



# Diagnosing pneumonia in patients with acute cough: clinical judgment compared to chest radiography

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**ABSTRACT** Pneumonia is often diagnosed and treated empirically. We set out to determine the diagnostic accuracy of clinical judgment based on signs and symptoms to detect radiographic pneumonia in patients presenting with acute cough in primary care.

In 2810 European patients with acute cough, general practitioners (GPs) recorded whether they considered pneumonia to be present (“yes” or “no”) immediately after history and physical examination. Chest radiography was performed within 1 week by local radiologists blind to other patient characteristics.

140 patients had radiographic pneumonia (5%), of whom 41 (29%) had been diagnosed as such. 31 (1%) patients had a clinical diagnosis that was not confirmed by radiography (n=2670). In clinically suspected pneumonia, 57% of subjects were subsequently diagnosed with radiographic pneumonia. Negative predictive value (NPV), sensitivity and specificity of GPs’ clinical judgment were 96%, 29% and 99%, respectively. Compared to patients with a clinical diagnosis of pneumonia, less severe symptoms were found in radiographic pneumonia cases not suspected clinically (p<0.05).

The predictive values of GPs’ clinical judgment, particularly the high NPVs, are helpful in routine care. Nonetheless, the majority of diagnoses of radiographic pneumonias was not suspected on clinical grounds. There is a need to further support the detection of clinically relevant pneumonia in primary care.



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## Introduction

Acute cough and lower respiratory tract symptoms are among the most frequent reasons for seeking primary healthcare. Most patients presenting with these symptoms in primary care are diagnosed as having acute bronchitis and a minority as having pneumonia. In general, pneumonia requires antibiotic treatment with close monitoring, while acute bronchitis is self-limiting and does not benefit meaningfully from antibiotic treatment [1–3]. General practitioners (GPs) usually have to either diagnose or exclude pneumonia on the basis of history, symptoms and signs alone, as it is neither feasible nor appropriate to perform chest radiographs in all patients presenting with acute cough or lower respiratory tract symptoms. Initial decisions on the most likely diagnosis, treatment and additional testing are therefore most often based on GPs' clinical judgment.

However, the performance of this clinical judgment is largely unknown. Several primary care studies have assessed the diagnostic value of signs and symptoms as individual items or in combination for diagnosing pneumonia [4, 5], but there is limited data on the accuracy of GPs' clinical judgment, independent of a formal diagnostic model in lower respiratory tract infection (LRTI). MACFARLANE *et al.* [1] found that GPs could not identify the need for antibiotic treatment with sufficient precision in patients with LRTI who had microbiological evidence of a bacterial infection. MELBYE *et al.* [5] compared GPs' clinical diagnosis of pneumonia with findings on chest radiographs and found that GPs made a clinical diagnosis of pneumonia in only a minority of the patients who had a radiographic diagnosis of pneumonia. However, these studies are limited by the small number of cases of pneumonia they included.

Knowledge on the performance of an empirical diagnosis of pneumonia in routine general practice is important for the development and implementation of diagnostic tools, such as formal diagnostic models and near-patient tests. We therefore set out to assess the diagnostic accuracy of a purely clinical diagnosis of pneumonia with a radiographic finding of pneumonia as the reference standard in a large sample of patients presenting with acute cough in primary care.

## Methods

### *Design and study population*

294 GPs in 16 primary care research networks in 12 European countries included 3106 consecutive patients presenting with acute cough in the GRACE-09 study (Genomics to combat Resistance against Antibiotics in Community-acquired LRTI in Europe; [www.grace-lrti.org](http://www.grace-lrti.org)) between October 2007 and April 2010. Recruited networks had access to a minimum of 20 000 patients and had a track record of conducting research. A national network coordinator and a national network facilitator took responsibility for their network's set up, recruitment and data management. Eligible patients were  $\geq 18$  years old, with an acute or worsened cough ( $\leq 28$ -day duration) as the main symptom or any clinical presentation considered to be caused by LRTI by the GP, and consulting for the first time for this illness episode. Exclusion criteria were pregnancy, breastfeeding and any serious condition associated with impaired immunity. All participants gave written, informed consent and the medical ethics committees of the participating centres approved the study.

