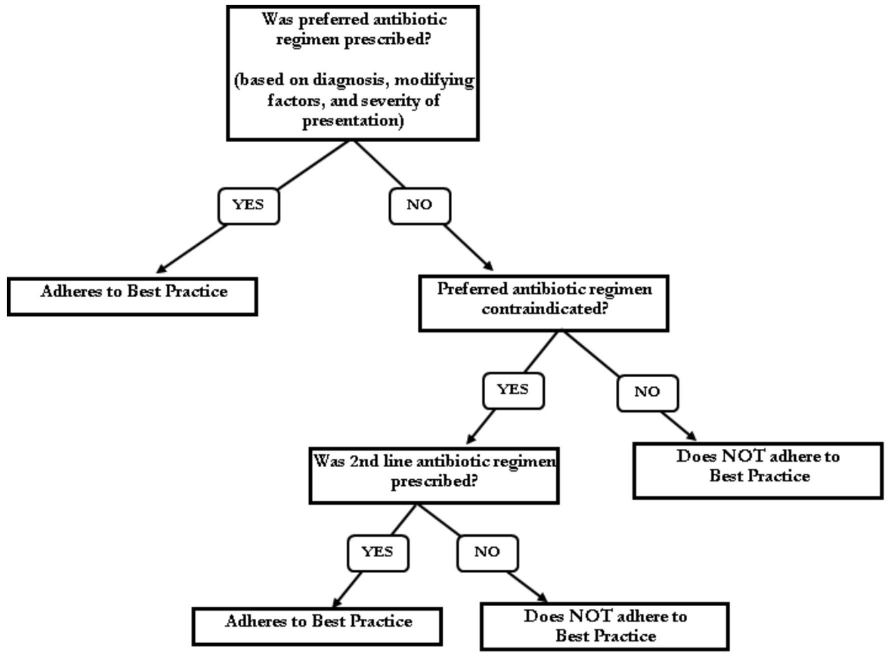

Figure 1. Study strategy for the AFFECT study (Audit and Feedback-Focused approach to Evidence-based Care in Treating patients with pneumonia in hospital). This strategy was used to determine whether each hospitalist adhered with best practice for antimicrobial prescribing for patients with pneumonia.

Table 1. Patient Characteristics

Characteristic	No. (%) of Patients*		*p* Value
	Pre-intervention (n = 21)	Post-intervention (n = 13)	
Sex, male	12 (57)	5 (38)	0.29
Age (years) (median and IQR)	81 (51.5–88.5)	80 (54.5–88)	0.88
Antibiotic allergy	2 (10)	3 (23)	0.27
Antibiotics in previous 3 months	13 (62)	6 (46)	0.37
Type of pneumonia			
Health care–associated	14 (67)	6 (46)	0.24
Hospital-acquired	4 (19)	2 (15)	0.78
Community-acquired	3 (14)	5 (38)	0.28
Risk factors for multidrug-resistant pathogens†			
Antimicrobial therapy in previous 3 months	13 (62)	5 (38)	0.37
Current hospital stay ≥ 5 days	3 (14)	2 (15)	0.53
Immunosuppressive disease or therapy	1 (5)	1 (8)	0.72
Total	17 (81)	8 (62)	0.21

IQR = interquartile range.
*Except where indicated otherwise.
†Associated with health care–associated, hospital-acquired, or community-acquired pneumonia.

Educational Intervention and Audit and Feedback

Literature searches with the subject headings "guideline adherence", "physician's practice patterns", "professional education", "audit and feedback", "antimicrobial stewardship", and "drug utilization" were conducted to identify previously successful strategies promoting antimicrobial stewardship and practice change. An educational strategy utilizing audit and feedback was then developed.

The primary investigator was invited to present at the monthly hospitalist meeting on November 29, 2012. The presentation focused on antimicrobial stewardship principles, identified best practice, and individual and group findings of the baseline audit.

Post-intervention Audit

The post-intervention chart audit was conducted in the same manner as the pre-intervention audit. χ^2 analysis was used to determine if there had been any improvement in adherence to best practice. The final study results were presented to the hospitalists on May 30, 2013.

