Association of population and primary healthcare factors with hospital admission rates for chronic obstructive pulmonary disease in England: national cross-sectional study

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ABSTRACT

Background Hospital admission rates for chronic obstructive pulmonary disease (COPD) are known to be strongly associated with population factors. Primary care services may also affect admission rates, but there is little direct supporting evidence.

Objectives To determine associations between population characteristics, diagnosed and undiagnosed COPD prevalence, primary healthcare factors, and COPD admission rates primary care trust (PCT) and general practice levels in England.

Design, setting, and participants National cross-sectional study (53,676,051 patients in 8,064 practices in 152 English PCTs), combining data on hospital admissions, populations, primary healthcare staffing, clinical practice quality and access, and prevalence.

Main outcome measures Directly and indirectly standardised hospital admission rates for COPD, for PCT and practice populations.

Results Mean annual COPD admission rates per 100 000 population varied from 124.7 to 646.5 for PCTs and 0.0 to 2175.2 for practices. Admissions were strongly associated with population deprivation at both levels. In a practice-level multivariate Poisson regression, registered and undiagnosed COPD prevalence, smoking prevalence and deprivation were risk factors for admission (p<0.001), while healthcare factors- influenza immunisation, patient-reported access to consultations within two days, and primary care staffing, were protective (p<0.05).

Conclusion Associations of COPD admission rates with deprivation, primary healthcare access and supply highlight the need for adequate services in deprived areas. An association between admission rates and undiagnosed COPD prevalence suggests that case-finding strategies should be evaluated. Of the COPD clinical quality indicators, only influenza immunisation was associated with reduced admission rates. Patients' experience of access to primary care may also be clinically important.

INTRODUCTION

Around 210 million people have chronic obstructive pulmonary disease (COPD) worldwide.[1] The WHO has estimated that there will be a 30% increase in COPD deaths in the next 10 years and that COPD will become the third leading cause of death by 2030.[2] The natural history of COPD involves gradual deterioration in lung function, marked by exacerbations requiring primary care intervention or hospital admission, a gradual decline in quality of life and reduced life expectancy.[3]

The total annual cost of COPD to the English National Health Service (NHS) is over £800 million (US$1215 million), and it has become the second largest cause of emergency hospital admissions in the UK.[4] The Department of Health (DH) for England has released a COPD national strategy[5] and it also has a range of policies to improve long-term condition management in primary care, with the aim of improving quality and length of life and reducing hospital admissions. For example, it has introduced a 'pay for performance' programme, the Quality and Outcomes Framework (QOF), which rewards general practices for identifying (by registering on practice computer systems) and managing effectively (by achieving a number of evidence-based quality indicators) a number of long-term conditions, including COPD. As a result, national data are available on registered prevalence and indicator achievement for almost all practices.[6] Over three quarters of a million people are on general practice COPD registers in England, but a mathematical prevalence model estimates that the actual number with the disease is about 1.2 million.[7]

Reducing unnecessary hospital admissions will play a critical role in ensuring the NHS and other health systems meet the challenge of real terms reductions in resources—the 2010 UK Budget report factors in potential savings of £2.4 billion from this source.[8] COPD is one of a number of ambulatory or primary care sensitive (PCS) conditions, for which it is hypothesised that risk of hospital admission will be reduced by effective primary care management.[9–11] However, PCS conditions have mainly been identified by expert opinion rather than empirically.[12 13] Previous research has also been hampered by lack of detailed data about practice populations and the quality of primary care services, such as is now available through QOF, or has been carried out only at primary care trust (PCT) level (PCTs are NHS organisations responsible for groupings of practices in geographic areas).[14–17]

Some population factors—especially deprivation—are strongly associated with PCS condition admission rates, and there are weaker associations with primary care access and supply factors. Effective management of COPD may reduce the risk of

hospital admission. Godtfredsen et al found a gradient of RR of hospital admission with increasing smoking prevalence.[18] In addition, combination treatment with long-acting beta-agonists and inhaled corticosteroids reduces the annual rate of COPD exacerbations and improves health status and spirometric values.[19] [20] A systematic review demonstrated that patients with COPD who received interventions with two or more components of the Chronic Care Model had lower rates of hospitalisations.[21]

