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Quality Improvement in Hospital Management of Community-Acquired Pneumonia: Focus on New Strategies and Current Challenges

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Abstract Community-acquired pneumonia is a common reason for hospitalization and leads to significant morbidity and mortality. There are published evidence-based guidelines for the diagnosis, treatment, and management of community-acquired pneumonia. Many countries, including the US, have developed national, publically reported quality measures related to the treatment of community-acquired pneumonia. This review highlights recent published innovations aimed at improving the quality of care for patients hospitalized for community-acquired pneumonia. Interventions include standardized protocols and pathways, education and feedback from antimicrobial stewardship teams, and automated pharmacy technology. The importance of multidisciplinary collaboration and multidimensional interventions are discussed. Insight into local context and institutional support are essential to understanding the implementation of improvement efforts and these factors should be reported in future publications related to quality improvement.

Keywords Community-acquired pneumonia · Quality improvement · Quality measures · Antimicrobial stewardship

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Introduction

Community-acquired pneumonia (CAP) is one of the most common causes of hospitalization in the US and results in 1.1 million hospitalizations annually [1]. Pneumonia and influenza combined are the ninth leading cause of death in the US [2]. Older patients are at higher risk of CAP and CAP-associated morbidity and mortality. Among people over the age of 85 years, approximately 1 in 20 will develop CAP each year and more than 50 % of the very elderly with CAP will be hospitalized [3].

Professional societies have established consensus guidelines focused on improving care of patients with CAP. In an effort to create a unified standard for quality CAP care, the Infectious Diseases Society of America (IDSA) and the American Thoracic Society (ATS) published joint guidelines in 2007 [4•]. The guidelines address the following issues: (1) use of severity of illness scores, combined with physician judgment, to distinguish between patients who could be treated as outpatients and those who require higher levels of care, (2) identifying which patients should receive diagnostic testing, such as blood and sputum cultures and tests for specific pathogens, (3) choice of empiric antibiotic therapy based on care setting and risk factors, (4) narrowing treatment, switching to oral antibiotics, and duration of therapy, (5) treatment of critically ill patients with CAP including use of noninvasive ventilation, and (6) prevention efforts including immunization against influenza and *Streptococcus pneumoniae* infection, smoking cessation and respiratory hygiene measures [4•].

Given that certain evidence-based practices have been shown to improve CAP-associated patient outcomes, metrics have been developed to assess the quality of inpatient CAP care. The Centers for Medicare and Medicaid Services (CMS) have established quality measures for CAP that include obtaining blood cultures prior to initial antibiotic treatment and initiation of appropriate antibiotic selection within 24

hours of admission [5]. Until 2012, antibiotic treatment initiation within 6 hours was an additional quality metric; however, this measure was no longer considered appropriate due to concerns that it promoted overuse of antibiotics in patients with other diagnoses [6–8]. Currently, there are no quality measures targeting the time to first dose of antibiotics and IDSA/ATS guidelines recommend initiating the first dose of antibiotic therapy in the emergency department (ED) without a specific time window [4•]. Quality measures also address whether patients are appropriately screened for and receive pneumococcal and influenza vaccinations, if eligible, while hospitalized [5]. Along with acute myocardial infarction and heart failure, pneumonia 30-day mortality rates and 30-day readmission rates are publically reported by CMS and the Hospital Quality Alliance [5]. Table 1 outlines the current CMS quality measures in greater detail. As one of the most common reasons for hospitalization due to any infectious disease, CAP has become a model for developing optimal quality measures, evaluating improvement strategies, and improving patient outcomes.

This review highlights recent developments published within the last year to improve care provided for hospitalized CAP patients with a focus on innovative improvement strategies and current challenges. Table 2 lists the study period, country, clinical setting, interventions and major results for the papers reviewed in this article. As we review successful CAP improvement reports, we focus not only on the specific interventions, but also the associated changes in the environmental and cultural context.

Standardized Multidimensional ICU Management

Dramatic improvements in CAP outcomes, such as mortality and readmission rates, often require multidimensional approaches. A recent study by Georges et al. used a before-and-after design to evaluate improvements achieved following new intensive care unit (ICU) procedures for the management of severe CAP [9•]. During the period 2001–2004, a single urban ICU implemented a sepsis management bundle derived from the Surviving Sepsis Campaign, adopted the use of a third-generation cephalosporin and levofloxacin as the initial empiric antimicrobial regimen for treatment of patients with CAP in the ICU, used low tidal volume ventilation, and standardized the use of noninvasive mechanical ventilation following extubation [9•]. These changes were achieved by implementing a standardized protocol addressing each clinical decision point, implementing an educational program, and making the standardized protocol available to each physician in written form. Patients treated between 2005 and 2010, after these inventions were adopted, had a 31 % mortality rate compared to a 44 % mortality rate for patients treated during the historical period from 1995 to 2000 ($p<0.02$) [9•]. Limitations included the wide time-span (15 years), lack of a contemporaneous control group and lack of data displayed over time; these limitations make it difficult to determine whether the improved outcomes were causally related to the described interventions or due to temporal trends [9•]. The decrease in mortality rate is clinically significant, and may reflect either successful implementation of comprehensive, standardized, written protocols or concurrent improvements in the standard management of CAP and sepsis [4•, 10].

