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Respiratory Medicine (2009) **103**, 558–565

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Stratification of COPD patients by previous admission for targeting of preventative care

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Received 2 August 2007; accepted 30 October 2008
Available online 10 January 2009

KEYWORDS
Chronic obstructive pulmonary disease;
Hospital admission;
Patient stratification;
Risk factor;
Targeted care;
Exacerbation

Summary
Background: Hospital admissions for exacerbations of chronic obstructive pulmonary disease (COPD) impact considerably on disease evolution and healthcare provision. Building on previous studies, this study postulated that COPD patients could be stratified by risk of admission to determine which groups provide the greatest burden on resources, and how interventions should be targeted to prevent admissions.
Methods: COPD admissions during 1997–2003 in three Strategic Health Authorities in England were analysed ($n = 80{,}291$). Patients admitted during winter (1 November–31 March) were stratified into three groups according to the number of admissions during the previous year: 0 (NIL), 1–2 (MOD) or $\geq$3 (FRQ). Winter weeks were classified as ''average'', ''above average'', ''high'', or ''very high'' risk, compared with the long-term mean.
Results: The risk of admission during winter for FRQ and MOD patients was 40% and 12% respectively. NIL patients contributed to 70% of winter admissions, and 90% of the variation between ''average'' and ''very high'' weeks, versus 9% and 1% for MOD and FRQ.
Conclusions: Patients with no previous admissions have lower individual risk, but contribute to a high overall utilisation of health care resources and should be targeted to prevent admissions. Focusing upon high-risk patients (frequent attenders or more severe) may only reduce a small proportion of admissions, and therefore clinicians should ensure that all COPD patients receive appropriate therapy to reduce risk of exacerbations.

Introduction

Chronic obstructive pulmonary disease (COPD) is one of the most frequent causes of hospital admission and a major burden to health services around the world. World Health

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doi:10.1016/j.rmed.2008.10.027

Organization (see http://www.who.int/en/) predictions suggest that it is set to become the fourth leading cause by 2030, accounting for 7.9% of total deaths.[1–4] COPD is estimated to affect three million people in England, accounting for over 30,000 deaths, 1.4 million general practice consultations and one million inpatient bed days each year.[5] COPD admissions to hospital in England have been rising on average at nearly 3% per annum (pa) since 1997/98,[6] and the public health burden is expected to continue to rise as the population ages and cigarette smoking persists.[5] The cost to the National Health Service (NHS) in England has been estimated to be over £800 million, with indirect costs to the economy a further £2.7 billion.[5]

Current Department of Health policy in England, United Kingdom (UK), aims to ''improve health outcomes for people with long-term conditions by offering a personalised care plan for vulnerable people most at risk; and to reduce emergency bed days by 5% by 2008 [from 2003/04 levels], through improved care in primary care and community settings for people with long-term conditions.''.[7] The UK Met Office has been working with primary care organisations in the NHS to develop a health forecasting service that triggers the provision of anticipatory care to patients with COPD. The overall aim is to reduce the risk of hospital admission, through targeted interventions and improved management of exacerbations. The Met Office/NHS service was piloted in winters 2004/05 and 2005/06 in general practices in more than 40 Primary Care Trusts (PCTs) in ten Strategic Health Authorities (SHAs), responsible for provision and funding health care services in the UK.[8] The service targets interventions by person, place and time, requiring a method of stratifying COPD patients by risk of exacerbation, and an understanding of how that risk varies through the winter in different parts of England.