RESULTS

Population

There were no significant differences between the pre- and post-intervention patient groups (Table 1). In the pre-intervention audit, the institution's Health Information Management Services identified 24 potentially eligible patient visits, of which 3 were excluded, leaving a total of 21 for study analysis (Figure 2). In the post-intervention audit, 21 patient visits were identified for review, of which 8 were excluded, leaving a total of 13 (Figure 3).

Development of Best Practice

A comprehensive literature search of the MEDLINE, International Pharmaceutical Abstracts, and Embase databases with subject headings "pneumonia", "anti-bacterial agents", and "practice guidelines" was completed to identify best practice for the treatment of HAP, HCAP, and CAP. The most recent local antibiogram (for 2010/2011) defining susceptibility of respiratory isolates was used to tailor antibiotic choices. Two treatment algorithms, one for CAP and one for HAP and HCAP, were then developed in collaboration with the hospitalist representative. Local infectious diseases specialists and a medical microbiologist, as well as infectious diseases pharmacists from other Canadian centres, were consulted to assist with the selection of antibiotic treatments to appear in the algorithms. The local infectious diseases and medical microbiology specialists made suggestions for changes, and final deliberation was completed in consultation with the hospitalist representative and local infectious diseases pharmacist. (The algorithms are available in Appendices 1 and 2, online at www.cjhp-online.ca/index.php/cjhp/issue/view/100/showToc).

Creation of the pneumonia treatment algorithms was challenging, as the guideline recommendations are wide-ranging and varied.[2-4,21-24] It is also not well defined whether HCAP treatment should align with CAP or HAP therapy.[38-46]

The classification of HCAP was introduced in the 2005 American Thoracic Society/Infectious Diseases Society of America (ATS/IDSA) guidelines,[3] which suggested that patients who develop pneumonia in the community and have specific risk factors should be treated similarly to those with HAP, including coverage for MDR pathogens (Table 2). The frequency of MDR pathogens and whether all MDR risk factors are relevant in all practice settings is unclear and complicate determination of antibiotic recommendations using local data.[38-46]

Given limited identification of MDR pathogens in the authors' health region and to prevent the unnecessary use of broad-spectrum antibiotics, the algorithms did not incorporate all MDR risk factors identified by the ATS/IDSA guidelines (Table 2). The most common MDR pathogens identified in the health region were *Pseudomonas aeruginosa* and methicillin-resistant *Staphylococcus aureus* (MRSA) (Table 3). Very few MDR Enterobacteriaceae species and *Acinetobacter* species have been identified in the health region.

It was felt that resistance patterns in this health region aligned more closely with those in Britain than those in the United States, which allowed for reduced use of broad-spectrum antibiotics.[47,48] *P. aeruginosa* is the most common MDR gram-negative pathogen causing HAP in the United States, with a prevalence of 14%–16% and resistance rates as high as 19% for ceftazidime, 14% for piperacillin–tazobactam, 18% for meropenem, 35% for ciprofloxacin, and 16% for tobramycin.[3,49] In contrast, the 2010/2011 local antibiogram identified the prevalence of *P. aeruginosa* in respiratory isolates as 8.7% and the resistance rates as 8% for ceftazidime, 5% for meropenem, 11% for ciprofloxacin, and 1% for tobramycin; i.e., considerably more susceptible (Table 3). Therefore, empiric *P. aeruginosa* coverage was recommended for a more defined patient population than in the ATS/IDSA guidelines, and carbapenems were not listed.

