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Do clinical findings in lower respiratory tract infection help general practitioners prescribe antibiotics appropriately? An observational cohort study in general practice

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Background. Antibiotics are over-prescribed for lower respiratory tract infection (LRTI). The influence of clinicians' history and examination findings on antibiotic prescribing for LRTI has not been directly assessed, and the extent to which these clinical findings predict appropriate antibiotic prescribing is unknown. A clearer understanding is crucial to achieving evidence-based prescribing.

Objectives. To directly assess the influence of general practitioners' history and examination findings on antibiotic prescribing for LRTI, and to explore the extent to which these clinical findings predict appropriate antibiotic prescribing.

Methods. In this observational cohort study 25 GPs in The Netherlands were recruited during routine consultations and 247 adult patients with a clinical diagnosis of LRTI. The GPs recorded clinical information. Odds ratios (ORs) with 95% confidence intervals (CIs) for clinical variables predicting a prescription for an antibiotic were calculated. The relationship between antibiotic prescription and radiographic evidence of pneumonia was explored in order to gauge appropriateness of antibiotic prescribing.

Results. Auscultation abnormalities (OR 11.5; 95% CI 5.4–24.7), and diarrhoea (OR > 11) were strongly associated with antibiotic prescribing. An antibiotic was prescribed for 195 (79%) patients. Assuming that an antibiotic definitely needs to be prescribed only for patients with pneumonia, antibiotics may have been inappropriately prescribed for 166/193 (86%) of the patients. Antibiotics were not prescribed for 5 of the 32 (16%) patients with a radiographic diagnosis of pneumonia.

Conclusions. Abnormal findings on auscultation in patients with LRTI strongly predict antibiotic prescribing and this is probably inappropriate for most patients. These results should prompt GPs to consider the extent to which finding 'crackles/rhonchi on auscultation' influences their decisions to prescribe antibiotics for their patients with LRTI, and to consider the predictive value of individual clinical signs in reaching evidence-based prescribing decisions.

Keywords. Antibiotics, general practice, pneumonia, predictive value of tests, respiratory tract infections.

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Introduction

Diagnosis for the vast majority of patients attending general practice with lower respiratory tract infection (LRTI) is based on history and clinical examination alone. GPs often prescribe an antibiotic for these patients, and may support their decision by recording abnormal findings on auscultation.[1] However, the influence of GPs' history and examination findings on antibiotic prescribing for LRTI has not been directly assessed, and the extent to which these clinical findings predict appropriate antibiotic prescribing is unknown. This gap in the evidence base is important because understanding the influence of clinical factors on antibiotic prescribing and identifying whether or not these factors influence prescribing appropriately, could lead to widespread changes in clinical decision making in the direction of more evidence-based antibiotic prescribing. This has wide potential impact: antibiotics are prescribed for about three-quarters of patients with LRTI;[2] 80% of LRTI patients have acute bronchitis (incidence 24–46 per 1000 patients per year) and 20% have community-acquired pneumonia (incidence 5–11 per 1000 patients).[3] Over-prescribing continues despite growing evidence that acute bronchitis is self-limiting and rarely requires antibiotic treatment. Systematic reviews of randomized controlled trials of treatment for patients with acute bronchitis concluded that the possible modest beneficial effect is similar to the harm caused by antibiotic treatment.[4,5] The studies included in these reviews recruited patients on the basis of clinical findings rather than etiologic agent, so findings are applicable to patients regardless of whether they are infected by a virus or bacterium. Antibiotic treatment is considered obligatory only for community-acquired pneumonia and may be clinically useful in more severe infectious exacerbations of chronic obstructive pulmonary disease (COPD).[6] Few studies of antibiotic treatment in LRTI have been large enough to identify which subgroups of patients are more likely to benefit from antibiotic treatment.

Qualitative and questionnaire studies on respiratory tract infections[7–9] revealed numerous factors that may contribute to inappropriate antibiotic prescribing. In order to gain insight into the actual diagnostic reasoning and therapeutic decision making process, we studied the influence of an array of clinical factors recorded in actual consultations on GPs decisions whether or not to prescribe an antibiotic in LRTI. We also explored whether or not these prescribing decisions were appropriate.

