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Understanding variation in quality of antibiotic use for community-acquired pneumonia: effect of patient, professional and hospital factors

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***Objectives*: To develop effective and targeted interventions to improve care for patients with community-acquired pneumonia (CAP), insight is needed into the factors that influence the quality of antibiotic use. Therefore, we measured the performance of nine quality indicators and studied determinants of variation in the quality of antibiotic use.**

***Patients and methods*: Data on 498 prospectively included patients with CAP from eight medium-sized Dutch hospitals were extracted from the medical charts. Outcomes of nine indicators were calculated using previously constructed algorithms. Multilevel logistic regression analysis was performed to explain differences in performance rates at the patient, doctor and hospital level.**

***Results*: Performance indicators were generally moderate. Markers of severe illness were found to be positive predictors of timely administration of antibiotics (low oxygen saturation on admission OR 1.11; 95% CI: 1.04–1.19) and obtaining blood samples for culture (low sodium concentration on admission OR 1.10; 95% CI: 1.03–1.16). Recent outpatient antibiotic therapy (OR 0.46; 95% CI: 0.26–0.80) and presence of a hospital antibiotic committee (OR 0.27; 95% CI: 0.08–0.90) were negatively associated with guideline-adherent empirical therapy. The main positive predictor of timely administration of antibiotics (within 4 h) was antibiotic administration in the Emergency Department (ED) (OR 3.9; 95% CI: 1.96–8.73).**

***Conclusions*: We gained new insights into factors that determine quality of antibiotic prescription in hospitals. Treatment in the ED, rather than in the ward, will result in earlier administration of antibiotics. Guidelines should clarify preferred antibiotic management of patients who have received antibiotics prior to admission. Hospital-based structures aimed at quality improvement, such as antibiotic committees, do not necessarily lead to better adherence to national standards. Efforts should be made to encourage these committees to implement national guidelines at a local level.**

Keywords: determinants, antibiotic therapy, quality of care, CAP, multilevel analysis

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Introduction

Community acquired pneumonia (CAP) affects 3–5 adults per thousand per year with a mortality of 7–14% in hospitalized patients.[1,2] Pneumonia-related deaths, expenditure and variation in hospital care have led to efforts to identify markers of the quality of inpatient care. These so-called quality indicators are defined as measurable elements of practice performance, for which there is evidence or consensus that they can assess the quality—and hence the change of quality—of care provided.[3] Several process-of-care quality indicators have been proposed for CAP.[4–6] Some of these markers have proved to be associated with improved clinical outcome[4,7–13] or with a reduction in healthcare cost;[14–16] others may simply represent good clinical practice.[17,18]

Performance levels of process markers in CAP vary considerably between hospitals.[19] Little is known about factors that explain this variation. Performance for some indicators has been associated with a variety of patient, physician and hospital factors.[20,21] However, no study has analysed possible determinants of all three levels in one model. Similarly, only a small selection of indicators was evaluated in these studies, although the description of a wider range of process variables might better reflect the quality of the whole process of care. Also, markers of hospital and physician commitment to the quality of antibiotic prescription (such as presence of automated feedback systems and membership to an antibiotic committee) were not taken into account.

We conducted a prospective study on nine indicators of the quality of clinical antibiotic prescription in patients with CAP and analysed the extent to which the variations in indicator performance could be explained by differences between hospitals, doctors and patients. Recognition of underlying factors could contribute to the development of effective and targeted interventions to improve the quality of care for patients with pneumonia.

Patients and methods

Setting and population

Our study was conducted on baseline measurements of a clustered randomized controlled trial to test a multifaceted implementation strategy to improve the quality of antibiotic use in lower respiratory tract infections (LRTI) in hospitals. For this purpose, all eligible medium-sized hospitals in the south-east of the Netherlands were asked to participate. Eight out of 14 available hospitals agreed to take part. These hospitals represent inpatient care at secondary care hospitals, because non-university teaching and non-teaching hospitals were included. Patients with CAP were selected using formal inclusion criteria: radiological evidence of an infiltrate on chest X-ray and ≥2 out of 6 clinical criteria (cough, coloured sputum, temperature >38.5°C, abnormal chest auscultation, white blood cells >10 or <4 × 10^9/L or positive blood or pleural fluid culture). We excluded patients with underlying immunodeficiency (HIV infection, neutropenia and/or treatment with immunomodulating drugs), patients already on treatment with antibiotics for another infection at the time of admission, patients who had recently been discharged from hospital with LRTI (<30 days) or who had been transferred to another hospital or ICU, and patients who had died within 24 h of admission or had a very poor prognosis (life expectancy <2 weeks on admission).