Antimicrobial Stewardship

A key quality measure for CAP focuses on the choice of an appropriate empiric antibiotic regimen on admission [5]. Other treatment goals outlined by the IDSA/ATS guidelines include narrowing treatment to pathogen-directed therapy when possible, using a standard duration of antibiotic therapy and using a standard transition from intravenous to oral therapy, particularly

Table 1 Centers for Medicare and Medicaid and the Joint Commission 2013 Quality Metrics relevant to CAP [5]

National Hospital Inpatient Quality Measures (hospital-reported)		Centers for Medicare and Medicaid Outcomes Measures (claims-based)
Pneumonia	Blood cultures performed within 24 h prior to or 24 h after hospital arrival for patients who were transferred or admitted to the ICU within 24 h of hospital arrival	Hospital 30-day, all-cause, risk-standardized mortality rate (RSMR) following pneumonia hospitalization
	Blood cultures performed in the emergency department prior to initial antibiotic received in hospital	Hospital 30-day, all-cause, risk-standardized readmission rate (RSRR) following pneumonia hospitalization
	Initial antibiotic selection for CAP in immunocompetent patient	
	(a) Immunocompetent ICU patient	
	(b) Immunocompetent non-ICU patient	
Prevention	Pneumococcal immunization, overall rate, age 65 years and older, high-risk populations (age 5–64 years)	
	Influenza, overall rate	
	Tobacco use screening and treatment	

Table 2 Recent studies on interventions to improve quality of care for CAP

Reference	Study period	Country	Clinical setting	Intervention	Results
[9•]	1995–2010	US	Multidisciplinary, 16-bed ICU in an urban academic medical center	Surviving Sepsis Campaign management bundle; use of a third-generation cephalosporin and levofloxacin as the initial empirical antimicrobial regimen, and noninvasive mechanical ventilation following extubation	Mortality decreased from 44 % in the historical group to 31 % in the intervention group ($p<0.05$)
[14•]	2008–2010	US	Tertiary care, urban, academic medical center	A survey related to diagnosis and treatment of CAP; an educational lecture about duration of antibiotics therapy; direct oral feedback to medical staff from the antimicrobial stewardship team	Median duration of antibiotic therapy decreased from 10 to 7 days ($p<0.05$)
[16•]	2007–2008	US	Suburban, tertiary care, community hospital	Automated dispensing cabinet alert; nurses required to answer a series of questions related to blood cultures before antibiotics released	Blood culture compliance increased from 84 % to 95 % following intervention ($p<0.05$)
[17••]	2008–2011	US	Urban, multi-campus, academic medical center	Algorithm to identify appropriate antibiotics in the ED; preloading automatic medication dispensing system	Rates of appropriate CAP antibiotics increased from 60 % in 2008 to 93 % in 2011 ($p<0.05$)
[21•]	2005–2007	Spain	Urban, public, university hospital and an urban, private hospital	Critical pathway consisting of early mobilization, use of objective criteria for transition to oral antibiotic treatment, and use of predefined criteria for hospital discharge	Median duration of intravenous antibiotic therapy decreased from 4.0 days to 2.0 days with intervention ($p<0.05$). Length of stay decreased from 6 to 3.9 days ($p<0.05$)
[23]	2009-2010	New Zealand	Academic medical center	Medical assessment and planning unit (MAPU) for CAP	MAPU patients less severely ill compared with ED patients. Time to initial physician assessment longer in MAPU compared with standard ED care

CAP Community-acquired pneumonia, *ICU* Intensive care unit, *ED* Emergency Department

when hospital discharge is otherwise indicated [4•]. Antimicrobial stewardship programs support clinical decision-making about antibiotic use such as the choice of antibiotic therapy and the duration of therapy. They usually comprise a multidisciplinary team that monitors inpatient data on antibiotic use and uses these data to make real-time recommendations to clinicians [11]. In a recent report, Nussenblatt et al. call on antimicrobial stewardship programs to target duration of therapy and transition to oral therapy as methods of improving patient safety, limiting the emergence of antimicrobial resistance, and reducing healthcare costs [12]. A recent review in this journal noted that there is strong evidence to support the use of active, postprescription interventions, such as postprescription audit and feedback directed by an infectious disease physician or pharmacist [11]. As with all quality improvement efforts, the design and implementation of antimicrobial stewardship programs must be tailored to local institutional practice patterns and needs [13].