Patients and methods

Patients

Patients aged 18 years and over were eligible if their GP made a diagnosis of LRTI and the patient had an acute (duration less than 29 days) or worsening cough. Additional inclusion criteria were the presence of at least one of the following four features: shortness of breath, wheezing, thoracic pain, auscultation abnormalities; and at least one of the following four: reported fever ($\geq$38°C), perspiring, headache, myalgia. Exclusions were pregnancy or lactation, history of hypersensitivity to penicillin or macrolide antibiotics, concomitant treatment with ergot alkaloids and/or terfenadine, severe disease requiring immediate hospitalization, treatment with antibiotics within the preceding 14 days and hospital admission for a respiratory indication in the previous 4 weeks. Some of the exclusion criteria were relevant to a randomized clinical trial, which was run in parallel to the present study.[10]

Procedures

All GPs in the district of Maastricht in the Netherlands were invited to participate in the study. Most of the 25 GPs who participated practised in rural areas (72%). Fifty-six percent of the GPs worked in dual practices, 20% in group practices, and the others in single-handed practices. The GPs performed and recorded a standardized medical history and physical examination on sequential, eligible consenting patients. GPs indicated the certainty of their clinical diagnosis (pneumonia or acute bronchitis) using a 5-point scale and their estimation of illness severity using a 4-point scale. Prescribing decisions and the reasons were then recorded. Those patients for whom the GPs felt an antibiotic was indicated were entered into a randomized controlled trial comparing the efficacy of amoxicillin to that of a macrolide antibiotic (roxithromycin).[10] All consenting patients were followed up in the same way, regardless of whether or not they were entered into the randomized trial aspect of this research program. Further management decisions were at the GPs' discretion. GPs were not informed of the aim underlying this aspect of the research, namely the identification of clinical influences on antibiotic prescribing. After the consultation, patients were asked to record their reasons for consulting their GP and whether or not, prior to the consultation, they had wanted a prescription for an antibiotic.

Radiographic pneumonia

Chest radiographs (lateral and posterio-anterior) were taken on the third day after recruitment.[11] Two radiologists, blinded to all other information, independently assessed the radiographs for infiltrates. A third radiologist assessed the radiographs in the event of disagreement between the findings of the first two radiologists. The findings of this third assessment were considered final and accurate. Evidence of radiographic pulmonary infiltrates was regarded as evidence of pneumonia.

Statistical analysis

The dichotomous outcomes of all recorded patient characteristics, symptoms and physical signs were compared with the dependent variable (antibiotic prescription yes or no) in two-by-two tables. Positive and negative predicted values (PV+, PV–) and diagnostic odds ratios (ORs) with 95% confidence intervals (CIs) were calculated.

To test the assumption that patients from the same GP are more alike in symptoms and signs than patients from different GPs the intracluster correlation coefficient (ICC) was calculated. The independent contributions of the clinical items to predicting antibiotic prescribing were assessed using multiple, logistic regression analysis, controlled for clustering at GP level (the random intercept model). To prevent excessive diagnostic variables being included for the available cases, three criteria had to be met before they were included in the analysis. First, each variable had to be present in at least 10 patients. Second, each variable had to be positive in at least five patients who had an antibiotic prescribed. Third, the association of the variables with antibiotic prescription had to have a P-value <0.10 (chi-square or Fisher's exact test). Backward elimination with $P > 0.05$ was used to exclude variables in multiple logistic regression. Those variables remaining were considered as the most important clinical associations with antibiotic prescribing.

The univariate and multiple logistic regression analyses were repeated, but this time with the clinical diagnosis of pneumonia (yes or no) as the dependent variable. 'Absent pneumonia' represented the diagnosis of acute bronchitis.

Sensitivity, specificity, PV+, PV–, and OR with 95% CI were calculated from 2 × 2 tables, comparing antibiotic prescribing (yes or no) with the presence or absence of radiographic pneumonia.

Ethical approval

The Medical Ethics Committee of Maastricht University and the Maastricht University Hospital approved the protocol. All participating patients provided written consent after GPs provided information about the study and after having read the patient information leaflet.

Results

Patients

GPs recruited 247 LRTI patients with a mean age of 52 (range 18–89, 52% female) years. History and physical examination data were not available for one patient. Chest radiography was not performed in three (two with and one without an antibiotic prescribed) of the remaining 246 patients. An antibiotic was prescribed for 195 (79%) remaining patients. GPs did not prescribe an antibiotic for 51 patients because of mild symptoms (n = 33; 65%) and/or because a bacterial cause was unlikely (n = 41; 80%). In 8 of these 41 patients (20%) with 'bacterial infection unlikely,' a bacterium was subsequently identified, which percentage is slightly less than that of the remaining patients' average of 27%.