Variables and data collection

Four data levels were analysed: processes of care (dependent variables) and patient, care provider and hospital characteristics (independent variables).

Dependent variables

Using a formal procedure, described in our recent publication[22] (flowchart in Appendix 1; available as Supplementary data at http://www.jac.oxfordjournals.org), we formulated draft indicators of the appropriate use of antibiotics for CAP based on (1) national guidelines, edited by the Dutch Working Party on Antibiotic Policy (SWAB)[23] and the National Society for Respiratory Physicians (NVALT),[24] (2) international guidelines[25–28] and (3) a systematic review of the literature (Appendix 2; available as Supplementary data at http://www.jac.oxfordjournals.org).[5–8,19,20,29–36] To assess the evidence base (grades A–D) of every indicator, a literature review was performed (Appendices 3 and 4; available as Supplementary data at http://www.jac.oxfordjournals.org). Grade A recommendations were considered valid. In grade B–D recommendations, a panel of 11 experts performed a consensus procedure on the indicators' relevance for (i) patient outcome, (ii) reducing antimicrobial resistance and (iii) cost-containment. To test applicability in practice, feasibility, reliability, opportunity for improvement and case-mix stability were determined (Appendix 1). This resulted in a set of nine quality indicators (Table 1). After selection, these indicators were implemented: numerators and enumerators were defined, including cut-off values and algorithms to calculate outcome. All relevant data were collected from chart review.

Independent variables and data collection

Relevant patient characteristics included demographic data (age, sex), comorbidity (cerebrovascular disease, congestive heart failure, neoplastic disease, liver disease, renal disease, chronic alcoholism, chronic lung disease and diabetes), physical examination on admission (mental status, temperature, pulse rate, respiratory rate and systolic blood pressure), and initial laboratory and radiology results (presence of pleural effusion, arterial pH, oxygen saturation, blood urea nitrogen, sodium, glucose and C-reactive protein). These variables were used to calculate the pneumonia severity index (PSI)[37] for every patient. We also recorded whether the patients had received treatment with an antibiotic within 30 days before admission, had arrived at night or during a weekend and whether a resident had been involved in the admission procedure. Over a 6 month period, data collection was performed by research assistants present (actually working) at the departments: they screened all new admissions 2–3 times a week and—once a new admission was detected—completed the case report form from the day of admission to the day of dismissal: this allowed the detection of important clinical data (e.g. timing of first administration of antibiotic; timing of performance of cultures, etc.) while the patient was still in the ward. Data were collected from admission sheets, medical and nursing records, medication charts, and microbiology and radiology reports. Research assistants received intensive training and were supervised at regular intervals by the study supervisor. Before the start of the project, as well as while it was being conducted, data collection was validated at regular intervals: double chart review was performed by two independent researchers in 10% of patients at two pilot hospitals. The percentage of agreement between these researchers on indicator level, corrected for chance, was expressed in kappa coefficients and ranged between 0.5 and 1 (moderate—good). After completion, data sheets were made anonymous and entered into a database by two research assistants. Double data entry was performed in 2% of the patient data sheets. In total, 36 entry errors were detected in the complete set of 4510 items (0.8%). The two data entry assistants had entered 275 differences from a sample of 58 data sheets; each

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Table 1. Performance levels of quality indicators for antibiotic use in CAP