Another area of controversy in developing the treatment algorithms related to the use of a second-generation cephalosporin (e.g., cefuroxime).[2-4,21,23,24] Oral amoxicillin–clavulanate was recommended over oral cefuroxime because of its better oral bioavailability and lower cost.[50,51] IV ceftriaxone, a third-generation cephalosporin, was preferred over IV cefuroxime on the basis of its increased coverage of *Streptococcus pneumoniae*, as well as broader coverage of gram-negative organisms.[50,51] The local antibiogram for respiratory isolates reported that *S. pneumoniae* susceptibility was 81% for cefuroxime and 92% for ceftriaxone; therefore, amoxicillin-clavulanate and ceftriaxone were chosen for the algorithms. The hospitalists expressed concern regarding gastrointestinal intolerance with amoxicillin-clavulanate but stated there had been no reports of patient gastrointestinal discomfort. Tobramycin was selected as the aminoglycoside of choice, as local susceptibility data showed *P. aeruginosa* isolates were 99% susceptible to this drug (only 90% susceptible to gentamicin), and there were no other limiting factors for use (e.g., tolerability, cost).

A variety of recommendations for empiric coverage of MRSA appear in the literature.[2-4,21-24] Given the low frequency of MRSA respiratory isolates in the health region (6.3%), empiric MRSA coverage was recommended only for patients with a previous positive culture or confirmed colonization with MRSA. During the post-intervention meeting, the hospitalists indicated that they often consider IV drug users to be at risk for MRSA. This is consistent with findings that IV drug users have a higher rate of nasal or skin colonization with *S. aureus* than the general population and that nasal carriage is associated with an increased risk of subsequent infection. The rate of MRSA colonization in IV drug users has been reported as about 19%.[52,53]

The algorithms emphasized avoidance of any antibiotic from the same class as used in the previous 3 months, as this may contribute to the development of antibiotic resistance.[54,55]

Educational Intervention

On November 29, 2012, at the monthly hospitalists' meeting, the primary investigator presented an overview of the study and provided instructions on using the treatment algorithms, to ensure accurate interpretation. Feedback was solicited to modify the algorithms, if warranted. There were only minor suggestions for change, which were subsequently incorporated. This process did not require re-examination of the pre-intervention audit results.

A pivotal point in the meeting was dissemination of the pre-intervention audit findings. Each hospitalist was given a sealed envelope containing his or her data on pre-intervention prescribing practices and a personal identifier to allow for anonymous comparison with the other hospitalists' practice, as well as comparison with the group's collective practice.

The hospitalists were encouraged to carry copies of the treatment algorithms with them, and posters were placed on the nursing units most commonly frequented by the hospitalists. Brief educational in-services about the study were provided to the nurses on these units and to the health region pharmacists, to increase their awareness of the study and its implications for potential change in antibiotic prescribing.

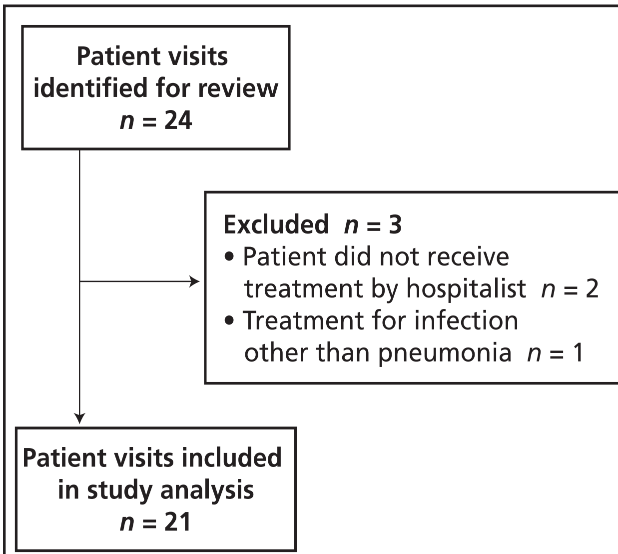

Figure 2. Identification of patient visits eligible for inclusion in the pre-intervention audit.