When asked after the consultation, 34% of patients indicated that they had hoped, before the consultation, to receive a prescription for an antibiotic. GPs indicated that because of perceived patient pressure, they prescribed an antibiotic for 4% of patients for whom they felt an antibiotic was not indicated.

Univariate analysis

Table 1 shows the patients' wide range of respiratory and general symptoms and signs. Abnormal findings on auscultation were common (84%). GPs prescribed antibiotics significantly less often to patients who had a dry cough, and more often to patients who had purulent sputum, moderate/severe illness, wheezing, and auscultation abnormalities. GPs prescribed an antibiotic to all patients with diarrhoea (n = 19), a high respiration rate (>20/min, n = 9) and crackles on auscultation (n = 50).

Multilevel logistic regression analysis

The features dry cough, purulent sputum, moderate/severe illness, wheezing, auscultation abnormalities, and diarrhoea were supplemented with clinical items not significantly correlated, but with $P < 0.10$ on univariate analysis (male sex, thoracic pain, myalgia, vomiting, COPD and upper respiratory tract signs). These items were then selected for multiple logistic regression analysis, controlled for clustering at GP level, to assess the independent contribution of the variables on the decision whether or not to prescribe an antibiotic (Table 2). The ICC in this analysis was 0.44. Although possibly of significance, high respiration rate (>20 per minutes) was not selected for the analysis because of the low number of patients with this feature (n = 9). The variables 'auscultation abnormalities' was a strong predictor of antibiotic prescribing. The variable included bronchial breathing, crackles and rhonchi and was included in the regression analysis rather than the individual sub-items as it had a higher OR in univariate analysis. Patients with the sub-item 'crackles' and patients with diarrhoea all received a prescription for an antibiotic and were, therefore, the strongest predictors of antibiotic prescribing. Because all patients with these features were prescribed antibiotics, the ORs of these variables could not be calculated exactly for methodological reasons, so were approximated by adding 0.5 to every cell of the 2 × 2 tables. The estimated OR was 35.7 for crackles and 11.4 for diarrhoea. The true OR will be higher than these estimated ORs. Vomiting also predicted prescribing an

TABLE 1 *Univariate comparison of age, symptoms and signs with GPs' decision whether or not to prescribe an antibiotic in 246 patients with LRTI*

	Antibiotic prescription [*N* = 195/246 (79.3%)]				
	N	%	OR (CI)	PV+ (%)	PV– (%)
Symptoms					
Age					
18–40 years	60	24.4	0.7 (0.4–1.4)	75.0	19.4
40–65 years	115	46.7	1.2 (0.6–2.2)	80.9	22.1
65 years or older	71	28.9	1.1 (0.5–2.2)	80.3	21.1
Male[a]	117	47.6	1.7 (0.9–3.2)	83.8	24.8
Recent cough ⩽2 days	11	4.5	1.2 (0.2–5.6)	81.8	20.8
Cough exacerbation ⩽2 days	35	23.3	1.6 (0.6–4.5)	85.7	20.9
Dry cough[a]	58	23.6	0.4 (0.2–0.7)*	65.5	16.5
Sputum purulence[a]	135	54.9	2.0 (1.1–3.8)*	84.4	27.0
Haemoptoe	14	5.7	1.6 (0.3–7.4)	85.7	21.1
Dyspnoea	191	77.6	1.4 (0.7–2.9)	80.6	25.5
Thoracic pain[a]	147	59.8	0.6 (0.3–1.1)	75.5	15.2
Fever[b]	85	34.6	1.2 (0.6–2.3)	81.2	21.7
Perspiring	184	74.8	0.8 (0.4–1.6)	78.3	17.7
Myalgia[a]	151	61.4	0.5 (0.3–1.0)	75.5	14.7
Chills	124	50.4	0.7 (0.3–1.2)	75.8	17.2
Headache	153	62.2	0.9 (0.5–1.7)	78.4	19.4
Confusion	8	3.3	0.4 (0.1–1.8)	62.5	20.2
Upper respiratory tract symptoms	168	68.3	0.8 (0.4–1.5)	78.0	17.9
Nausea	39	15.9	1.5 (0.6–3.9)	84.6	21.7
Vomiting[a]	28	11.4	3.8 (0.9–16.4)	92.9	22.5
Diarrhoea[a]	19	7.7	–	100	22.5
Stomach ache	9	3.7	2.1 (0.3–17.5)	88.9	21.1
Current smoking	83	33.7	0.7 (0.4–1.4)	75.9	19.0
Smoking past or present	153	62.2	1.3 (0.7–2.5)	81.0	23.7
Comorbidity					
Asthma	48	19.5	1.4 (0.6–3.2)	83.3	21.7
COPD[a]	32	13.0	2.8 (0.8–9.6)	90.6	22.4
Heart failure	8	3.3	1.9 (0.2–15.5)	87.5	21.0
Physical signs					
General impression					
Moderate/severe illness[a]	65	26.4	2.7 (1.1–6.3)*	89.2	24.3
Upper respiratory tract signs[a]	136	55.3	0.5 (0.3–1.0)	75.0	15.5
Respiration rate >20/minutes[c]	9	3.7	–	100	21.5
Wheezing[a]	105	42.7	3.4 (1.6–7.0)*	89.5	28.4
Percussion dullness	11	4.5	1.2 (0.2–5.7)	81.8	20.9
Auscultation abnormality	206	83.7	11.5 (5.4–24.7)*	87.4	62.5
Bronchial breathing[a]	65	26.4	3.3 (1.3–8.0)*	90.8	24.9
Crackles[a]	50	20.3	–	100	26.0
Rhonchi[a]	154	62.6	3.8 (2.0–7.2)*	87.7	34.8
Body temperature ⩾38°C	58	23.6	1.2 (0.5–2.4)	81.0	21.3
Clinical diagnosis of pneumonia	21	8.5	–	100	22.7