### *GPs' assessment and radiographic findings*

GPs recorded patients' symptoms, signs, comorbidities (diabetes and respiratory and cardiovascular disease), medication use and, directly thereafter, his or her estimated diagnosis (open question) at presentation. All patients underwent chest radiography in local services within 1 week. Radiographs were assessed by local service radiologists blind to patients' current clinical information, but aware of the studies inclusion criteria and with free access to previous radiographs if available. The radiologists made a radiographic diagnosis by selecting one of the following fixed option responses: "normal X-ray", "acute bronchitis", "lobar or bronchopneumonia" or "other". There was a free text option to specify "other". Radiologists were allowed to inform responsible GPs if they found consolidation or made any diagnosis that required further investigation. In all other cases, GPs received the results after the study had been completed.

A subset of 1544 chest radiographs that were available for reassessment were reassessed by an independent radiologist (P.A. de Jong) at the University Medical Center Utrecht (Utrecht, the Netherlands) and interobserver variability was determined [6–8].

### *Data analysis*

Of the patients' clinical characteristics,  $< 1\%$  were missing. Missing data rarely occur completely at random and, therefore, imputation using multiple regression techniques was applied as recommended by many methodologists [9, 10].

GPs' empirical diagnoses were categorised into: "pneumonia", "exacerbation chronic obstructive pulmonary disease (COPD)/asthma", "upper respiratory tract infection (URTI)", "LRTI" (either

unspecified or viral cause), “acute cough” or “other”, and the proportions of these diagnoses in each country were calculated.

We subsequently dichotomised GPs’ diagnoses into “pneumonia” or “no pneumonia” and calculated sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and likelihood ratios (LR) of the clinical assessment of the presence or absence of pneumonia.

Because radiographic pneumonia was diagnosed less often than expected in some networks, based on previous prevalence studies [1, 11], we repeated the analyses excluding all countries with pneumonia prevalence <3% (Poland, France and Italy).

We compared patients with radiographic pneumonia who had been diagnosed with pneumonia on clinical grounds with those with radiographic pneumonia but who had not received this diagnosis on empirical grounds in terms of symptoms, signs and patients’ severity scores.

Data were analysed using SPSS (version 17.0; SPSS Inc., Chicago, IL, USA).

## Results

### Patient characteristics

Of the 3106 eligible patients with acute cough, 296 were excluded because chest radiography was not performed (n=258) or was of insufficient quality (n=28), and 10 because results of GPs’ clinical judgment were not available (fig. 1). The mean age of the 2810 remaining patients was 50 years, 40% were male and 28% were current smokers (table 1). 140 (5%) patients had radiographic pneumonia. The observed proportional agreement between the original and second radiological diagnosis was 1445 (94%) in 1544 patients. Kappa was 0.45 (95% CI 0.36–0.54; moderate agreement). The observed positive agreement (48%) was much lower than the negative agreement (97%). Patient characteristics did not differ significantly between analysed patients and excluded patients (due to missing radiograph results or clinical judgment), apart from age. Excluded patients were younger (mean age 44 years) (results not shown).

### GPs’ diagnoses

72 (3%) patients were judged to have pneumonia by the GPs. The proportion of diagnosed COPD/asthma exacerbations was 4%, of URTI 16% and of acute bronchitis 73%, which included 61% “not otherwise specified” and 12% specified as a viral cause. 4% of the patients were diagnosed with a symptom and not a disorder (“acute cough”), and three patients with “other diagnoses” (headache, cardiac failure or pertussis). The proportion of the most common diagnoses differed between the 12 European countries (table 2). 91% of patients underwent chest radiography within 5 days and the mean  $\pm$ SD duration between the first consultation for acute cough and chest radiography was  $1.6 \pm 2.6$  days.