Quality indicator	Adherence (median, %)	Range (eight hospitals, %)	Supporting evidence[b]
1. Timely initiation of antibiotic therapy (within 4 h after presentation)	68	36–87	B
2. Empirical antibiotic regimen according to national guidelines	45	5–59	B
3. Adapting dose and dose interval of antibiotics to renal function	77	40–100	D
4. Switching from iv to oral therapy, according to existing criteria and when clinically stable	81	35–93	B
5. Changing broad-spectrum empirical into pathogen-directed therapy (streamlining therapy)	80	50–100	C
6. Stopping antibiotic therapy after three consecutive days of defervescence[a]	11	2–32	D
7. Taking two sets of blood samples for culture	57	48–67	B
8. Obtaining sputum samples for Gram stain and culture	54	24–100	D
9. Urine antigen testing against *Legionella* spp. upon clinical suspicion	84	67–100	B

[a]Indicator not included in multilevel analysis.
[b]Grades A–D including references: for comment see Appendices 3 and 4 (available as Supplementary data at http://www.jac.oxfordjournals.org).

contained 294 variables: 1.6% (275/17052). The regional research ethics committee approved the study. As our data were collected as part of a local quality improvement (QI) project, all local hospital committees waived the need for a written informed consent from patients. Nonetheless, measures were taken to protect patient privacy.

Care provider characteristics were collected from individual questionnaires completed by all the specialists at our study hospitals. These included demographic data (age, sex), subspecialty, clinical experience (years of professional experience since specialist registration and number of patients with CAP treated per year) and membership of an antibiotic control and/or quality of care committee.

Hospital characteristics were obtained from a survey on Dutch secondary care hospitals[38] and included hospital size, teaching status, presence of educational strategies (e.g. local guidelines, continuous medical education on antibiotic prescription for residents and specialists), audit and feedback (e.g. feedback systems on antibiotic therapy), organisational strategies (e.g. presence of an antibiotic committee, attendance of medical microbiologists and/or clinical pharmacists at ward rounds), restrictive strategies (e.g. restricted list of antibiotics, automatic stop order or antibiotic order form), quality of care policies (e.g. QI projects on antibiotic use performed in past 5 years) and factors of guideline availability and accessibility (e.g. the use of national guidelines in the composition process of local antibiotic policies, publication of a pocket booklet with guidelines, presence of computerized guidelines).

Analysis

Frequencies were calculated to evaluate adherence to nine quality indicators for antibiotic use (Table 1). Descriptive statistics were used to compare hospital characteristics of our study sample with national data (*t*-test and χ^2 test). Dichotomous hospital variables that contained fewer than two cases per category and patient variables that contained fewer than 30 cases per category were excluded from analysis. Table 2 presents most independent variables that were suitable for analysis. If a correlation was detected between two independent variables (correlation coefficient >0.4), only one variable was tested (e.g. the blood glucose level or presence of diabetes). Single relationships between adherence to quality indicators and all characteristics were studied, using univariate analysis (cross tabulations, χ^2 test and Student's *t*-test). Multilevel (hospital, professional, patient) stepwise logistic regression analysis was performed to explain differences in adherence levels to process of care (dependent) variables. Separate multivariate backwards stepwise logistic regression models were constructed in which each evaluable process of care formed the dependent outcome and all the patient, doctor and hospital characteristics that had bivariate associations with $P < 0.10$ formed the independent variables. A random coefficient model was composed using three levels (patients, care providers and hospitals) with a Glimmix procedure in SAS (SAS for Windows V8.2). For every indicator, the percentage of variance that the determinants could explain, was calculated. The explained variance was computed using a method based on a threshold model.[39] Multilevel analysis was only performed on data from doctors who had treated six or more patients during the study period. We considered the attending specialist to have been the primary decision-maker. Odds ratios were calculated to describe associations between determinants and quality indicators. An OR >1 means a positive association with the quality indicator. Two-sided *P*-levels of <0.05 were considered to be statistically significant.