CI = 95% confidence interval; PV+ = positive predictive value; PV– = negative predictive value.
*Statistically significant ($P < 0.05$).
[a] Variable with $P < 0.10$ selected for multiple logistic regression analysis.
[b] Rectal temperature ⩾38.0°C or axillary temperature ⩾37.5°C and measured less than 24 hours ago.
[c] Not selected for multiple logistic regression analysis because of low number of cases (<10 patients with characteristic).

antibiotic, while the presence of thoracic pain predicted management without an antibiotic prescription.

A clinical diagnosis of pneumonia was made in 21 of the 246 patients (8.5%). Twelve GPs were at least moderately certain of this diagnosis in 20 (95%) cases and judged the illness in 14 (67%) as at least moderately severe (Table 3). The finding of crackles and dullness to percussion were statistically significant predictors of a clinical diagnosis of pneumonia (Table 4). Auscultation abnormalities were present in all patients with a clinical diagnosis of pneumonia. Productive cough was a clinical predictor of the diagnosis of acute bronchitis.

Appropriateness of the antibiotic prescriptions

Lateral and posterio-anterior chest radiographs were available in 243 patients, of whom 193 received an antibiotic. Radiographic pneumonia was diagnosed in 32 (13%) patients. Based on the assumption that an antibiotic should definitely be prescribed only for patients with pneumonia, the appropriateness of the

TABLE 2 *Multiple logistic regression analysis, controlled for clustering at GP level*

Clinical items	Antibiotic versus no antibiotic	
	OR	CI
History		
Thoracic pain	0.3	0.1–0.9
Vomiting	29.6	2.2–393.1
Sex: male	n.s.	
Dry cough	n.s.	
Sputum purulence	n.s.	
Myalgia	n.s.	
COPD	n.s.	
Physical examination		
Auscultation abnormalities	28.8	6.3–132.5
General impression		
Moderate/severe illness	n.s.	
Wheezing	n.s.	
Upper respiratory tract signs	n.s.	

n.s. = Non-significant test result.
Odds ratios (OR) and 95% confidence intervals (CI) for factors from history and physical examination that were statistically significantly associated, on univariate analysis, with general practitioners' antibiotic prescribing decision for 227 (patients with diarrhoea were not included because all patients with this clinical item were prescribed antibiotics, which precluded ORs to be calculated) patients with LRTI.