COPD exacerbations occur at all stages of the disease but become more common as lung function declines.[9,10] An exacerbation is defined as a sustained worsening of the patient's condition, from the stable state and beyond normal day-to-day variations, that is acute in onset.[11] Previous studies suggest that some mild exacerbations are not reported to clinicians and effectively self-managed by patients at home. Some exacerbations are managed in the community by general practitioners. However, it is the exacerbations that result in admission to hospital that are the most disruptive to patients and expensive to health care systems. Between 16% and 22% of patients with exacerbations are admitted to hospital,[12] and it is these exacerbations that are analysed in this study. The Health Resource Group tariff for a severe exacerbation requiring hospital admission without/with complications was £1726/£2367 in 2005/06.[13] While the nature of COPD exacerbations may be very heterogeneous, it is conceivable that a proportion of those without complications may be managed in the community by a general practitioner or outpatient clinic, or even at home, costing £95 and £14 respectively.[5,13,14] Previous studies have shown that that overall admission rates can be predicted using a combination of epidemiological and environmental data,[15,16] and that patients admitted to hospital often have risk factors that could be modified.[17,18] Within the population of patients with COPD, some appear to be at higher risk of requiring hospitalisation. Different healthcare systems have tried various means of identifying the most vulnerable patients. Two of the most consistent predictors of hospitalisation are exacerbation frequency and a history of a previous admission, particularly within the last year.[18,19,20] This approach has been used by organisations such as Castlefields Health Centre and the Evercare model of care management, to classify patients as high risk if they have been admitted more than twice in the previous 12 months.[21,22] However, many other factors contribute to the risk of an admission. The Department of Health PARR (Patients at Risk of Re-hospitalisation) project has developed a model using hospital patient details to predict high-risk patients, and this will soon integrate primary care data.[23]

The study was funded by the Met Office as part of development of the pilot COPD Health Forecasting and Anticipatory Care service.[8] Building on previous studies, this study postulated that COPD patients could be stratified by risk of exacerbation requiring admission, to determine the patient groups which provide the greatest burden on resources, how risk varies during winter, and hence when and how interventions should be targeted to reduce admissions. It was anticipated that there would be implications for implementation of health policy aimed at reducing bed days, and an application in development of a protocol of interventions and anticipatory care as part of the Met Office/NHS service.

Methods

Data

The design was a retrospective cohort population-based study, using data from the Hospital Episode Statistics (HES) database. HES is the national warehouse for England of statistical data of the care provided by NHS hospitals and for NHS hospital patients treated elsewhere. The HES database is a record level database of hospital admissions. Each patient has a unique anonymised identifier, which can be traced between records.

Data for COPD emergency admissions (diagnosis of ICD10 J40-44) were extracted from the HES database for the period April 1997—March 2003, for all NHS organisations in Birmingham and the Black Country SHA; Cheshire & Merseyside SHA; and Norfolk, Suffolk and Cambridgeshire SHA. These SHAs were chosen as they were participants in the pilot Met Office/NHS service, with different geographical and socioeconomic characteristics. We aimed to establish that our conclusions could be independent of population, rather than to explain any geographical variation, which was out of scope of this study. All COPD admissions between 1 April 1997 and 31 March 2003 were included in the study. In-hospital mortality during the period of study was not corrected for.

Data for COPD prevalence in the three SHAs were available from the Quality Outcomes Framework (QOF) of the new general medical services contract.[24] Data describing the SHA populations were available from QOF and general practice registered population data.[25] Data for smoking were available from the Health Development Agency report *The smoking epidemic in England*.[26]

Analysis

The data were primarily analysed using pivot tables and look-up tables in Microsoft Excel. Relationships between variables were explored using linear regression. Winter was defined as the period from 1 November to 31 March, chosen as the months clinically associated with the highest number of COPD admissions. Two measures of risk were calculated:

1. the risk of admission of patients, according to their previous admissions;
2. the risk level of each week during winter, according to the standard deviations of admissions above the long-term mean.

Each patient appearing in the HES data was stratified according to how many admissions they had had during the 12 months prior to 1 November of each year. So at the beginning of winter, there was a category of patients who had been admitted once in the previous 12 months, and other categories who had been admitted 2, 3, 4, or $\geq$5 times. The risk of admission was defined as the proportion of patients in each category who were subsequently admitted during winter. Linear regression was used to determine how much the variation in this risk between categories could be explained by the number of previous admissions. The total number of admissions and average length of stay for each category were also calculated. Again, linear regression was used to determine how much the variation in average length of stay between categories could be explained by the number of previous admissions.