Results

Study population

Eight hospitals agreed to participate in our study. On several characteristics, our sample was comparable to 59 other Dutch

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Table 2. Descriptive statistics: patients, professionals and hospitals

Hospitals	*n* = 8	*n* = 59[a]	*P*	Professionals	*n* = 68	SD
Mean number of beds, *n* (SD)	524 (169)	491 (286)	0.74[b]	Mean age, years	48	8
Teaching hospital, *n* (%)	4 (50)	27 (46)	0.82[c]	Gender, % male	84	
Antibiotic committee, *n* (%)	4 (50)	43 (73)	0.18[c]	Mean years in practice	21	9
Local antibiotic guidelines, *n* (%)	8 (100)	56 (95)	0.51[c]	Specialty professional, %	53	
Use of national guidelines in composition	2 (25)	9 (15)	0.52[c]	Respiratory care physician		
process of local policies, *n* (%)	3 (38)	31 (53)	0.43[c]	Clinical experience,	78	
Routine feedback on pathogen-directed	6 (75)	29 (49)	0.17[c]	% >25 CAP patients/year		
therapy, *n* (%)	3 (38)	23 (39)	0.92[c]	Member of local antibiotic	7	
Quality improvement project				committee, %		
in past 5 years, *n* (%)				Special task in quality	70	
Pharmacist present at ward rounds				improvement projects, %		
discussing antibiotic prescription, *n* (%)				Special task in guideline		
				composition, %	32	

Patients	*n* = 498	SD	Patients	*n* = 498	SD
Evaluable patients, *n* (%)	432 (88)		Sodium mean	137	4
Excluded patients, *n* (%)	62 (12)		(mmol/L)		
Male sex, *n* (%)	251 (58)		pH, median	7.44	0.6
Age, median in years	74	15	Antibiotic therapy	139 (32)	
PSI score >3 (%)	47		within 30 days, *n* (%)		
Co-morbidity score[d] ≥1 (%)	62		Admitted at night	210 (49)	
COPD, *n* (%)	194 (45)		or weekend, *n* (%)		
Chronic heart failure, *n* (%)	154 (35)		Admission to	332 (77)	
Diabetes mellitus, *n* (%)	154 (35)		respiratory unit, *n* (%)		
Oxygen saturation, % mean	65 (15)		Resident involved in the	230 (53)	
Temperature, °C mean	92.3		admission procedure, *n* (%)		
Pulse (beats per min), mean	38.1				
	97	5			
		1.1			
		21			

[a]Data from 59 Dutch secondary care hospitals.[38]
[b]*t*-test.
[c]χ^2 test.
[d]Sum score of eight items: malignancy, liver disease, chronic heart failure, stroke, renal failure, diabetes, alcohol abuse and chronic lung disease.

secondary care hospitals (Table 2). Between September 2002 and March 2003, 498 patients with CAP were admitted to the internal and respiratory medicine wards at these eight hospitals. A total of 62 were excluded out of 498 eligible patients, due to neutropenia (2), immunosuppressive therapy (38), admission to ICU, death or transfer to another hospital within 24 h (12), another culture-proven infection, already receiving antibiotics on admission (4), recent admission to hospital for LRTI (11) and poor prognosis (2). Table 2 outlines the characteristics of patients, professionals and hospital settings. The doctors responsible for the management of patients with CAP were predominantly male (84%), with a mean age of 48 years (SD 8). About half were respiratory care specialists (53%). In 59% of cases, residents had been involved in the admission procedure. Mean patient age was 74 years (SD 15), 62% had one or more co-morbid disorders and 47% had a PSI > 3 on admission.

Performance of process-of-care (dependent) variables

Table 1 shows the median performance of nine process-of-care indicators. There was wide interhospital variation. Lowest adherence (median of 11%) was found for discontinuing antibiotic therapy when no fever was present for three consecutive days. This variable was not entered into analysis because multilevel modelling was impossible due to the small number of patients (with little variation among hospitals) in the adherent group.

Table 3 shows the results of multilevel regression analysis on a selection of indicators and the explained variance of the determinants on indicator outcome.

Factors associated with timely antibiotic administration

Several patient and hospital characteristics were independently associated with antibiotic administration within 4 h of admission. In 83 out of the 372 evaluable patients (22.3%), the first dose of antibiotics was administered in the Emergency Department (ED). Administration of antibiotics in the ED was strongly associated with antibiotic administration within 4 h (OR 3.9; 95% CI: 1.96–8.73). Another predictor of timely administration of antibiotics was low oxygen saturation on admission (OR 1.11; 95% CI: 1.04–1.19).