### GPs’ clinical judgment of pneumonia

The GPs’ judgment regarding the presence or absence of pneumonia agreed with the radiographic diagnosis in 2680 (95%) patients (table 3). Of all patients diagnosed with radiographic pneumonia, 29% were diagnosed with pneumonia by GPs after history and physical examination (sensitivity). Specificity, PPV and NPV were 99%, 57% and 96%, respectively. Positive and negative LRs for GPs’ clinical judgment were 24 and 0.72, respectively. The agreement between clinical and radiographic diagnoses after exclusion of networks based in Poland, France and Italy is also shown in table 3, and this resulted in a sensitivity, specificity, PPV and NPV of 30%, 99%, 59% and 96%, respectively.

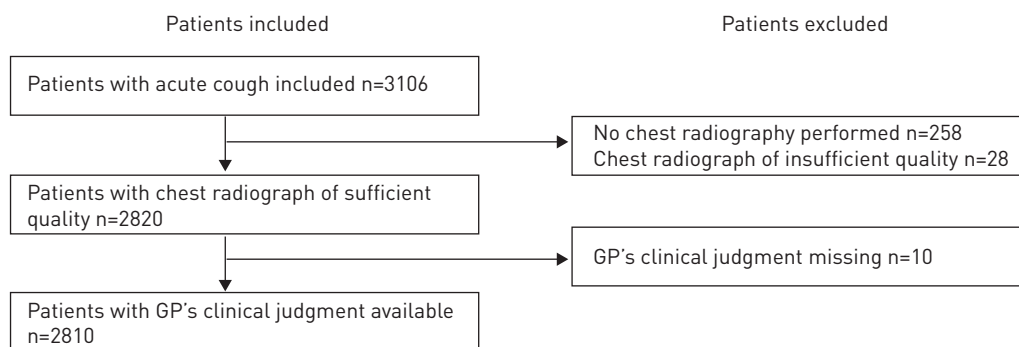


FIGURE 1 Flow chart of the study and participants. GP: general practitioner.

TABLE 1 Patient characteristics, including symptoms and signs, in 2810 patients presenting with acute cough in primary care

<b>Patient history</b>	
Age years	50 ± 17
Male	1122 (40)
Current smoking	780 (28)
Comorbidity (pulmonary, cardiac or DM) <sup>#</sup>	763 (27)
Days ill prior to consultation	9 ± 8
Cough present	2808 (100)
Breathlessness present	1592 (57)
Chest pain present	1301 (46)
<b>Physical examination</b>	
Diminished vesicular breathing	358 (13)
Crackles	265 (9)
Temperature >37.8°C	121 (4)
<b>Clinical judgment of general practitioner</b>	
Pneumonia present	72 (3)
<b>Chest radiograph (reference test)</b>	
Pneumonia present	140 (5)

Data are presented as mean ± SD or n (%). DM: diabetes mellitus. <sup>#</sup>: pulmonary comorbidity was defined as history of asthma or chronic obstructive pulmonary disease and cardiac comorbidity was defined as history of heart failure or ischaemic heart disease.

#### Clinical importance of clinically unidentified radiographic pneumonia

Patients who had not received a clinical diagnosis of pneumonia but who had radiographic pneumonia (n=99), had lower self-reported symptom severity scores and less severe individual symptoms, such as fever, crackles and signs of systemic inflammatory response syndrome, when compared with those patients who had both an empirical clinical diagnosis and radiographic diagnosis of pneumonia (n=41) (table 4).

## Discussion

### Main findings

In patients presenting with acute cough in primary care, GPs diagnosed pneumonia on clinical grounds alone in 29% of all patients who were subsequently found to have radiographic pneumonia (positive LR 24). In patients without radiographic pneumonia (n=2670), GPs diagnosed pneumonia in 31 (1%) patients on clinical grounds alone. The NPV of the GPs' judgment was 96%.