The initial categorisation was then simplified to two groups: 1–2 previous admissions (MOD group) or $\geq$3 previous admissions (FRQ group). A third group was defined, comprising patients who were admitted during the winter, but had not been admitted during the previous 12 months (NIL group). These patients may have had an admission more than 12 months ago, but otherwise it was not possible using admissions data alone to estimate the size of this group of patients at the beginning of winter. Instead, an estimate of the risk of admission was calculated as the ratio of total winter admissions of NIL patients, averaged over the years 1997/98–2002/03, against QOF data for COPD register counts in 2004/05.[24]

The risk level of each week was found by comparing admissions during the week with the long-term mean. The HES data were summed to give a daily time-series of admissions. Linear regression was used to determine how much of the variation in daily admissions could be explained by a trend variable. Significant trends were removed from the data. Detrended daily admissions were summed to give weekly admissions, and the long-term mean weekly admissions and standard deviations (SDs) calculated. The risk level of each week during winter was classified as ''average'', (less than 0.5 SDs above the long-term mean) ''above average'' (between 0.5 and 1.5 SDs above the mean), ''high'' (between 1.5 and 3.0 SDs above the mean), and ''very high'' (more than 3.0 SDs above the mean).

For each patient group (NIL, MOD and FRQ), the number of admissions in each week and the average admissions by risk level of week were calculated. For each patient group, linear regression was used to determine how much the week-by-week variation in average admissions could be explained by the risk level of the week.

Results

There were substantial differences in the prevalence of COPD, the annual admission rates for COPD per person aged over 65 and the mean daily admissions for COPD between the three SHAs (Table 1). Nevertheless there were similar temporal trends in admission rates across the SHAs and there was no statistically significant variation in length of stay between winters, SHAs or groups of patients.

Table 1 Characterising COPD in three Strategic Health Authorities (SHAs).

Financial year	Cheshire & Merseyside SHA	Birmingham and the Black Country SHA	Norfolk, Suffolk and Cambridgeshire SHA	Total
Number of COPD admissions[6]				
1997/98	5554	3278	2682	
1998/99	6319	3730	3093	
1999/00	6670	3867	3094	
2000/01	6690	3846	2980	
2001/02	6596	4049	3117	
2002/03	6705	4876	3145	
Total admissions	38534	23646	18111	80291
Mean daily admissions	17.6	10.8	8.3	36.6
Standard deviation	7.3	5.2	4.4	14.2
Number of COPD patients	20383	13354	10763	44486
Prevalence of COPD				
Average age of admissions[6]	71.3	71.4	72.2	
Population over 65[25]	393408	361721	403594	
Admissions pa per pop. over 65	0.016	0.011	0.007	
COPD prevalence[24]	2.0%	1.3%	1.3%	
Smoking prevalence[26]	29%	29%	27%	