A recent study by Advic et al. investigated the use of an antimicrobial stewardship program to improve CAP care [14•]. While the study institution, a large urban academic medical center, had performed well on nationally reported quality metrics, they recognized the need for ongoing improvement. To identify improvement targets, they conducted a prospective, observational trial. The results showed that the greatest deficiencies in meeting CAP guidelines involved further inpatient management following initial empiric therapy. The authors hypothesized that compliance with publically reported measures has led to prompt initiation of appropriate antibiotic therapy, but fewer resources have been focused on assessing the ongoing downstream treatment of patients with CAP resulting in lower compliance [14•].

Leveraging the resources of an existing antimicrobial stewardship program, they implemented an education and prospective feedback intervention to reduce the duration of antibiotic therapy, increase the use of microbiology results to narrow antibiotic regimens, and decrease any duplicate therapy within the first 24 hours of care [14•]. The existing antimicrobial stewardship team, comprising an infectious disease physician and a pharmacist, reviewed the medical records of all adult patients who were admitted with CAP [14•]. For the study purposes, this team confirmed the diagnosis of CAP using

IDSA guidelines [14•]. During the intervention period, the antimicrobial stewardship team provided an education program to medical staff about antibiotic duration and gave direct feedback about prescribing patterns [14•]. Comparing the postintervention period to the preintervention period, the median duration of antibiotic therapy decreased from 10 days to 7 days [14•]. Causative pathogens were less frequently identified in microbiology studies during the postintervention period. Nonetheless, antibiotics were more frequently narrowed or modified on the basis of susceptibility results [14•].

Automated Pharmacy Technology to Improve Performance with Blood Culture Timing

Although the role of blood cultures in CAP remains controversial, obtaining blood cultures in the ED prior to initiating antibiotics to treat CAP is a CMS quality measure [5, 15]. Automated pharmacy technology was utilized in a study by Sikka et al. to remind clinicians to obtain blood cultures prior to antibiotic administration [16•]. Before ED nurses accessed any antibiotics that were commonly used to treat CAP in the ED, the automated dispensing cabinet presented a series of questions about blood cultures [16•]. The automated system would not release antibiotics unless all questions were answered [16•]. If blood cultures had not been ordered or drawn, nurses were reminded to initiate this process prior to administering the antibiotics [16•]. In addition to the alert, any nurses who were noncompliant with the timing of blood cultures or answers to the alert questions received a letter detailing the process [16•]. In their before-and-after study, the rate of compliance with blood cultures prior to antibiotics increased from 84 % before the intervention to 95 % after the intervention [16•].

Antimicrobial Stewardship Combined with Automated Pharmacy Technology

A recent study at the Montefiore Medical Center (MMC) investigated an antimicrobial stewardship intervention at two of its affiliated hospitals [17••]. MMC is a large academic urban healthcare delivery system that regularly engages in quality improvement work. A team comprising improvement specialists, ED staff and an antimicrobial stewardship team including an infectious disease physician and two pharmacists convened to improve appropriateness of empiric antibiotic therapy for CAP. Lack of coverage for atypical bacteria was the most common reason for noncompliance with current recommendations [17••]. The team designed a color-coded algorithm detailing appropriate triaging, diagnostic testing and empiric antibiotics for CAP patients based on IDSA/ATS guidelines and local microbiology patterns. They also designed a "CAP kit" which consisted of intravenous ceftriaxone and oral azithromycin packaged in a drawer of a computerized pharmacy dispensing system, which was triggered by entering a CAP diagnosis. Educational sessions were conducted explaining the guidelines and new processes. The stewardship program used data from the computerized pharmacy dispensing system to examine antimicrobial prescribing patterns and provide feedback to clinicians. Overall, these interventions increased use of appropriate antibiotics for CAP from 60.3 % appropriate use in 2008 to 92.4 % in 2011 [17••]. This study suggests that antimicrobial stewardship programs can be valuable assets in quality improvement efforts in CAP. Interdisciplinary stewardship teams are well placed to collect data on antibiotic use and monitor ongoing improvement in multiple settings (EDs, inpatient wards, ICUs) where prescribing occurs. This study also provides another example of successfully utilizing algorithms and automated pharmacy technology to alter prescribing patterns. The application of specific aspects of algorithms should be influenced by local characteristics of CAP. For example, having a nonquinolone antimicrobial regimen at MMC was appropriate because of the higher rate of tuberculosis in New York City, a diagnosis that may be delayed by the use of a quinolone alone.