TABLE 3 *Clinical diagnoses of pneumonia and acute bronchitis in 246 LRTI patients: GPs' estimation of their diagnostic certainty and the illness severity*

	Pneumonia [*n* =21 (%[a])]	Acute bronchitis [*n* = 225 (%[a])]
Clinical diagnosis		
Very certain	4 (19)	24 (11)
Certain	7 (33)	61 (27)
Pretty certain	9 (43)	114 (51)
Uncertain	1 (5)	21 (9)
Very uncertain	0 (0)	5 (2)
Illness		
Very severe	0 (0)	0 (0)
Severe	3 (14)	11 (5)
Moderately severe	11 (52)	157 (70)
Mild	7 (33)	57 (25)

[a] Column percentages per characteristic.

antibiotic was tested in a two-by-two table. We found that 166/193 (86%) of the antibiotics were inappropriately prescribed according to this criterion (Figure 1). Based on a less conservative assumption that both pneumonia patients and patients with comorbidity of COPD needed to be prescribed an antibiotic, still 140/193 (73%) of the antibiotics were inappropriately prescribed. An antibiotic was not prescribed in 5 of the 32 (16%) patients with radiographic signs of pneumonia. An antibiotic was eventually prescribed in one of these five patients who re-consulted 5 days later.

TABLE 4 *Multiple logistic regression analysis*

Clinical items	Clinical diagnosis of pneumonia versus acute bronchitis	
	OR	CI
History		
Productive cough	0.1	0.0–0.4
Thoracic pain	n.s.	
Wheezing	n.s.	
Perspiring	n.s.	
Upper respiratory tract symptoms	n.s.	
Physical examination		
Crackles	41.0	9.5–177.3
Percussion dullness	34.1	3.9–297.1

n.s. = Non-significant test result.
Odds ratios (OR) and 95% confidence intervals (CI) for factors from history and physical examination that were statistically significant associated, on univariate analysis, with general practitioners' clinical diagnosis of pneumonia among a group of 246 patients with LRTI.

Discussion

Summary of main findings

GPs prescribed an antibiotic for 79% of the patients with LRTI. Auscultation abnormalities, especially crackles, and diarrhoea were the strongest predictors for GPs to prescribe an antibiotic. Assuming that antibiotics should be prescribed only for patients with pneumonia and not for other cases of LRTI, antibiotics may have been prescribed inappropriately to 86% of the patients included in this study. These findings are important because acute respiratory tract infection is the commonest reason for patients to consult and for antibiotics to be prescribed.[3,13] About 75% of all outpatient antibiotic prescriptions are for respiratory tract infections.[14] Systematic reviews of therapeutic trials demonstrate that possible benefits of antibiotic treatment do not outweigh the disadvantages for most people with respiratory tract infections, regardless of whether the infecting agent is a virus or bacterium.[4,15] Unnecessary antibiotic use is associated with antimicrobial resistance, wastes resources and impacts negatively on help-seeking behaviour.[16,17] The Netherlands has the lowest antibiotic prescribing rate in Europe.[18] Nevertheless, antibiotics are over-prescribed and the unjustified prescription of broad-spectrum antibiotics including quinolones and second and third generation cephalosporins is rising.[19] The greater understanding that this study has generated may prompt GPs to

	Pneumonia	No pneumonia	Total
Antibiotic	27	166	193
No antibiotic	5	45	50
Total	32	211	243

Sensitivity	27/32	84.4%
Specificity	45/211	21.3%
Positive predicted value	27/193	14.0%
Negative predicted value	45/50	90.0%
Odds ratio	1.5 (95% CI 0.5-4.0)	

FIGURE 1 *Sensitivity, specificity, positive predictive value, negative predictive value and OR of a prescription for an antibiotic predicting the presence of radiographic evidence of pneumonia in 243 LRTI patients.*

consider the clinical influences on their prescribing decisions.

Strength and limitations of the study

Adult patients with a wide range of lower respiratory tract symptoms were opportunistically recruited, diagnosed and treated by GPs in this pragmatic study. The sample included patients with acute bronchitis and pneumonia. Various symptoms and signs, like crackles and bronchial breathing on auscultation, are traditionally believed to be associated with pneumonia, but are also commonly observed in acute bronchitis. The presence of these signs in our study population was statistically not different between the patients with pneumonia and those with acute bronchitis.[12] This sample is, therefore, likely to represent a group of patients in which there is diagnostic uncertainty and for whom there is a dilemma about antibiotic prescribing. The independent contribution of individual symptoms and signs to an often finely balanced and implicit prescribing decision was evaluated. Previous studies on the influences on prescribing have largely used either qualitative interview and/or questionnaire-based methods that assessed GPs' perceptions of their management of mild respiratory tract infections. The GPs in the present study were unaware that this research would examine factors influencing prescribing, and the study involved direct assessments of these factors and prescribing decisions.