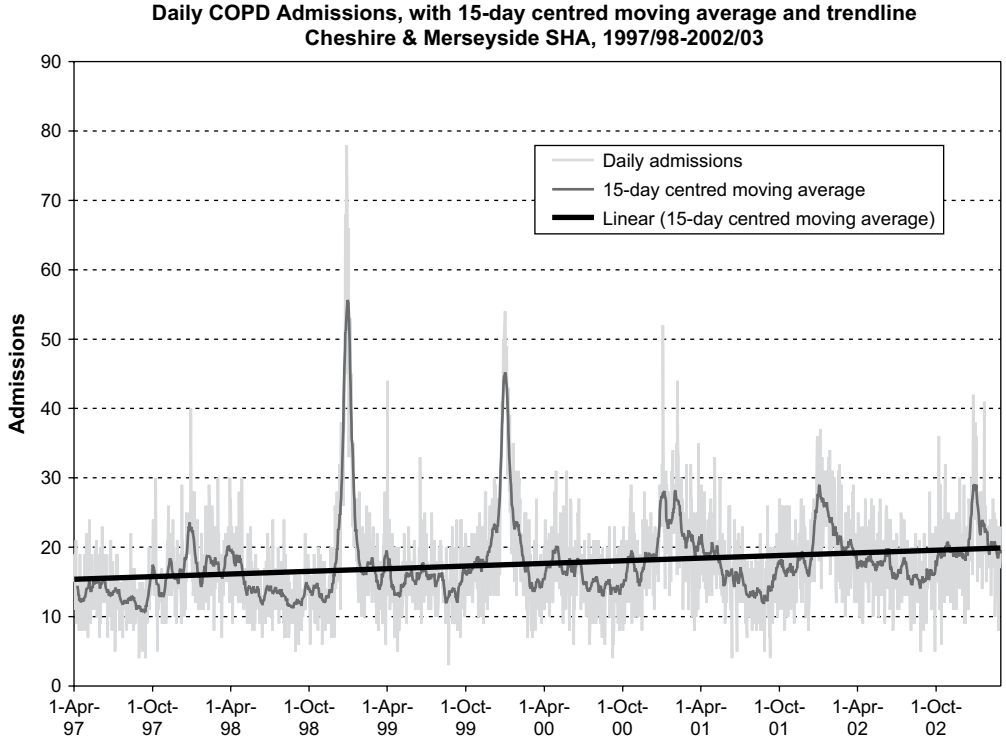

Figure 1 Daily admissions in Cheshire & Merseyside SHA.

The profile of admissions for each SHA shows an upwards trend and seasonal variation with a peak in winter with varying amplitude year by year (illustrated for Cheshire & Merseyside SHA in Figure 1).

On average across all SHAs and all winters between 1998/99 and 2002/03, 75% of patients admitted had had no admissions (NIL group) during the previous 12 months. Twenty per cent had had 1–2 previous admissions (MOD group), and 5% had had $\geq$3 previous admissions (FRQ group). Some of the patients were admitted more than once. NIL patients who were admitted had an average of 1.1 admissions during the same winter (i.e. on average 0.1 re-admissions), MOD had 1.3 admissions and FRQ 2.0 admissions. NIL patients account for 70% of all winter admissions, MOD 22% and FRQ 8%.

Previous admissions in the last 12 months (categorised as 1, 2, 3, 4, 5+) were highly predictive of future admissions in the following winter ($R^2 > 0.90$, $p < 0.001$). Using the simplified classification of NIL, MOD and FRQ, the risk of admission during winter was 40% for FRQ patients and 12% for MOD (Table 2). The QOF-based estimate of risk for NIL patients (ratio admissions of these patients admitted during winter to COPD register counts) gave a 4% risk of admission.

Sixty-five per cent of weeks during the winters of 1997/98–2002/03 were classified as ''average'' risk, 21% as ''above average'', and 8% as ''high'' and 6% as ''very high''. Typically, the higher weeks occur during the peaks of influenza epidemics, and the highest when the influenza peak coincides with a period of low temperatures. Outside the winters, there are very few weeks that are not ''average''.

The numbers of admissions during winter, and the breakdown by patient group, varies substantially with the risk level of the week (Table 3). As the risk level of the week increases, admissions and bed days increase substantially, with NIL patients accounting for most of the variation.

During ''average'' risk weeks in winter, NIL patients made up 67% of admissions, compared with 24% MOD and 10% FRQ. During ''very high'' risk weeks, NIL patients made up 81% of admissions, compared with 15% MOD and 4% FRQ. Averaged over all winters and SHAs, weekly admissions increased by 150% between ''average'' and ''very high'' risk weeks; admissions of NIL patients increased by 204% (variation between weeks significant to $p < 0.001$) compared with 51% ($p < 0.001$) and 14% (not significant) for MOD and FRQ patients respectively. NIL patients made up 90% of the variation between ''average'' and ''very high'' weeks, compared with 9% and 1% for MOD and FRQ patients.

Length of stay was not found to vary significantly with number of previous admissions in any of the SHAs, and hence trends in numbers of admissions and in bed days are similar when analysed according to the previous admission category of the patients.

From these data we calculated that a reduction of 5% in COPD emergency bed days during winter is equivalent to either a reduction of 62% in bed days (or admissions) of FRQ patients, or a 23% reduction in bed days (or admissions) of MOD patients, or a 7% reduction in bed days (or admissions) of NIL patients.

Discussion

Our results clearly confirm that COPD patients with a previous history of admissions are more at *individual* risk of readmission. However, at a *population* level COPD

Table 2 Number of patients with admissions in 12 months preceding each winter, subsequent admission during winter and length of stay categorised by number of previous admissions.