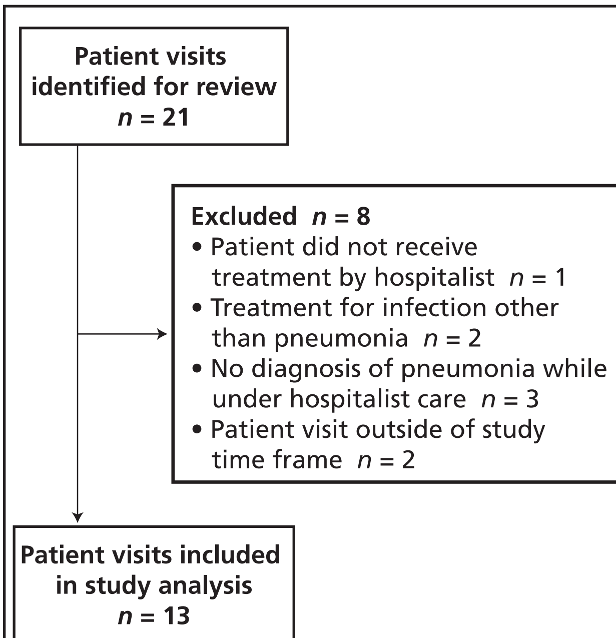

Figure 3. Identification of patient visits eligible for inclusion in the post-intervention audit.

Adherence to Best Practice

The results from the pre- and post-intervention audits were compared with identified best practice to determine the proportion of orders in adherence (Figure 1). The adherence rates were 10% (2/21) at baseline and 38% (5/13) in the post-intervention audit, a statistically significant 4-fold increase (Table 4).

Table 2. American Thoracic Society/Infectious Diseases Society of America Risk Factors for Multidrug-Resistant Pathogens[3]

Antimicrobial therapy in preceding 90 days
Current hospital stay of 5 days or more
High frequency of antibiotic resistance in community (or in specific hospital unit)*
Risk factors for health care–associated pneumonia: • Admission to hospital for 2 days or more in preceding 90 days • Residence in a nursing home or extended care facility • Home infusion therapy (including antibiotics) • Long-term dialysis within 30 days • Home wound care • Family member with multidrug-resistant pathogen*
Immunosuppressive disease and/or therapy

*These factors were excluded from consideration in the AFFECT study.

Table 3. Positive Respiratory Isolates for Inpatients*

Organism	No. (%) of Respiratory Isolates (*n* = 621)
Streptococcus pneumoniae	104 (16.7)
Haemophilus spp.	95 (15.3)
Methicillin-susceptible *Staphylococcus aureus*	84 (13.5)
Pseudomonas aeruginosa	54 (8.7)
Moraxella catarrhalis	46 (7.4)
Methicillin-resistant *Staphylococcus aureus*	39 (6.3)

*Based on local antibiogram 2010/2011.

Major changes from the pre-intervention audit to the post-intervention audit were increases in the prescribing of amoxicillin-clavulanate and azithromycin and reductions in use of levofloxacin and moxifloxacin, changes that are consistent with the treatment algorithm recommendations (Table 5).

There were no significant changes in the duration of IV, oral, or total treatment from the pre-intervention to the post-intervention audit, except for oral therapy in HCAP patients, which significantly decreased (Table 6). This finding was in direct contrast to the study objective of reducing the duration of IV therapy. There was, however, a nonsignificant trend to reduced duration of total therapy in the post-intervention group.

In the pre-intervention audit only 2 patients had a positive blood or respiratory culture, and the antibiotic was appropriately de-escalated to a narrower-spectrum agent on the basis of culture and sensitivity results. In the post-intervention audit, one patient had a positive respiratory culture, which was also appropriately de-escalated.

PSI and CURB-65 scores were not documented by any of the physicians in either phase of the study; however, the primary investigator was able to calculate the scores for all patients. Although these scores have not been validated for use in patients with HCAP and HAP, they were calculated for all patients in the AFFECT study in an attempt to measure disease severity in each group. The mean PSI and CURB-65 scores did not differ significantly between the pre-intervention and post-intervention groups (Table 7). According to the PSI score, 33% and 23% of patients in the pre- and post-intervention groups, respectively, qualified for outpatient management (Table 8). In both the pre- and the post-intervention groups, the CURB-65 scores suggested that a greater proportion of patients qualified for outpatient treatment, 52% and 31%, respectively (Table 8). The difference in site-of-care recommendations between the PSI and CURB-65 scores was influenced by the advanced age of the study population (given that age influences the PSI score more significantly).[18] The patients included in the study had a wide range of comorbid conditions that were not captured by either the PSI or CURB-65 scores but that likely influenced the severity of illness.