The decision to prescribe an antibiotic to the patient was left to the discretion of the GP, as in daily general practice. If an antibiotic was prescribed the patient entered into a randomized controlled trial. There were no advantages (neither diagnostically, nor financially, nor in terms of time) for the GPs and the patients to believe that this decision was made on other than medical grounds. The rate of antibiotic prescribing (79%) in the present study was the same as in an epidemiological survey describing the prescription of antimicrobial agents in cases of LRTI in Dutch general practice,[20] which supports our interpretation.

The high rate of antibiotic prescribing left a relatively small group of patients who did not receive a prescription for an antibiotic. Our restrictions for entering variables into the logistic regression analyses resulted in a satisfactory number of diagnostic variables. However, in the secondary diagnostic analyses of clinical features for diagnosing pneumonia, an even greater reduction of variables would have been better from a statistical point of view, given the small number of patients with clinically diagnosed pneumonia.

There is no internationally agreed definition of LRTI. We derived our definition from one used in a previous study.[21] Our wide, pragmatic inclusion criteria meant that patients with a range of aetiology and severity were included. Our focus was those patients GPs suspected of having an LRTI. As the main exclusions were for pregnancy and lactation, this is unlikely to have biased our sample.

Chest radiographs (lateral and posterio-anterior) were made of every patient on the third day after inclusion; the third day being chosen to ensure that possible infiltrates were detectable on the chest radiograph.[11] The conclusive finding of an infiltrate after assessment by two—or in cases of disagreement three—independent radiologists, was regarded as evidence of pneumonia. This reference standard is widely acknowledged for studies on community-acquired pneumonia. To get a better hold on the limitations of this reference standard, the results from our study on the inter-observer agreement in the interpretation of chest radiographs for pneumonia are of particular interest.[22] The moderate agreement found is considered clinically sufficient by radiologists. On the other hand, it confirms that the validity of chest radiography for diagnosing pneumonia is not optimal. By adding a third radiologist, who performed a third and decisive re-assessment of the chest radiographs in cases of disagreement, we believe to have countered this validity problem sufficiently.

Generalization of our findings to everyday care may not be valid. To explore possible selection bias, we compared the actual numbers of patients presenting with LRTI in three practices (with a total of nine GPs

and a combined patient list of 13 269) with the numbers included from those practices in the present study during 1 year of the recruitment period. Of the 463 potentially eligible patients, 43 (9%) were actually recruited. This proportion is not unusual for studies in primary care.[23] Recruited patients did not differ from eligible patients who were not recruited with regard to age, clinical diagnosis, severity of illness and GPs' assessment of need for antibiotic treatment.

GPs in everyday practice may sometimes record diagnoses and clinical findings only after having made a decision to prescribe an antibiotic.[8,24] Thus, recording history and examination findings can be done selectively in order to justify a diagnosis that warrants antibiotic treatment. This may have occurred in the present study. However, the diagnosis of pneumonia, which would uncontroversially justify antibiotic prescription, was made at a rate no more frequent than expected.[3]

Comparison with other studies

Despite being set in the country with the overall lowest antibiotic prescribing rate in Europe, antibiotic prescribing in this study was high (79%), and comparable to previous UK (72–76%)[2,25] and Europe-wide studies (83%).[26] This relatively high prescribing may have been because patients in this study presented with more severe illnesses and had a higher percentage of abnormal findings on auscultation (84%) than in previous studies (25%,[2] and 32%[25]). This may reflect both a high threshold for diagnosing LRTI among Dutch GPs and a high threshold for consulting among Dutch patients with common infectious syndromes. GPs almost always prescribed antibiotics when crackles and bronchial breathing were found on auscultation. These findings are commonly associated with pneumonia. However, evidence is emerging that these signs are neither discriminative[12,27] nor sufficient (crackles) to either rule in or rule out pneumonia in community settings.[28] The finding of rhonchi on auscultation—an acknowledged sign of acute bronchitis—was also commonly associated with a prescription for an antibiotic, despite the evidence that antibiotic treatment is not indicated for most cases of acute bronchitis.[4,5] GPs tended to prescribe an antibiotic to almost all patients with positive findings on auscultation. This was also the case in a study in which auscultation abnormalities were infrequently present.[2] Antibiotics were prescribed for 80% of patients for whom GPs were unsure about the diagnosis and for 74% of patients for whom they were sure of the diagnosis. Non-clinical reasons like time and patient pressure are additional influences on GPs to prescribe an antibiotic, but the influence of these factors was not assessed in this study.