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Table 3. Multivariate predictors of performance levels of quality indicators and explained variance[a]

	OR (95% CI)	*P*
Timely initiation of antibiotic therapy (within 4 h)		
low oxygen saturation on admission	1.11 (1.04–1.19)[b]	0.004
COPD	0.51 (0.27–0.96)	0.026
initiation of antibiotic therapy at the ED	3.9 (1.96–8.73)	0.001
explained variance (%)	31.3	
Empirical antibiotics according to national guidelines		
pleural effusion present on admission	0.27 (0.12–0.65)	0.004
COPD	2.40 (1.40–4.08)	0.002
recent antibiotic therapy in outpatient setting (<30 days)	0.46 (0.26–0.80)	0.007
presence of an antibiotic committee	0.27 (0.08–0.90)	0.034
explained variance (%)	14.4	
Adapting dose of antibiotic to renal function		
age (patient)	0.55 (0.39–0.68)[c]	<0.0001
heart failure	0.52 (0.28–0.96)	0.038
admission to a respiratory care ward	5.13 (2.56–10.23)	<0.0001
presence of an antibiotic committee	8.82 (1.03–75.88)	0.048
explained variance (%)	37.4	
Switching from iv to oral therapy		
elinical experience of treating physician (no. of years)	0.95 (0.92–0.99)	0.042
explained variance (%)	34.1	
Streamlining therapy		
presence of a clinical pharmacist at ward meetings	0.24 (0.08–0.72)	0.012
teaching hospital	4.14 (1.44–11.96)	0.010
explained variance (%)	27.9	
Taking two blood samples for culture		
temperature on admission (>37.5°C or <36.0°C)	7.75 (4.53–13.23)	<0.0001
low sodium concentration on admission	1.10 (1.03–1.16)[d]	0.003
treating physician other than pulmonologist	2.82 (1.30–6.13)	0.009
explained variance (%)	27.6	
Obtaining sputum samples for Gram stain and culture		
male sex (patient)	2.15 (1.29–3.56)	0.003
COPD	1.95 (1.16–3.26)	0.012
recent antibiotic therapy in outpatient setting (<30 days)	2.16 (1.28–3.64)	0.004
admission to a respiratory care ward	2.35 (1.18–4.59)	0.017
explained variance (%)	13.9	

[a]Data are presented as OR (95% CI); indicator 'Urine antigen testing for *Legionella*' is not shown; an OR >1 means a positive association with the outcome variable.
[b]OR per % decrease in oxygen saturation.
[c]OR per 10 years increase in age (per 1 year increase in age: OR 0.94; 95% CI: 0.91–0.96).
[d]OR per mmol/L decrease in sodium concentration.

Factors associated with guideline-adherent empirical therapy

There was poor adherence to a national, multidisciplinary guideline on empirical antibiotic therapy for CAP from the Dutch Working Party on Antibiotic Policy (39%) and also to the most recent guideline from the National Society for Respiratory Physicians (37%). Predictors associated with guideline-adherent antibiotic prescription included the presence of co-morbid chronic obstructive pulmonary disease (COPD) (OR 2.40; 95% CI: 1.40–4.08).

Patients who had been treated with antibiotics for respiratory tract infection prior to admission (43%) were less likely to be treated according to national guidelines (OR 0.46; 95% CI: 0.26–0.80). On a hospital level, adherence was poorest at hospitals that had antibiotic committees (OR 0.27; 95% CI: 0.08–0.90).

Factors associated with adapting antibiotic therapy: dosage reduction in the presence of decreased renal function, switching and streamlining therapy

Adaptation of dose or dose interval according to renal function, adherent to local guidelines, was performed considerably well (77%) and was associated with a number of factors: more advanced age of the patients (OR 0.55; 95% CI: 0.39–0.68), admission to a

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respiratory care unit (OR 5.13; 95% CI: 2.56–10.23) and the presence of a local antibiotic committee (OR 8.82; 95% CI: 1.03–75.9).