### Strengths and limitations

To our knowledge, this is the first study on GPs' diagnostic judgment of pneumonia in acute cough with an adequate number of pneumonia cases. Strengths of our study include the recording of clinical judgment in

TABLE 2 General practitioners' diagnoses in 2810 patients presenting with acute cough, by country

Country	Patients n	Diagnosis						Radiographic pneumonia	
		Pneumonia	Exacerbation COPD/asthma	LRTI unspecified	LRTI viral	Acute cough	URTI		Other
Belgium	367	2.5	5.4	67.3	2.2	0.3	0.3	0.0	5.4
France	29	0.0	3.4	62.1	10.3	3.4	3.4	0.0	0.0
Germany	158	4.4	7.0	41.1	32.9	11.4	11.4	1.0	5.1
Italy	76	1.3	1.3	96.1	0.0	0.0	0.0	0.0	2.6
The Netherlands	273	4.4	5.5	38.8	15.0	0.4	0.4	0.0	8.1
Poland	551	0.5	1.8	61.2	14.7	2.7	2.7	0.0	0.7
Slovakia	146	0.0	2.1	78.8	0.7	0.0	0.0	0.0	4.1
Slovenia	74	0.0	0.0	86.5	13.5	0.0	0.0	0.0	5.4
Spain	585	5.6	6.2	72.0	6.7	5.6	5.6	0.0	6.5
Sweden	98	2.0	2	74.5	19.4	1.0	1.0	0.0	6.1
England	203	2.0	5.4	49.3	24.6	1.5	1.5	0.0	6.9
Wales	250	0.4	2.4	40.0	10.4	16.4	16.4	0.0	6.4
<b>Total</b>		<b>2.6</b>	<b>4.1</b>	<b>61.2</b>	<b>11.7</b>	<b>4.1</b>	<b>4.1</b>	<b>0.1</b>	<b>5.0</b>

Data are presented as %, unless otherwise stated. COPD: chronic obstructive pulmonary disease; LRTI: lower respiratory tract infection; URTI: upper respiratory tract infection.

TABLE 3 The general practitioners' (GPs') clinical judgment of pneumonia compared to chest radiography

GPs' judgment	Chest radiography		
	Pneumonia present	Pneumonia absent	Total
<b>Including all countries</b>			
Pneumonia present	41	31	72
Pneumonia absent	99	2639	2738
Total	140	2670	2810
<b>Without including low-prevalence countries</b>			
Pneumonia present	40	28	68
Pneumonia absent	94	1992	2086
Total	134	2020	2154

Data are presented as n.

conditions similar to those of routine care, immediately after taking a history and performing a physical examination, and all patients undergoing a similar reference test for pneumonia, irrespective of the GPs' clinical judgment. A limitation regarding the reference standard is that all chest radiographs were examined by local radiologists in the European centres. We attempted to increase uniformity in assessment by using a protocol for reporting. Interobserver variability remained, but the moderate unweighted kappa of 0.45 was similar to other studies [6, 8]. Moreover, re-analysis with radiographic pneumonia as a reference test, as diagnosed by a second single assessor, showed comparable results (sensitivity, specificity, PPV and NPV of 20%, 98%, 42% and 94%, respectively).

A second possible limitation of our study regards the fact that, given that LRTI is common, many more eligible patients than were recruited would have been consulted during the recruitment period. Therefore, we probably did not achieve the goal of recruiting consecutive, eligible patients (e.g. the networks based in France, Slovakia and Slovenia included no patients with a clinical diagnosis of pneumonia). Nevertheless,

TABLE 4 Characteristics of clinically identified and unrecognised radiographic pneumonias