We previously showed that dry cough is one of the clinical predictors of radiographic pneumonia.[12] In the present analysis, dry cough was associated with a clinical diagnosis of pneumonia. However, GPs prescribed an antibiotic less often if a dry cough was present (Table 1). All patients reporting a history of diarrhoea (n = 19) received a prescription for antibiotics. Although an infrequent symptom, a history of diarrhoea statistically significantly predicted radiographic pneumonia in our previous study.[12] Diarrhoea may well be a hitherto undescribed symptom of 'serious' illness for which GPs have developed 'a sixth sense' which was expressed in the prescription of an antibiotic. To our knowledge, diarrhoea has never previously been considered as a diagnostic variable in studies on LRTI.

GPs were confident in their clinical diagnosis of pneumonia 95% of the time. However, the predictive value of the clinical diagnosis of pneumonia, as previously described,[12] turned out to be poor: radiographic evidence of pneumonia was found in only 4 of the 21 patients with a clinical diagnosis of pneumonia (PV+ 19%, prior probability of pneumonia 13%), and 28 of the 32 (87%) cases of radiographic pneumonia were diagnosed as acute bronchitis by the GPs. The discrepancy between the GPs' confidences in their diagnosis compared with radiographically confirmed diagnoses is striking. Our secondary analysis of clinical reasons for diagnosing pneumonia suggests that this confidence is based on a belief in the diagnostic accuracy of finding crackles on auscultation and dullness to percussion.

Conclusion

Abnormal findings on auscultation, identified as possibly relevant in previous qualitative and questionnaire studies, were an important clinical reason for GPs to prescribe antibiotics in this practice-based, diagnostic study that explored the relationship between actual clinical findings (as opposed to general recall and perception) and actual antibiotic prescribing. The influence of abnormal auscultation appears to be overestimated and is associated with inappropriate antibiotic prescribing. GPs appeared overconfident in their diagnosis of pneumonia. In addition, we confirmed that GPs over-prescribe antibiotics for LRTI, and that more patients were prescribed an antibiotic than those who wished to receive one. This study provides better insight into the clinical factors associated with GPs' decisions to prescribe an antibiotic for patients with LRTI. This clearer insight is an essential precondition for developing successful, future strategies to reduce antibiotic prescribing. These results should prompt GPs to consider the extent to which finding 'crackles/rhonchi on auscultation' influences their decisions to prescribe antibiotics for patients with LRTI, and to consider the predictive value of individual clinical signs in reaching evidence based prescribing decisions.

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References

[1] Coenen S, Michiels B, Van Royen P, Van Der Auwera JC, Denekens J. Antibiotics for coughing in general practice: a questionnaire study to quantify and condense the reasons for prescribing. *BMC Fam Pract* 2002; **3:** 16.

[2] Holmes WF, Macfarlane JT, Macfarlane RM, Hubbard R. Symptoms, signs, and prescribing for acute lower respiratory tract illness. *Br J Gen Pract* 2001; **51:** 177–181.

[3] Okkes IM, Oskam SK, Lamberts H. Van klacht naar diagnose: episodegegevens uit de huisartspraktijk. [From complaint to diagnosis: Disease episodes in general practice]. Bussum: Couthino; 1998.

[4] Smucny J, Fahey T, Becker L, Glazier R. Antibiotics for acute bronchitis (Cochrane review). The Cochrane Library. Issue 1, 2004. Chichester, UK: John Wiley & Sons, Ltd; 2004.

[5] Fahey T, Stocks N, Thomas T. Quantitative systematic review of randomised controlled trials comparing antibiotic with placebo for acute cough in adults. *Br Med J* 1998; **316:** 906–910.

[6] The COPD Guidelines Group of the Standards of Care Committee of the BTS. BTS guidelines for the management of chronic obstructive pulmonary disease. 1997; **52(Suppl. 5):** S1–S28.

[7] Butler CC, Rollnick S, Pill R, Maggs Rapport F, Stott N. Understanding the culture of prescribing: qualitative study of general practitioners' and patients' perceptions of antibiotics for sore throats. *Br Med J* 1998; **317:** 637–642.

[8] Coenen S, Van Royen P, Vermeire E, Hermann I, Denekens J. Antibiotics for coughing in general practice: a qualitative decision analysis. *Fam Pract* 2000; **17:** 380–385.

[9] Macfarlane J, Holmes W, Macfarlane R, Britten N. Influence of patients' expectations on antibiotic management of acute lower respiratory tract illness in general practice: questionnaire study. *Br Med J* 1997; **315:** 1211–1214.