In 81% of the patients with CAP, who were receiving intravenous (iv) antibiotics, the treating physician had made the correct decision to switch, or not to switch, from iv to oral antibiotics, based on generally accepted criteria. When iv–oral switch was performed, it had been done in a timely manner, but the right choice of oral antibiotic formulation was made in only 64 of 181 evaluable patients (35%). Overall, switching could have been performed safely at a median of 1.3 days (SD 2.3) earlier. In 103 out of 432 evaluable patients (24%), results of blood, sputum or pleural fluid cultures with susceptibility testing or serology for atypical pathogens (IgM for *Mycoplasma pneumoniae* and *Legionella* serotype 1 antigen in urine) were available and considered relevant. In 80 out of these 103 patients, the physicians had changed from empirical therapy to narrow spectrum antibiotic therapy targeted at the causative pathogen (78%). In 54 out of the 80 cases (68%) this occurred within 2 days after results had been brought to their attention. Few independent predictors were detected by multilevel analyses on accurate therapy switching and streamlining. Younger specialists (fewer years of clinical experience) showed better therapy-switching behaviour (OR 0.95; 95% CI: 0.92–0.99) while streamlining was performed better at teaching hospitals (OR 4.14; 95% CI: 1.44–11.96). Attendance of a clinical pharmacist at ward rounds was inversely associated with correct streamlining of therapy (OR 0.24; 95% CI: 0.08–0.72).

Factors associated with the performance of diagnostic procedures: sputum cultures, blood cultures and Legionella urine antigen testing

In 272 out of the 385 patients (71%), a physician's order to perform a sputum culture and Gram stain had been recorded on the medical or nursing chart. In 54% of the patients with CAP, a sputum sample for culture had actually been obtained and sent for culture during hospital stay, as witnessed by written microbiology reports. In 39% (26 out of the 67 evaluable patients), these samples had been obtained before the start of antibiotic therapy. Receiving antibiotic therapy in the 30 days preceding admission and the presence of co-morbid COPD predicted the performance of sputum culture. Respiratory care physicians were more likely to perform sputum cultures than other hospital physicians. Collecting blood samples for culture (57%) was associated with elevated/reduced temperature and low sodium level on admission. Respiratory care physicians performed fewer blood cultures than the other treating physicians.

Urine testing for *Legionella* spp. had been performed in only 56 out of the 371 (15%) evaluable patients. When clinical suspicion of *Legionella* spp. infection was explicitly mentioned in the medical records, urine antigen testing was performed in 84%. Performance of urine antigen testing was associated with markers of severe illness at presentation: high C-reactive protein, low serum sodium concentration and presence of co-morbidity, e.g. COPD (data not shown). No significant determinants were found for 'performing a urine antigen test upon clinical suspicion'.

Discussion

On the basis of our results, we conclude that there is ample room for improvement on almost all the quality indicators: on the initiation of treatment, re-evaluating or changing treatment and on performance of diagnostic procedures. Several important associations were demonstrated between patient, professional and hospital characteristics and measured processes of care for CAP.

Factors that influence timely antibiotic administration, timely collection of blood samples for culture and adherence to an admission guideline have been reported before.[20,21] We studied performance on a set of nine quality indicators, which enabled us to describe not just initial management, but the entire process of antibiotic use in CAP, from admission to discharge.

In line with previous reports,[20] vital sign abnormalities that reflect severe disease (e.g. low oxygen saturation and low serum sodium concentration) were positively associated with timely antibiotic administration and collection of blood cultures. These results suggest that quality performance is generally better in patients who are more seriously ill. However, since guidelines do not distinguish between patients by severity of fever or de-saturation, blood cultures should be performed in patients with CAP even if there is no fever, and antibiotics should be promptly administered even to patients with normal oxygen saturation on admission. A strong association was found between antibiotic administration at the ED and administration within 4 h (OR 3.9). This may seem a trivial finding, but it offers an opportunity for QI strategies: in earlier studies, administration of antibiotics at the ED yielded low performance scores and important variations between hospitals.[8,40,41]