The aim of this study was to examine the associations between population characteristics, including both diagnosed and undiagnosed prevalence, primary healthcare factors, and COPD admission rates at PCT and practice levels in England. Both levels of analysis are desirable, as aggregation to PCT level could mask important associations present at practice level. Specific objectives were first to investigate the associations between rates of hospital admission for COPD and population factors (deprivation, smoking prevalence, QOF registered/diagnosed prevalence rates and undiagnosed, ie, expected minus QOF registered prevalence rates). The second objective was to investigate associations between admission rates and a range of healthcare factors, after adjustment for population factors. These included access factors (general practitioner (GP) and practice nurse supply and QOF access indicators), COPD-specific QOF quality indicators, and smoking cessation advice or referral, to explore their relative impacts. As all UK residents are entitled to primary care consultations which are free at the point of use, and as the vast majority of residents are registered with a practice, there are no apparent barriers to access. However, despite NHS resources being allocated on a needs-weighted population basis, there are quite wide variations in access as measured by patients' experience of the availability of unscheduled care and appointments—hence the inclusion of these indicators in QOF.

METHODS
Hospital episodes statistics data

NHS-funded hospitals in England are responsible for providing data to the Hospital Episodes Statistics (HES) database. A hospital episode forms all or part of an overall hospital spell (one complete admission). We used hospital spells for this analysis to avoid multi-counting. Admissions were selected where the primary diagnosis, that is, main reason for admission met International Classification of Diseases version 10 J44.0—44.9 (other COPD, excluding asthma and other non-COPD) for all patients 15 years of age and over admitted during financial years 2006—2007, 2007—2008, 2008—2009 to maximise the number of admissions per practice. It was not possible to validate the HES diagnosis against data from practice COPD registers as only aggregate QOF data are available.

QOF data
QOF includes standardised information on the quality of care provided by 8229 general practices in 152 English PCTs. We used QOF data from the Health and Social Care Information Centre website for April 2008—March 2009.[6] QOF indicators are split between four quality domains (clinical, organisational, patient experience and additional services). The QOF clinical domain included 129 evidence-based indicators of the clinical quality of care including five indicators for COPD (table 1). We used the number of COPD patients recorded by general practices (registered prevalence), the total list sizes of patients per practice as denominators (the definition used by the Information Centre), the total QOF points achieved for the COPD domain

and individual indicators for specific COPD care (ie, spirometric confirmation of diagnosis, recent record of forced expiratory volume in one second (FEV_1), inhaler technique and influenza immunisation offered). Since stopping smoking affects the prognosis of COPD, we also included the percentage of patients with a chronic disease whose notes record that smoking cessation advice or referral to a specialist service has been offered within the previous 15 months (Smoking 4). To measure broad access to care from the patient perspective we used two new patient experience (PE) indicators introduced in the 2008—2009 QOF, which were derived from the results of the national GP Patient Survey, and which measure ability to access a GP consultation within 2 days (PE7), and ability to book an appointment with a GP more than 2 days ahead (PE8).

Practice staffing
The Health and Social Care Information Centre provided data on GP and nurse supply (GPs and practice nurses per 100 000 population), at practice and PCT levels, respectively, as of September 2007.[22] Practice nurse numbers do not include other nurses working in the community, such as 'community matrons' or district nurses, who may have contact with COPD patients.

Undiagnosed prevalence data
We used practice-level predictions of COPD prevalence from the Association of Public Health Observatories website, which uses a model developed by Nacul et al[7] This uses spirometry data from the 2001 Health Survey for England to produce prevalence estimates for population subgroups. It uses the British Thoracic Society definition of COPD, that is, FEV_1 divided by forced vital capacity (FVC) under 0.70, and FEV_1 less than 80% of predicted, a more stringent definition than the National Strategy. The model includes practice-level values of age, sex (population data as of March 2007), ethnicity, deprivation, smoking and urbanisation to estimate overall COPD prevalence, and has been validated against estimates from population surveys. Practice-registered COPD prevalence was then subtracted to estimate undiagnosed prevalence. Further information about the COPD model development is provided on the Association of Public Health Observatories website.[23]

Population data
The Care Quality Commission (CQC) provided estimates by sex and 5-year age band of registered patients by practice and PCT in England, as of April 2008. The Department of Communities & Local Government Index of Multiple Deprivation (IMD) 2004 data for England were used to measure deprivation[24]—high scores indicate a high level of deprivation. IMD data were available for 152 PCTs. A deprivation weighting for each practice was obtained from the CQC. This was produced by aggregating IMD scores from postcodes of individual patients in practice populations.