[10] Hopstaken RM, Nelemans P, Stobberingh EE, Muris JWM, Rinkens PELM, Dinant GJ. Is roxithromycin better than amoxicillin in the treatment of acute lower respiratory tract infections in primary care? A double-blind randomized controlled trial. *J Fam Pract* 2002; **51:** 329–336.

[11] Bartlett JG, Mundy LM. Community-acquired pneumonia. *N Engl J Med* 1995; **333:** 1618–1624.

[12] Hopstaken RM, Muris JWM, Knottnerus JA, Kester ADM, Rinkens PELM, Dinant GJ. Contributions of symptoms, signs, erythrocyte sedimentation rate and C-reactive protein to a diagnosis of pneumonia in acute lower respiratory tract infection. *Br J Gen Pract* 2003; **53:** 358–364.

[13] Office of Population Censuses and Surveys. Morbidity statistics from general practice: 4th National Study 1991–-1992 Series MB5, 3. London: HMSO; 1995.

[14] Gonzales R, Bartlett JG, Besser RE, Cooper RJ, Hickner JM, Hoffman JR, et al. Principles of appropriate antibiotic use for treatment of acute respiratory tract infections in adults: background, specific aims, and methods. *Ann Intern Med* 2001; **134:** 479–486.

[15] Del Mar CB, Glasziou PP, Spinks AB. Antibiotics for sore throat. *Cochrane database Syst Rev* **2000:** Cd000023.

[16] Swartz MN. Use of antimicrobial agents and drug resistance. *N Engl J Med* 1997; **337:** 491–492.

[17] Butler CC, Rollnick S, Kinnersley P, Jones A, Stott N. Reducing antibiotics for respiratory tract symptoms in primary care: consolidating 'why' and considering 'how'. *Br J Gen Pract* 1998; **48:** 1865–1870.

[18] Cars O, Molstad S, Melander A. Variation in antibiotic use in the European Union. *Lancet* 2001; **357:** 1851–1853.

[19] Kuyvenhoven MM, Van Balen FA, Verheij TJ. Outpatient antibiotic prescriptions from 1992 to 2001 in The Netherlands. *J Antimicrob Chemother* 2003; **52:** 675–678.

[20] Kuyvenhoven MM, Verheij TJ, de Melker RA, van der Velden J. Antimicrobial agents in lower respiratory tract infections in Dutch general practice. *Br J Gen Pract* 2000; **50:** 133–134.

[21] Macfarlane JT, Colville A, Guion A, Macfarlane RM, Rose DH. Prospective study of aetiology and outcome of adult lower-respiratory-tract infections in the community. *Lancet* 1993; **341:** 511–514.

[22] Hopstaken RM, Witbraad T, van Engelshoven JMA, Dinant GJ. Interobserver variation in the interpretation of chest radiographs for pneumonia in community-acquired lower respiratory tract infections. *Clin Radiol* 2004; **59:** 743–752.

[23] Wilson S, Delaney BC, Roalfe A, Roberts L, Redman V, Wearn AM, et al. Randomised controlled trials in primary care: case study. *BMJ* 2000; **321:** 24–27.

[24] Vinson DC, Lutz LJ. The effect of parental expectations on treatment of children with a cough: a report from ASPN. *J Fam Pract* 1993; **37:** 23–27.

[25] Macfarlane JT, Holmes WF, Macfarlane RM. Reducing reconsultations for acute lower respiratory tract illness with an information leaflet: a randomized controlled study of patients in primary care. *Br J Gen Pract* 1997; **47:** 719–722.

[26] Huchon GJ, Gialdroni-Grassi G, Leophonte P, Manresa F, Schaberg T, Woodhead M. Initial antibiotic therapy for lower respiratory tract infection in the community: a European survey. *Eur Respir J* 1996; **9:** 1590–1595.

[27] Melbye H, Straume B, Aasebo U, Dale K. Diagnosis of pneumonia in adults in general practice. Relative importance of typical symptoms and abnormal chest signs evaluated against a radiographic reference standard. *Scand J Prim Health Care* 1992; **10:** 226–233.

[28] Heckerling PS, Tape TG, Wigton RS, Hissong KK, Leikin JB, Ornato JP, et al. Clinical prediction rule for pulmonary infiltrates. *Ann Intern Med* 1990; **113:** 664–670.