Choosing an antibiotic that was not in accordance with national guidelines was strongly associated with a history of treatment with antibiotics within 30 days before hospital admission. Unless previous antibiotic use was specifically mentioned in national guidelines for a small subgroup[23] (patients with COPD who have recently been treated with antibiotics) this variable was not integrated into our algorithms. Performance on this indicator was probably underrated: deviation from national guidelines may have been justified in a considerable number of these patients. Subgroup analysis showed that in patients who had not received prior antibiotic treatment, guideline adherence was 50% compared with 30% in those who had received previous treatment (χ^2 test; $P < 0.05$). Prior antibiotic therapy is a major factor that influences adherence to guidelines on empirical treatment when a patient with CAP is admitted to hospital. Large retrospective studies on the effectiveness of different empirical antibiotic regimens did not take this into account.[10–12,42] As an increasing number of patients are being treated in outpatient settings with broad-spectrum antibiotics,[43] clear recommendations are needed on what should be done if a patient fails to improve during initial outpatient management. Therefore, a transmural guideline should be formulated on management of CAP, which is currently lacking in the Netherlands.

The presence of a local antibiotic committee was also associated with a lower likelihood of adherence to national guidelines on empirical therapy. This finding may initially seem surprising: hospital antibiotic committees are thought to play an important role in the design and implementation of local practice guidelines on antibiotic prescription. In the Netherlands, national guidelines on treatment of CAP were distributed to antibiotic committees in all hospitals. In addition, the guideline was published in the Dutch Journal of Medicine.[23] Thus, better adherence to antibiotic policies would be expected at hospitals with a local antibiotic committee. A possible explanation for this paradox is that the hospitals with an antibiotic committee were more pro-active in making tailor-made recommendations on antibiotic therapy in selected patients, which may have led to increased deviation

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from national guideline recommendations. Also, these committees may have been more up-to-date with the recent literature on empirical treatment for CAP, regarding issues that have not yet been incorporated into the national guidelines (dating from 1998). Finally, national guidelines, even if they were adequately disseminated, may have been insufficiently implemented at the local hospital level: our recent survey at Dutch hospitals indeed showed that only 19% had consulted national guidelines during the composition of local practice guidelines.[38] A more generally accepted prescription quality measure, 'adapting of antibiotic dose to decreased renal function', was found to be positively associated with the presence of a local antibiotic committee.

There was wide interhospital variation in the performance of some of our quality indicators. Some hospital factors (e.g. the presence of an antibiotic control committee, presence of a clinical pharmacist at clinical rounds) were found to independently predict performance levels, but our sample size was too small to detect other potential hospital determinants of adherence. Independent variables, such as the presence of local guidelines, a restricted list of antibiotics, or the presence of a medical microbiologist at ward rounds, were not evaluable due to skewed distribution of these variables within our group of hospitals. However, no significant differences in baseline characteristics were found between our hospitals and 59 other Dutch general hospitals (Table 2). Despite the small sample size, we therefore feel that our positive findings are generally applicable.

Unfortunately, we were also unable to ascertain involvement of a microbiologist or a clinical pharmacist at the individual patient level, as data on their (routine) involvement was collected at hospital level. More individualized data might have helped to study the role of microbiologists and clinical pharmacists in depth.

Finally, our sample of hospitals was a convenience sample. This may have introduced a bias, as our hospitals may have been more willing to participate in QI projects. However, no differences between our sample and the 59 other Dutch general hospitals were found in baseline characteristics and measures that would suggest a positive attitude towards quality of antibiotic use (e.g. performance of a QI project on antibiotic use in the past 5 years).

This study generates insight into factors that determine the quality of antibiotic use in hospitals. To ensure antibiotic administration within 4 h, patients with CAP should receive their first dose of antibiotics at the ED. National guidelines on empirical therapy should clarify the preferred antibiotic management of patients who have been treated with antibiotics prior to admission. Hospital-based QI structures, such as antibiotic committees, do not necessarily lead to better adherence to national standards. Efforts should be made to encourage these committees to implement national guidelines at a local level.

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Transparency declarations

We have no conflicts of interest to report.

Supplementary data

Appendices 1–4 are available as Supplementary data at http://www.jac.oxfordjournals.org.

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