Statistical analysis
The basic unit of analysis was the general practice population. Indirect standardisation is generally accepted as more robust when counts are relatively small, so indirectly standardised admission rates were calculated at the practice level, to produce overall expected admission rates for each practice based on the England age/sex specific rates. These were compared to the observed practice-level admission numbers. Baseline PCT characteristics were then calculated including registered population (the sum of registers of general practices located within PCTs' geographic boundaries), age distribution, IMD, practices per

Table 1 Quality and Outcomes Framework indicators for COPD management and patient experience in 2008—2009 which were analysed

Indicator	Points	Payment thresholds*
COPD quality indicators		
Records		
COPD 1		
The practice can produce a register of patients with COPD	3	
Initial diagnosis		
COPD 12		
The percentage of all patients with COPD diagnosed after 1 April 2008 in whom the diagnosis has been confirmed by post bronchodilator spirometry	5	40—80%
Ongoing management		
COPD 10		
The percentage of patients with COPD with a record of FEV1 in the previous 15 months	7	40—70%
COPD 11		
The percentage of patients with COPD receiving inhaled treatment in whom there is a record that inhaler technique has been checked in the previous 15 months	7	40—90%
COPD 8		
The percentage of patients with COPD who have had influenza immunisation in the preceding 1 September to 31 March	6	40—85%
Smoking quality indicator		
Smoking 4		
The percentage of patients with coronary heart disease, stroke or TIA, hypertension, diabetes, COPD, CKD, asthma, schizophrenia, bipolar affective disorder or other psychoses who smoke whose notes contain a record that smoking cessation advice or referral to a specialist service, where available, has been offered within the previous 15 months	35	40—90%
Patient experience indicators		
PE7 Patient experience of access (1)		
The percentage of patients who, in the appropriate national survey, indicate that they were able to obtain a consultation with a GP (in England)	23.5	70—90%
PE8 Patient experience of access (2)		
The percentage of patients who, in the appropriate national survey, indicate that they were able to book an appointment with a GP more than 2 days ahead	35	60—90%

*The lower and upper achievement levels required to receive the minimum and maximum payment.
CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; GP, general practitioner; TIA, transient ischaemic attack.

PCT and practice list size. Practice level characteristics (QOF points and indicator breakdown) were aggregated to PCT level, as required. As admission counts were larger at PCT level, directly standardised (age and sex) admission rates were calculated per 100 000 GP registered population, using the total England population as the standard with which to weight the PCT rates. Three-year averages of registered and estimated COPD prevalences were summarised and undiagnosed prevalence calculated.

At practice and PCT levels, bivariate associations between admission rates and the above continuous independent variables were first assessed using Spearman's correlation coefficient. For the PCT level analysis, least-squares linear multivariate

regression models were then fitted to examine the effects of all independent variables. At the practice level, because of low admission numbers, we applied Poisson regression, where standard errors have been scaled using the square root of the deviance-based dispersion. The dependent variable was observed count of hospital admissions and the offset was the expected number of admissions. Poisson regression returns incidence rate ratios (IRRs), which in this context can be considered as analogous to ORs. Microsoft Excel and Access were used to manage the data and the software package Stata10 was used for all statistical analysis.