Critical Pathways and Operational Improvements

Over the last several decades, critical pathways have been used to improve quality of care particularly for common inpatient diagnoses. Critical pathways, also known as care paths or clinical pathways, are intended to coordinate the efforts of multidisciplinary teams and standardize diagnosis and treatment of common conditions in order to improve quality, increase efficiency, and control costs of care [18, 19]. Critical pathways can take many formats including checklists, order sets, and guided diagnosis and treatment tools [10, 18]. The development and implementation of critical pathways are common tasks of antimicrobial stewardship programs [10], and improve efficiency without any negative impact on patient outcomes in CAP [18]. The development of critical pathways is a time-intensive undertaking for an interdisciplinary team and creation of a pathway does not ensure widespread utilization [20].

In a recent prospective randomized trial from Spain by Carratala et al. a three-step critical pathway was used to reduce length of stay for patients with CAP [21•]. The pathway consisted of early mobilization, use of objective criteria for switching to oral antibiotic therapy, and predefined criteria for deciding on hospital discharge [21•]. A printed checklist was placed in the medical chart of each patient assigned to the intervention arm. The checklist was intended to remind hospital physicians of early mobilization goals, and the criteria for transition to oral antibiotic therapy and hospital discharge [21•]. The results of a randomized trial of this critical pathway

showed a 2.1-day decrease in the mean length of stay, a 2-day decrease in duration of intravenous antibiotics, and no difference in readmission rate or overall mortality for the intervention group compared with usual care [21•]. However, an accompanying editorial questioned whether the improvements were causally related to the critical pathway and underscored the challenges of behavioral change in healthcare, even for seemingly simple interventions such as early mobilization [22]. Patients involved in the trial were seen daily by the study investigators in addition to their hospital physicians; this high intensity involvement of the investigators and other unmeasured influences may have contributed to the observed improvements in outcome measures [21•, 22].

Another proposed organization change is the creation of an acute medical assessment unit, particularly for patients who require hospitalization but for less severe CAP. A study by Tripp showed that in a single center in New Zealand a medical assessment unit relieved some of the burden from ED assessment of patients with less severe CAP [23]. However, there was no evidence of improved patient outcomes and the causal effect of the medical assessment unit could not be determined given several other concurrent organizational changes [23]. The timeliness of evaluation was reduced in the medical assessment unit, possibly because patients were less severely ill than patients admitted through the ED and there was less urgency in their assessment [23].

The Importance of Local Context in Quality Improvement Implementation Efforts

Evidence-based guidelines are typically based upon clinical trials and large retrospective cohort studies where selected process interventions or practice changes are associated with improved patient outcomes. However, there is varying success in implementing such guidelines due to local contextual factors that exist such as provider culture, patient population characteristics, hospital resources and leadership, and institutional support for improvement efforts. These local contextual factors also make interpretation of quality improvement reports difficult, as success in a quality improvement project in one setting may not be readily applicable to a different clinical environment or institution. A classic example is the Michigan "Keystone" ICU project that showed a reduction in catheter-associated bloodstream infections with the use of a checklist. While a checklist intervention was used to achieve remarkable results, the checklist had to be adapted to each local ICU and simply installing a generic checklist into a given ICU does not lead to sustained improvements in care [24, 25]. Instead, a checklist or any other improvement initiative must be adapted to the local context and setting in order to ultimately lead to sustained changes in local provider practice patterns and the desired improvements in patient outcomes [24].

The Importance of Multidisciplinary Teams and Teamwork on Improvement Work

Many of the successful interventions reviewed were developed and implemented by multidisciplinary teams consisting of physicians, nurses and pharmacists. Healthcare is delivered in increasingly complex systems and developing and implementing interventions to improve such systems depend on teams of providers to thoughtfully analyze current systems and contextual factors and develop improvement interventions based on that knowledge. These teams should ideally comprise of front-line care providers who are most aware of the care that is provided to patients and who would also be acutely aware of any unintended consequences that can occur after implementation.

Conclusions

A wide variety of interventions have led to important improvements in the quality of care for hospitalized patients with CAP. Recent innovations in standardized protocols and pathways, education and feedback from antimicrobial stewardship teams, and automated pharmacy technology have the potential to improve patient outcomes and reduce resource utilization. However, replicating some of these studies may be difficult due to the lack of published details on implementation of the specific interventions. As recommended in the SQUIRE guidelines, reports of quality improvement studies should include descriptions of the local context, institutional culture and leadership support for quality improvement efforts [26]. As multidisciplinary work to improve care for patients with CAP continues, reports of quality improvement studies should include sufficient information to implement similar interventions in other settings.

Compliance with Ethics Guidelines

Conflicts of Interest Elizabeth A. Richey, Lauren Dudley, and Stephen K. Liu declare that they have no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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