Post-Intervention Feedback

The primary investigator shared the post-intervention audit results with the hospitalists at their monthly meeting on May 30, 2013. Feedback on the post-intervention data was provided in the same concealed and individualized manner as during the initial presentation.

DISCUSSION

The following were the primary reasons for non-adherence to the pneumonia treatment algorithms by hospitalists: using fluoroquinolone or a second-generation cephalosporin, not prescribing treatment for MDR organisms for patients with a risk factor, treating patients with HCAP the same as those with CAP, and prescribing ciprofloxacin instead of tobramycin in patients with estimated creatinine clearance above 50 mL/min. In the pre-intervention audit, fluoroquinolone monotherapy was prescribed for the majority of patients, as recommended in the IDSA/ATS guidelines[2,3]; however, use of fluoroquinolone was not a recommendation in the local treatment algorithms. Low adherence in the pre-intervention audit can also be explained by the fact that antibiotic choices were likely based on past practice and published guidelines, not local treatment algorithms.

Table 4. Adherence to Best-Practice Antibiotic Regimens

Type of Pneumonia	No. (%) of Patients* Pre-intervention	No. (%) of Patients* Post-intervention	*p* Value
Health care–associated	1/14 (7)	1/6 (17)	0.52
Hospital-acquired	0/4 (0)	0/2 (0)	NA
Community-acquired	1/3 (33)	4/5 (80)	0.19
Total	2/21 (10)	5/13 (38)	0.043

*Percentages are calculated on the basis of the number of cases within each type.

Table 5. Antibiotic Utilization

Antibiotic	No. (%) of Patients Pre-intervention (n = 21)	No. (%) of Patients Post-intervention (n = 13)	*p* Value
Cefuroxime	7 (33)	3 (23)	0.52
Levofloxacin	7 (33)	0	0.029
Moxifloxacin	7 (33)	1 (8)	0.09
Ceftriaxone	5 (24)	3 (23)	0.96
Piperacillin–tazobactam	4 (19)	3 (23)	0.78
Azithromycin	3 (14)	7 (54)	0.014
Ciprofloxacin	3 (14)	2 (15)	0.93
Vancomycin	3 (14)	1 (8)	0.56
Ceftazidime	2 (10)	1 (8)	0.86
Metronidazole	1 (5)	0	0.42
Trimethoprim–sulfamethoxazole	1 (5)	0	0.42
Amoxicillin-clavulanate	0	4 (31)	0.015
Gentamicin	0	0	NA
Tobramycin	0	0	NA

NA = not applicable.

Table 6. Duration of Therapy

Type of Pneumonia and Type of Therapy	Mean Duration ± SD (days) Pre-intervention (n = 21)	Mean Duration ± SD (days) Post-intervention (n = 13)	*p* Value
All types of pneumonia			
Overall	10.8 ± 4.2	9.1 ± 3.8	0.23
IV	4.7 ± 5.5	5.0 ± 4.7	0.88
Oral	6.3 ± 4.1	4.5 ± 4.4	0.24
Health care–associated pneumonia			
Overall	10.4 ± 4.0	9.0 ± 5.1	0.53
IV	2.8 ± 3.7	6.5 ± 5.2	0.08
Oral	7.9 ± 3.2	3.5 ± 3.2	0.012
Hospital-acquired pneumonia			
Overall	12.8 ± 6.2	8.0 ± 1.4	0.37
IV	10.5 ± 7.9	7.0 ± 0.0	0.58
Oral	2.3 ± 3.2	1.0 ± 1.4	0.64
Community-acquired pneumonia			
Overall	10.3 ± 2.1	9.6 ± 3.2	0.74
IV	6.0 ± 4.6	2.4 ± 4.3	0.31
Oral	4.3 ± 5.1	7.2 ± 5.2	0.48

SD = standard deviation.