RESULTS

The 152 English PCTs had a total GP-registered population of 53 547 488 patients (table 2). The GP-registered population in each PCT varied from 94 635 to 1 294 596 (mean 352 286). We were able to match all the data required for 8064 (90.3%) GP practices from a total of 8932. List size varied from 984 to 38 343 (mean 6603). Estimated smoking prevalence at practice level varied from 13.2% to 51.7%. QOF scores achieved were generally high, for influenza immunisation, inhaler technique and spirometry, although there was a wider variance in PCTs recording spirometry (76.0—96.4%) and recording FEV_1 (75.5—89.3%). The range of QOF Patient Experience scores also tended to be lower.

Table 3 summarises the observed, estimated and calculated undiagnosed prevalence levels for COPD at the PCT and practice level. The England mean prevalence of registered COPD in the whole population is 1.5% (SD 0.0%), and undiagnosed COPD is 2.2% (SD 0.1%). Mean (over 3 years) annual hospital admission rates for COPD per 100 000 population varied from 124.7 to 646.5 (median 241.5, IQR 178.1—331.4) at PCT level and 0.0 to 2175.2 (median 179.0, IQR 111.1—288.2) at general practice level, illustrating the greater variance observable in a practice level analysis. Over 98% of admissions were in the 45 years and over age group.

Regression modelling

In the bivariate regression of exposure variables against hospital admission rates at PCT level, deprivation and smoking prevalence were the variables with highest explanatory power, accounting for 59.3% and 51.4% of the total variance, respectively (p<0.001). Estimated prevalence accounted for 45.1% of the variance (p<0.001) compared to the observed (registered) COPD prevalence (21.9%, p<0.001). About 14.4% of the variance in hospital admissions was explained by GP supply (p<0.001). The QOF COPD overall clinical quality score was shown to account for only 2.1% of the variance (p=0.034). Among all specific clinical QOF indicators, the score for influenza immunisation showed the highest explanatory capacity (6.9%, p<0.001). In the multivariate regression model using reverse stepwise variable selection (R^2=75.0%), the undiagnosed disease prevalence as well as all QOF clinical indicators were not retained in the model using a probability criterion of 0.1 (table 4).

Table 4 also shows the practice-level analysis using Poisson regression with reverse stepwise variable selection. The highest IRR was estimated for observed prevalence (IRR=1.224, p<0.001), and undiagnosed prevalence, deprivation, smoking prevalence, GP supply and access to a GP consultation, and influenza immunisation status were also retained in the final model using reverse stepwise variable selection and a probability criterion of 0.1. Overall COPD score, and clinical quality indicators COPD 10, COPD 11, COPD 12 and Smoking 4 all dropped out of this model.

Table 2 Characteristics of PCT and practice populations

	PCT level					Practice level			
	Mean	(SD)	Min—Max	Median	IQR	(SD)	Min—Max	Median	IQR
PCT population	352286	193433	94635—1294596	292118	225238—422895	—	—	—	—
Practice population	6603	—	—	—	—	4011	984—38343	5774	3394—9011
Percentage of people 15—34 years	27.5	25.7	19.6—43.1	43.1	25.7	7.8	10.5—98.5	25.7	22.4—30.0
Percentage of people 35—74 years	48.1	3.8	34.2—53.7	49.3	45.5—50.9	6.6	1.3—64.4	49.5	45.3—52.5
Percentage of people 75+ years	7.2	1.8	2.9—12.3	7.2	6.3—8.2	2.9	0.0—26.4	7.2	5.3—8.9
IMD (deprivation) score	23.7	9.1	8.1—48.3	23.6	16.1—29.8	12.6	2.2—71.9	21.3	13.4—32.0
Smoking prevalence	24.7	4.3	14.5—40.9	24.3	21.7—27.1	6.4	13.2—51.7	23.7	19.7—28.9
GPs/100000 population	60	7	44—81	59	55—64	17	8—334	55	10—180
Practice nurses/100 000 population	28	7	0—60	28	24—32	—	—	—	—
QOF clinical indicators*									
Total COPD score	96.2%	2.6%	83.7—99.9%	96.8%	94.8—98.2%	9.9%	0.0—100%	100%	99.4—100%
Influenza immunisation	91.6%	1.2%	86.9—95.5%	91.8%	90.9—92.4%	6.3%	0.0—100%	92.7%	89.5—96.1%
Record of FEV₁	82.4%	2.6%	75.5—89.3%	82.4%	81.0—84.2%	12.1%	0.0—100%	83.8%	77.3—89.7%
Record of inhaler technique	91.6%	1.6%	87.4—95.1%	91.8%	90.6—92.7%	8.9%	0.0—100%	93.4%	90.9—96.2%
Record of post-bronchodilator spirometry	90.1%	3.4%	76.0—96.4%	90.9%	88.8—92.2%	25.0%	0.0—100%	100%	86.2—100%
Smoking cessation advice or referral to a specialist service	92.7%	1.1%	89.2—95.3%	92.9%	92.1—93.5%	5.3%	26.6—100%	93.1%	91.1—95.8%
QOF patient care experience indicators*									
Ability to obtain a consultation within two working days	84.8%	8.4%	0.0—92.8%	85.6%	82.9—88.3%	14.1%	0.0—100%	87.3%	79.3—93.0%
Ability to book an appointment with a GP more than 2 days ahead	77.3%	8.4%	0.0—89.0%	77.8%	75.2—81.0%	17.6%	0.0—100%	80.8%	67.3—90.3%