Clinical characteristics	Clinically identified radiographic pneumonia	Clinically unrecognised radiographic pneumonia	p-value
<b>Patients n</b>	41	99	
<b>Symptoms and signs</b>			
Runny nose	44	64	0.031
Fever	90	41	<0.001
Chest pain	68	52	0.068
Comorbidity (pulmonary, cardiac or DM) <sup>#</sup>	20	23	0.629
Abnormal auscultation lungs	83	50	<0.001
Diminished vesicular breathing	15	20	0.441
Crackles	66	16	<0.001
Rhonchi	27	23	0.652
Heart rate >100 beats·min <sup>-1</sup>	24	7	0.004
Breathing frequency >24 breaths·min <sup>-1</sup>	10	2	0.040
Blood pressure <90/60 mmHg	12	4	0.073
<b>Gradation of illness<sup>†</sup></b>			
Severe cough	30	43	0.143
Severe breathlessness	26	13	0.133
Severe fever	31	7	0.002
Severe chest pain	23	8	0.045
Severe general unwellness	25	26	0.912
Severe interference with daily activities	23	27	0.697

Data are presented as %, unless otherwise stated. DM: diabetes mellitus. <sup>#</sup>: pulmonary comorbidity was defined as history of asthma or chronic obstructive pulmonary disease and cardiac comorbidity was defined as history of heart failure or ischaemic heart disease; <sup>†</sup>: as judged by the patient.

we believe the findings of the study are at low risk of selection bias because feedback from recruiting clinicians during and after the study indicated that the time required to recruit and assess each patient made sequential recruitment of every eligible patient impossible. A recent observational study [12] in the same recruiting primary care networks used the same case definition and a very similar baseline case record form, but was much simpler to implement and that study recruited patients with similar characteristics to the current study (e.g. age 45 years, 37% male, and 26% comorbidity of either pulmonary, cardiac or diabetes mellitus).

#### Comparison with other studies

Several previous studies in primary care assessed the diagnostic value of history taking and physical examination to identify pneumonia [4, 5]. A validation study of clinical prediction models in primary care patients found PPVs ranging from 17 to 47% and NPVs ranging from 79% to 88% [11], but did not include GPs' clinical judgment. Two previous studies evaluated GPs' empirical clinical judgments in primary care patients with LRTI. MACFARLANE *et al.* [1] assessed GPs' clinical judgment in 318 adults with LRTI, and found no relationship between their clinical judgment and microbiological evidence of bacterial and/or atypical pathogens]. MELBYE *et al.* [5] studied 402 adults with LRTI, of whom 20 had pneumonia on chest radiography, and found that GPs identified seven of the 20 cases with radiographic pneumonia on clinical grounds. They also diagnosed pneumonia in 22 patients without radiographic pneumonia. Our results confirm that GPs make a clinical judgment of pneumonia in the minority of patients who are subsequently found to be diagnosed with pneumonia on chest radiography.

#### Implication of the results

It has been shown that many clinicians justify their use of broad-spectrum antibiotics on the grounds of not wanting to miss a case of pneumonia [13]. It is therefore helpful that we found the NPV of clinical judgment to be as high as 96%. This can support GPs to rely on their ability to exclude pneumonia and withhold antibiotic treatment in a large proportion of their patients [12].

Still, the large proportion of radiographic pneumonia not diagnosed on clinical grounds alone may seem worrisome. However, radiographic pneumonia cases that were clinically unrecognised in our study had symptoms of severe illness (e.g. fever and chest pain) less often at presentation (table 4). It has been shown before that milder pneumonia cases not suspected clinically may have a relatively more benign course [14]. Moreover, we assume that the serious negative health effects of a "missed" pneumonia in outpatients can be limited by instructing patients to revisit if symptoms persist or worsen. Improving the NPV of GPs' assessment of 96% will be difficult. However, two small studies showed that adding C-reactive protein level to signs and symptoms can result in a NPV of 97% [4, 15]. Further studies on the diagnostic value of C-reactive protein point-of-care tests in primary care in larger cohorts are needed.

#### Conclusions

Although the predictive values of GPs' clinical judgment are helpful in daily management of patients and especially the NPV of the clinical assessment is high, the majority of radiographic pneumonias were not recognised on clinical grounds alone. There is a need to further support the detection of clinically relevant pneumonia in primary care.

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