	Cheshire & Merseyside SHA			Birmingham and the Black Country SHA			Norfolk, Suffolk and Cambridgeshire SHA		
	0 (NIL)	1–2 (MOD)	3+ (FRQ)	0 (NIL)	1–2 (MOD)	3+ (FRQ)	0 (NIL)	1–2 (MOD)	3+ (FRQ)
Number of patients with admissions in 12 months preceding winter									
1998/99		3779	320		2512	155		2133	131
1999/00		4560	367		2621	189		2197	121
2000/01		4524	403		2836	195		2429	141
2001/02		4347	406		2732	222		2129	165
2002/03		4488	425		3077	282		2201	168
Total		21698	1921		13778	1043		11089	726
Number of patients admitted during winter									
1998/99	2166	508	130	1296	283	67	1131	218	43
1999/00	2075	586	149	1469	284	82	1242	235	46
2000/01	1823	614	169	1207	328	80	918	244	53
2001/02	1875	555	158	1258	341	92	977	239	54
2002/03	1729	575	174	1311	370	117	892	241	67
Total	9668	2838	780	6541	1606	438	5160	1177	263
Risk of admission during winter									
1998/99		13%	41%		11%	43%		10%	33%
1999/00		13%	41%		11%	43%		11%	38%
2000/01		14%	42%		12%	41%		10%	38%
2001/02		13%	39%		12%	41%		11%	33%
2002/03		13%	41%		12%	41%		11%	40%
Total		13%	41%		12%	42%		11%	36%
Average length of stay during winter (days)									
1998/99	10.29	10.22	10.69	9.27	12.08	8.50	9.51	9.23	9.39
1999/00	10.19	10.79	10.37	9.73	9.94	12.63	9.24	10.44	12.62
2000/01	10.91	11.65	10.08	10.84	9.71	12.47	10.37	10.61	8.61
2001/02	11.26	11.75	12.21	11.24	12.54	11.15	9.78	11.20	10.39
2002/03	9.50	9.64	11.05	8.38	9.95	9.72	9.19	8.88	10.50
Total	10.44	10.82	10.88	9.86	10.82	10.77	9.59	10.08	10.35

patients with no admissions in the previous 12 months are responsible for the greatest winter hospitalisation burden and most of the week-on-week variation in hospitalisations. Patients with no previous admission account for two-thirds of admissions during winter, and 90% of variation in admissions and bed days between ''average'' and ''very high'' risk level weeks. Our data suggest that patients with no previous admissions for COPD should be targeted with preventative care. This may result in more efficient management of total winter admissions and peaks in demand. However, in order to achieve this it is essential that the huge problem of COPD underdiagnosis is addressed. Unless strategies such as screening smokers with respiratory symptoms using spirometry are introduced, the first time some patients will be diagnosed will be at the time of their admission with an exacerbation.

The outcomes of this study were used in the pilot Met Office/NHS COPD Health Forecasting and Anticipatory Care service, and the analysis was based on the service's need for a simple and pragmatic method of stratifying patients at the beginning of each winter. The number of previous admissions in the past year is a very good predictor of future admissions and better than FEV_1 (forced expiratory volume in 1 second).[27] For health care institutions wanting to use Health Forecasting, admissions data are more likely to be available than more complex models of prediction. Stratifying by admissions in the previous 12 months, rather than for 3 years or longer, minimises the time required to search case notes for recorded admissions. Furthermore, the HES database is only available back to 1997/98, which both gives a limited dataset and truncates the patient record. It would be useful to follow up this analysis using methodologies such as Cox regression or time-series analysis, to confirm the findings.

A further potential limitation of the study is the reliance on accurate coding of COPD in the HES data, which is not necessarily consistent between organisations. However, the biases in the coding are likely to be consistent across organisations and the large number of Trusts contributing data make it unlikely that these differences will have a significant impact on our conclusions. The HES database is the definitive record of all admissions in each of the SHAs, and is therefore totally representative of these populations. Furthermore, epidemiological patterns are consistent across COPD data sources and healthcare use is likely to reflect the underlying prevalence and severity of disease.[28] The data period of study predates the introduction of the new general practice contract, which

Table 3 Average admissions per week and length of stay in winter categorised by number of previous admissions and risk level of week.