*Total points/available %.
COPD, chronic obstructive pulmonary disease; GP, general practitioner; IMD, Index of Multiple Deprivation; PCT, primary care trust; QOF, Quality and Outcomes Framework.

DISCUSSION

In this cross-sectional study of hospital admissions for COPD, registered COPD prevalence, undiagnosed prevalence, smoking prevalence and deprivation were all risk factors for hospital admission (p<0.001). Primary healthcare factors such as being offered influenza immunisation, patient-reported access to primary care consultations within 2 days, and primary care supply (GPs and practice nurses per 100 000 population) were protective factors (p<0.05). There was an overall consistency in the findings at organisation and practice levels, but with additional independent variables being retained in the practice level model and with stronger associations apparent. At practice level, after adjustment for deprivation, undiagnosed COPD prevalence as well as diagnosed disease was strongly associated with the rate of hospital admission. Primary healthcare factors such as being offered influenza immunisation, patient-reported good access to GP consultation, and GP and practice nurse supply were also significantly associated with reduced hospital admission rates.

Hospital admissions for COPD were strongly associated with deprivation scores and smoking prevalence at both PCT and practice level. This relationship has been documented previously,[25 26] but associations with primary care supply less often. Saxena et al studied the association at London PCT level between population and practice factors with hospital admission rates for PCS conditions (including COPD).[17] They found some associations between primary healthcare factors and admission rates, but not with practice resourcing. By contrast, a practice level analysis of hospital admissions for asthma in East London found that practice characteristics were the strongest predictor of the admission rate, but the most likely explanation for this result could be that the geographically small region under investigation was uniformly deprived.[16] In our study, GP supply was inversely associated with hospital admission rates at the practice (but not PCT) level. Conversely, practice nurse supply was associated with lower admission rates at PCT level, but unfortunately these data are not readily available at practice level. These and similar findings, together

Table 3 Summary of estimated, observed and undiagnosed COPD prevalence and admission rates

	PCT level					Practice level			
	Mean	(SD)	Min—Max	Median	IQR	(SD)	Min—Max	Median	IQR
Populations	352286	193433	94635—1294596	292118	225238—422895	4011	984—38343	5774	3394—9011
Estimated prevalence	3.8%	0.9%	2.1—6.0%	3.6%	3.1—4.4%	1.1%	0.7—7.5%	3.6%	2.9—4.6%
Observed prevalence	1.5%	0.4%	0.7—2.5%	1.5%	1.3—1.8%	0.8%	0.0—7.5%	1.4%	1.0—2.0%
Estimated/observed (undiagnosed) prevalence	2.2%	0.9%	0.6—4.3%	2.0%	1.5—3.0%	1.0%	−2.6—6.0%	2.1%	1.4—3.0%
Estimated/observed prevalence ratio	2.6	0.7	1.4—5.0	2.4	2.0—3.0	8.4	0.5—577.4	2.5	1.9—3.5
Undiagnosed/observed prevalence ratio	1.6	0.7	0.4—4.0	1.4	1.0—2.0	8.4	−0.5—576.4	1.5	0.9—2.5
Admissions/100000 population*	265.3	104.2	124.7—646.5	241.5	178.1—331.4	170.8	0.0—2175.2	179.0	111.1—288.2

*Admission rates are directly standardised at PCT level and adjusted for age and sex (indirectly standardised) at practice level.