The hospitalists identified 2 additional reasons for nonadherence: the paper copy of the algorithm was inconvenient, and antibiotic therapy was often started in the emergency department, before the patient was seen by a hospitalist. If a patient had received only one dose before the hospitalist assumed care, the hospitalists generally felt comfortable changing therapy to adhere to the algorithm; however, if more than one dose had been administered, they felt less comfortable changing the therapy, especially if a therapeutic response had already occurred. It was suggested that a similar educational strategy be conducted with emergency department physicians, to promote consistent use of the algorithms. It was also suggested that transformation of the algorithms into a format compatible with mobile devices would facilitate increased use.

At the end of the post-intervention meeting, the hospitalists expressed interest in continued use of the algorithms. One of the hospitalists stated, "I like the algorithms. They slow me down in my thinking." Another said, "They are not algorithms that you are going to remember after using a few times. You have to reflect on the choices and then apply them to practice." The hospitalists also indicated that no situation arose in which they consciously decided not to use the algorithms.

The effectiveness of restrictive interventions on antibiotic prescribing has been shown to decrease with time; however, combining restrictive interventions with additional persuasive interventions, such as audit and feedback, may promote the longevity of effect.[27] To promote the sustainability of the AFFECT study, the possibility of repeat audits of hospitalists' prescribing (either by the physicians themselves or by medical residents) being completed every 6 to 12 months was discussed. It was further suggested that a prospective audit could be developed using a simplified process and audit form, and that involving physicians in auditing their own practice could potentially have a greater and more sustainable impact.

Limitations

This study had several limitations. The data collection period was short, resulting in a small sample size, which made detection of a statistically significaµnt difference difficult, as well as reducing the external generalizability of the results. The short study duration also prevented participation by all hospitalists, as not all of the hospitalists were scheduled to work during the study period.

Because of the short duration of data collection, outcomes such as 30-day mortality and hospital readmission were not considered.

More generally, the hospitalists at this institution are a small group of physicians with a keen interest in practice improvement. The study methods used here may not be suitable for other, more diverse physician groups.

Table 7. Mean PSI and CURB-65 Scores

	Mean ± SD		
	Pre-intervention	Post-intervention	*p* Value
PSI*	99.7 ± 33.8	112.2 ± 25.9	0.26
CURB-65†	1.6 ± 1.5	1.8 ± 1.0	0.75

PSI = Pneumonia Severity Index; CURB-65 = severity score based on confusion, urea, respiratory rate, blood pressure, and age; SD = standard deviation.
*Maximum possible score for PSI varies with age, with the highest score class having values > 130.
†Maximum possible score for CURB-65 = 5.

CONCLUSIONS

An audit and feedback–based intervention focusing on hospitalists' antibiotic prescribing for pneumonia increased adherence to local best practice and resulted in a nonsignificant trend toward reduced duration of treatment. Future audit and feedback–based interventions focusing on other physician groups and different infections or disease states could be undertaken using these study methods.

Table 8. Percentage of Patients in PSI and CURB-65 Risk Classes before and after Intervention

Risk Class	Recommended Site of Care	No. (%) of Patients: Pre-intervention (*n* = 21)	No. (%) of Patients: Post-intervention (*n* = 13)
PSI			
I	Outpatient	0 (0)	0 (0)
II	Outpatient	4 (19)	0 (0)
III	Outpatient	3 (14)	3 (23)
IV	Inpatient	9 (43)	6 (46)
V	Inpatient	5 (24)	4 (31)
CURB-65			
0	Outpatient	5 (24)	1 (8)
1	Outpatient	6 (29)	3 (23)
2	Short-stay inpatient or supervised outpatient	5 (24)	7 (54)
3	Inpatient	2 (10)	1 (8)
4	Inpatient	0 (0)	1 (8)
5	Inpatient/ ICU	2 (10)	0 (0)

PSI = Pneumonia Severity Index; CURB-65 = severity score based on confusion, urea, respiratory rate, blood pressure, and age; ICU = intensive care unit.

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