	Cheshire & Merseyside SHA			Birmingham and the Black Country SHA			Norfolk, Suffolk and Cambridgeshire SHA		
	0 (NIL)	1–2 (MOD)	3+ (FRQ)	0 (NIL)	1–2 (MOD)	3+ (FRQ)	0 (NIL)	1–2 (MOD)	3+ (FRQ)
Average admissions per week in winter									
Average	82.49	32.96	13.97	56.39	18.34	7.92	42.42	13.35	4.03
Above average	115.33	39.67	15.67	73.12	20.40	7.84	61.78	18.28	5.39
High	147.57	43.71	14.29	99.00	25.78	11.11	82.67	16.33	6.11
Very high	261.80	56.80	15.60	144.86	24.86	9.29	142.83	19.33	4.50
All weeks	102.88	36.34	14.46	69.92	19.90	8.27	54.92	14.79	4.47
Significance of variation with risk level of week	$p < 0.001$	$p < 0.001$	not sig	$p < 0.001$	$p < 0.05$	not sig	$p < 0.001$	$p < 0.05$	not sig
Average length of stay in winter									
Average	10.34	10.80	10.62	9.89	10.42	10.78	9.84	9.99	10.97
Above average	10.91	11.12	11.36	10.29	10.98	11.44	9.70	9.84	8.10
High	10.57	10.76	11.33	9.85	12.64	8.69	9.12	10.30	11.16
Very high	9.77	10.06	11.23	9.03	10.66	11.89	8.96	11.30	10.00
All weeks	10.44	10.82	10.88	9.86	10.82	10.77	9.59	10.08	10.35
Significance of variation with risk level of week	not sig	not sig	not sig	not sig	not sig	not sig	not sig	not sig	not sig

encouraged more rigorous assessment and diagnosis of patients with COPD in primary care. A clinical audit of primary and secondary care pathways could usefully expose any variations in coding, as well as highlight how many patients admitted with COPD have not been previously diagnosed.

The NIL group makes up the majority of COPD admissions, and can include patients diagnosed with COPD during the admission but with no previous diagnosis. Research is required to identify if there is a sub-group of COPD patients in the NIL group who are most at risk of admission or exacerbation. One way to address this is to use a multidimensional assessment tool such as the Clinical COPD Questionnaire (CCQ) to identify the patients with no previous admissions who have a higher risk of future admission.[29,30] Year round, the weeks that are classified as ''above average'', ''high'' or ''very high'' account for 16% of all weeks but 24% of all admissions. These are the weeks when low-risk patients have a higher risk of admission. We are not in a position to address the reasons behind the differences in variation in admission rates between the NIL, MOD and FRQ groups. The data suggest that hospitalisation in MOD and FRQ patients is less dependent on variable factors such as infections and climate and may be more influenced by small variations in underlying disease severity and co-morbidities. The important point is that the majority of admissions and variation in admissions are seen in the NIL group and therefore these patients are the ones who must be considered when trying to reduce admissions. Although there were substantial differences in the prevalence of COPD and annual admission rates across the three SHAs, similar temporal trends were observed. The prevalence of COPD shows geographical variation[24] but we found that there was no statistically significant variation in length of stay between groups of patients, winters or SHAs. Thus, it seems unlikely that regional differences have had any significant impact on the detailed results, and further exploration of geographical factors was not undertaken.

The Department of Health in England has outlined an objective and associated performance target to ''improve health outcomes for people with long-term conditions by offering a personalised care plan for vulnerable people most at risk; and to reduce emergency bed days by 5% by 2008, through improved care in primary care and community settings for people with long-term conditions.''[7] COPD is a long-term condition and our data show that patients with three or more admissions during the last 12 months (FRQ group) are the ''vulnerable people most at risk''. In keeping with previous findings,[19–23] we have confirmed that for COPD patients the number of previous admissions is highly predictive of future admissions. The FRQ group shows the least variation in admissions/bed days throughout the year, suggesting that if case management works it may reduce the risk of future admissions in this easily-identifiable group. However, these patients account for only about 8% of total winter bed days. To reduce emergency bed days during winter by 5% one would have to prevent 62% of these high-risk patients from being admitted, which is a considerable challenge, especially as many of these admissions are likely to be appropriate. Because there was no significant difference in length of stay between NIL and FRQ patients, reducing admissions among frequently-admitted patients would not bring any multiplicative saving in terms of bed days. Alternatively, just a 7% reduction in COPD admissions in the NIL group would achieve the 5% reduction in emergency bed days. This is also a challenge since the risk of admission for each patient is much lower, and there are

many more of these patients with mild symptoms and some with no current COPD diagnosis.[31]