Table 4 Multiple regression analyses

PCT level*	Regression coefficient	95% CIs	p Value
Observed prevalence	1.325	1.204 to 1.459	<0.001
IMD (deprivation) score	1.023	1.018 to 1.028	<0.001
GPs/100000 population	0.995	0.991 to 1.000	0.052
Practice nurses/100000 population	0.992	0.987 to 0.996	0.001
Smoking prevalence	1.023 (Ed)	1.012 to 1.033	<0.001
QOF PE7	0.678	0.466 to 0.985	0.042

Practice level†	Incidence rate ratio	95% CIs	p Value
Observed prevalence	1.224	1.206 to 1.243	<0.001
Undiagnosed prevalence	1.045	1.032 to 1.059	<0.001
IMD (deprivation) score	1.009	1.006 to 1.012	<0.001
Smoking prevalence	1.036	1.031 to 1.042	<0.001
GPs/100000 population	0.998	0.998 to 0.999	<0.001
QOF PE7	0.790	0.730 to 0.855	<0.001
QOF PE8	0.902	0.850 to 0.957	0.001
COPD clinical quality 8 (influenza immunisation) (Ed)	0.825	0.690 to 0.987	0.036

*Stepwise linear regression. Adjusted R-squared=0.75. Dependent variable: admission rates for COPD.
†Stepwise Poisson regression, Dependent variable: observed admission count.
COPD, chronic obstructive pulmonary disease; COPD 8, the percentage of patients with COPD who have had influenza immunisation in the preceding 1 September to 31 March; GP, general practitioner; IMD, Index of Multiple Deprivation; PCT, primary care trust; PE7, score for ability to obtain a consultation within two working days; PE8, score for ability to book an appointment with a GP more than 2 days ahead; QOF, Quality and Outcomes Framework.

with the impacts demonstrated in our QOF indicator analysis, highlight the need for adequate primary care provision in deprived areas. Geographical inequalities in GP supply have been persistent despite needs-based funding of PCTs.[27]

Our study was strengthened by using data from a national population, giving a high level of statistical power, and by combining practice-level data and estimates from a number of sources which were previously unavailable or only available locally. This revealed associations which may have been masked in previous studies which used the organisation as the level of analysis. This study is also the first to examine estimates of undiagnosed disease and its association with hospital admissions.

The BTS definition of COPD used for the prevalence estimates is stringent, which may lead to underestimation of the effect of undiagnosed disease prevalence. Conversely, the COPD model does not include lack of bronchodilator responsiveness in the definition of COPD, so this will slightly overestimate prevalence. We were able to include several new QOF clinical quality and patient experience indicators. Our analysis also illustrates the greater benefits of using practice level rather than organisation level data. Our findings would be strengthened by similar analyses of other long-term conditions, which would also validate the selection of PCS conditions, and assist in regulation of primary care.

There are several limitations. Hospital or general practice diagnostic coding may be incorrect. However, the advent of diagnosis-based payment of hospitals has accelerated improvement in data quality. We only considered primary or principal diagnosis, and 87.2% of primary diagnoses for hospital admissions in England are coded correctly.[28] Counts of annual hospital admissions per practice were relatively low, even using means of 3 years' data (mean per year=12.9, median per year=10.0). We used appropriate methods (indirect standardisation and Poisson regression) to deal with this, and were reassured by the overall consistency between the results at organisation and practice levels. Furthermore, a number of UK agencies use practice-level admission data to support commissioning and

quality improvement, so its use should prompt similar scrutiny to that which followed use of similar data at hospital level. In the case of COPD, general practices may add patients to COPD registers without necessary confirmatory spirometry—only 82.4% have a record of this test. This will overestimate the correctly diagnosed prevalence.

Reported practice populations may overestimate actual numbers, especially in urban areas with high mobility. Conversely, a small number of residents may not be registered with a practice. There is also a high level of achievement of many QOF indicators which results in a 'ceiling effect', which may reduce the ability to detect real differences in clinical quality. Many QOF indicators measure care processes which may not be strongly related to disease outcomes (as our analysis suggests). The impact of recent changes in quality of care on outcomes such as hospital admission may be delayed, but changes in QOF scores between 2005 and 2007 were small. Other data inevitably covered slightly different periods and dates. HES data do not include privately funded hospital admissions, but the vast majority of unplanned admissions for COPD are to NHS hospitals. We did not analyse readmissions separately as the focus was on factors affecting exacerbations in the community. Practice-level COPD and smoking prevalence estimates are based on the limited range of risk factor data available locally.

There are now several disease prevalence models for England which enable comparisons of QOF-registered and expected prevalence counts. We showed an association between admission rates and undiagnosed prevalence. The National COPD Audit has shown that 90% of those hospitalised with COPD were known to have the diagnosis before admission and to suffer exacerbations frequently.[29] However, a population survey from Spain showed a high rate of undiagnosed COPD, and significant impairment in health-related quality of life and activities of daily living in undiagnosed individuals.[30] Patients who have frequent exacerbations irrespective of disease severity may represent a distinct COPD phenotype, implying that earlier diagnosis and intervention may improve outcomes.[31] The validity of the model, and the cost-effectiveness of targeted COPD case-finding strategies in practices with high estimates of undiagnosed disease, should therefore be evaluated.

The new QOF Patient Experience indicators were introduced, as their title suggests, to improve patient satisfaction with access to primary healthcare. However, the strong association between these indicators and admission rates suggests that they also reflect clinically important aspects of access. The National COPD Audit showed that 74% of admitted patients make contact with their general practice in the month before admission and 31% have three or more contacts in those 4 weeks.[29] Given that the ability to access primary care rapidly during a COPD exacerbation may well reduce admission risks, the association with PE7, the ease of obtaining a consultation, is plausible. That there is also an association with PE8, the ease of making non-urgent appointments, and with GPs per 100 000 practice population, suggests that access barriers may also affect ongoing COPD management.

At practice level, only QOF COPD indicator 8, uptake of influenza immunisation, was associated with hospital admission rates. This is clinically plausible. The other QOF COPD indicators are measures of clinical processes and standards which are less likely to affect outcomes. Alternatives which are more likely to affect outcomes should be considered. For example, practices could be incentivised to deliver more intensive smoking cessation services to COPD patients. The updated NICE COPD guidelines currently out for consultation recommend that

pulmonary rehabilitation should be made available to all appropriate patients with COPD, and that newer long-acting drugs be prescribed to appropriate patients.[32] The interventions in the Chronic Care Model reduce admission rates, although they are difficult to measure.[21] Finally, other factors which could affect admission rates include the quality of out of hours services, the presence of specialist nurse services, and the supply and quality of hospital services.

Competing interests None.

Contributors MS and AM conceived and planned the study. AC and AB undertook the statistical analysis and all authors were involved in the interpretation of the data. LC wrote the first draft of the paper. All authors revised it critically for important intellectual content and approved the final version.

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Correction

Calderón-Larrañaga A, Carney L, Soljak M, *et al*. Association of population and primary healthcare factors with hospital admission rates for chronic obstructive pulmonary disease in England: national cross-sectional study. *Thorax* 2011;66:191–96.

We wish to report a single error in our paper on associations of population and primary healthcare factors with hospital admission rates for chronic obstructive pulmonary disease. An observant researcher has questioned an R squared value for a univariate analysis at primary care trust level. In our paper we reported that about 14.4% of the variance in hospital admissions was explained by GP supply. We have re-run the analyses and confirm that there was a typographical error on our part. The R squared value of 14.4% was actually for the variable GP list size and not for GP supply (the latter has a R squared of 0.1%). The rest of the values are correct. We consider that this correction has no effect on the overall conclusions of our paper, as the important findings were at general practice level.