Any intervention that seeks to reach the low-risk patients needs to address the fact that they constitute the vast majority on the COPD register. The Met Office/NHS COPD Health Forecasting and Anticipatory Care service aims to target the right preventative care to the right cohort of patients at the right time. During the winters of 2004/05 and 2005/06, the Met Office provided the service to more than 40 Primary Care Trusts in England. Participating general practices stratified their registers into NIL, MOD, FRQ groups. All patients were provided with an education pack at the beginning of the winter, containing basic information about COPD and Health Forecasting, evidenced-based actions that they can take to protect themselves, and two thermometers to ensure they are keeping their house warm enough. The Met Office provided forecasts twice-weekly of the risk of exacerbation for the next week. Practices then contacted patients with anticipatory care according to the protocol: FRQ patients were contacted when the forecast was ''above average'' or higher, MOD patients when the forecast was ''high'' or higher, and NIL patients when the forecast was ''very high''. Hence the high-risk but small group were contacted more frequently, and the low-risk but large group less frequently when the forecast risk was higher. Health Forecasting does not extend case management to the lower-risk patients, but complements it through empowering patients for self-care through education and timely reminders. Patient contact and anticipatory care by the practice was according to national guidelines,[11] and aimed at reducing risk. Care included for example support for smoking cessation, ensuring COPD patients were aware of their symptoms, and had adequate medication at home and knew who to call for advice in the case their symptoms worsened. Preliminary evidence from the 2005/06 pilot showed reductions in the admissions of 25—75% across practices which took part in different SHAs. Practices in the regions which did not participate saw either substantially smaller reductions or increases. This is borne out by findings from the East London Study that patient recognition of exacerbation symptoms and prompt treatment improves exacerbation recovery, reduces risks of hospitalisation, and is associated with a better health-related quality of life.[32]

The service was further developed in the winter of 2006/07, when the Met Office is trialled an automated patient contact system aimed at further reducing the burden on practices of contacting the low-risk patients. Again, all patients are provided with the education pack. When the Health Forecast indicates a period of increased risk, this system automatically telephones the patient at a time they have indicated is convenient. An interactive script asks questions about the patient's symptoms and whether they have enough medication at home in case their symptoms worsen. The patient's responses are logged, and the practice is alerted to follow up those patients who have indicated worse symptoms and/or no medication.

In conclusion, most patientsadmitted during winter in this study had had no admission for COPD during the previous year. These patients accounted for over 90% of variation in admissions between ''average'' and ''very high'' weeks. Patients with no previous admissions have lower individual risk, but contribute considerably to a high overall utilisation of health care resources and should be targeted to prevent admissions. Focusing upon high-risk patients (frequent attenders or more severe) may only reduce a small proportion of admissions, and therefore clinicians should ensure that all COPD patients receive appropriate therapy to reduce risk of exacerbations.

Conflict of interest statement

Clare Bryden is employed by the Met Office. At the time of the study, William Bird was employed by the Met Office as a consultant. David M.G. Halpin has no conflicting interests. Mark L. Levy has accepted sponsorship to attend international scientific conferences, and has accepted consultancy fees and speaker fees for participating in educational activities for: Altana Pharmaceuticals, Astra Zeneca, Boehringer Ingelheim, Cheisi-Trinity, GlaxoSmithKline, Innovata Biomedica, Merck Generics, MSD, Novartis Pharma, Schering-Plough, Sweden Diagnostics (Pharmacia) and Viatris. Helen A. Titley is employed by the Met Office.

Acknowledgements

We thank the Strategic Health Authorities (SHAs) who participated in the Met Office winter 2004/05 pilot COPD Health Forecasting and Anticipatory Care service: Birmingham and the Black Country SHA; Cheshire & Merseyside SHA; Norfolk, Suffolk & Cambridgeshire SHA; North West London SHA; South West London SHA; South West Peninsula SHA; South Yorkshire SHA; West Midlands South SHA.

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