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A retrospective study of the impact of a telephone alert service (Healthy Outlook) on hospital admissions for patients with chronic obstructive pulmonary disease

Christophe Sarran¹, David Halpin², Mark L Levy^{3,5}, Samantha Prigmore⁴ and Patrick Sachon¹

BACKGROUND: Healthy Outlook is a service delivered by the UK Met Office directly to patients with chronic obstructive pulmonary disease (COPD) that has been in place since 2006. Its objective is to reduce the severity and length of COPD exacerbations, hence improving the quality of life and life expectancy.

AIMS: To assess the effect of the Healthy Outlook service on hospital admission rates of all general practitioners that have used the service.

METHODS: Control practices were selected for each of the 661 participating practices. The number of hospital admissions for each practice was extracted from the Hospital Episode Statistics database. The differences in admission rates per practice between the first year of use of the Healthy Outlook service and the previous year were compared by paired *t*-test analyses.

RESULTS: For admissions with a primary diagnosis of COPD, the difference between participating and control practices was -0.8% (95% confidence interval (CI) = -1.8 to 0.2% ; $P=0.13$). For admissions with a primary or co-morbid diagnosis of COPD, the difference was -2.3% (95% CI = -4.2 to -0.4% ; $P=0.02$).

CONCLUSIONS: Participation in the Healthy Outlook service reduces hospital admission rates for patients coded on discharge with COPD (including co-morbid).

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a frequent cause of hospital admission and a significant burden to health services worldwide. It is predicted that it will be the third likely leading cause of death globally by 2020.^{1,2} In England, it is estimated that COPD affects 3 million people and accounts for 1.4 million general practice consultations, one million inpatient bed days and over 23,000 deaths each year.³ COPD is the second most common cause of emergency admission to hospital in England and one of the most costly inpatient conditions treated by the NHS.³ It results in an indirect cost to the economy of £3.8 billion. COPD exacerbations, in particular those requiring hospitalisation, are associated with significant mortality and morbidity. Patient recovery is slow and is a major burden for health services.⁴⁻⁶

Several studies have shown an association between symptoms of COPD and meteorological factors. Coughing has been associated with minimum temperature, humidity and wind speed, as well as with shortness of breath with minimum temperature.⁷ Exhaled nitric oxide levels, an indicator of airway inflammation, have been associated with lower temperatures.⁸ In Bavaria, the daily number of ambulatory care visits was associated with temperature, atmospheric pressure and solar radiation, with further associations with humidity and wind speed in North Bavaria.⁹ Koskela *et al.*¹⁰ have measured in the laboratory the effect of low temperatures on respiratory health, including bronchoconstriction present in COPD patients undergoing hyper-ventilation with cold air. A recent analysis by Hondula *et al.*¹¹

found that, although the association between respiratory health and meteorological variables are complex, models using meteorological parameters may be sufficiently predictive to be used as an early warning system. Indeed, using the UK Met Office's Healthy Outlook service, the predictive ability of weather parameters for COPD exacerbations has been demonstrated.¹²

Some telemedicine interventions¹³ and disease management models¹⁴ have reported reductions in hospital admission rates and significant improvements in outcomes of care,¹⁵⁻¹⁷ whereas others have shown no benefit.¹⁸ Patient education and self-management may have contributed to these positive outcomes.¹⁹⁻²¹ The physical exercise component of pulmonary rehabilitation also improves outcomes,²² although the weather has been reported as a major environmental barrier to improvement.²³

Developed in conjunction with clinicians, Healthy Outlook is a service delivered by the Met Office directly to COPD patients utilising automated telephone calls; this has been in place since 2006 and ended in 2013 when the service was closed. Periods of higher risk of COPD exacerbations are forecast using a rule-based model, combining observed and forecast parameters including season, humidity, temperature, air quality and rates of influenza-like illness. The service provides COPD patients with a 10-day advance warning of forthcoming periods of higher risk and encourages them to act proactively to reduce their exposure to risk; in particular, the telephone call asks them to check for early symptoms of an exacerbation and ensure they have sufficient medication.¹² Telephone calls were no more than fortnightly with typically four telephone calls in an average winter.

¹Met Office, Exeter, UK; ²Royal Devon and Exeter Hospital, Exeter, UK; ³Allergy and Respiratory Research Group, Centre for Population Health Sciences: GP Section, University of Edinburgh, Edinburgh, UK and ⁴St George's Healthcare NHS Trust, London, UK.

Correspondence: C Sarran (christophe.sarran@metoffice.gov.uk)

⁵Current address: Locum General Practitioner, London, UK.

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The primary goal of the Healthy Outlook service is to reduce the severity and length of COPD exacerbations, hence improving the quality of life and life expectancy. Previous observational studies have reported a reduction in mortality and hospital admissions.^{24,25}

A number of small studies have been carried out to assess the effectiveness of the Healthy Outlook service. A multicentre randomised controlled trial concluded that it may help reduce exacerbation rates, but the results were not statistically significant, possibly because of low (78) patient numbers.²⁶ Another group, Bakerly *et al.*,²⁷ Salford Primary Care Trust, noted a reduction in visits to general practitioners and out-of-hours services; however, the number of home visits and the overall cost per patient increased. In Bradford and Airedale, Maheswaran *et al.*²⁸ did not find any significant change in hospital admissions associated with the service.

Although the primary goal of the Healthy Outlook service is not necessarily to reduce hospital admission rates, the Hospital Episodes Statistics database has been used to assess the effect of the Healthy Outlook service on hospital admission rates of all general practitioners that have used the automated service; this is the largest analysis of the effect of the Healthy Outlook service on hospital admissions and the results are presented here.

MATERIALS AND METHODS

Between 2007 and 2011, the Healthy Outlook service was provided to 31,941 COPD patients in 661 participating practices in England. A control practice with similar characteristics of deprivation, age profile and rurality was selected for each participating practice. The emergency hospital admission rates of COPD patients registered in participating practices were compared with those for control practices.

Calculation of COPD admission rates

The difference, Δy_{HO} , in admission rates per practice between the first year of use of the Healthy Outlook service and the previous year was calculated. This ensures that any change in hospital admission rate is based on rates that are normalised for the practices using the rate from the previous year as a baseline. This is compared with the difference, Δy_C , in admission rates for the same years for the matched control practice. The difference in differences, $\Delta y_{HO} - \Delta y_C$, was calculated and a paired *t*-test was used to compare the admission rates between the participating and control practices.

This analysis was extended to estimate the effect of the service on the admission rate for the individual participating patient. An enrolled patient is assumed to be fully participating such that their individual difference in admission rate may be regarded as the difference in admission rate of the practice adjusted for the participation rate within the practice. The $\Delta y_{HO} - \Delta y_C$ difference was adjusted for patient participation rate by means of the linear regression of $\Delta y_{HO} - \Delta y_C$ against the participation rate. The coefficient of this regression provides an estimate of the effect of the Healthy Outlook service on the individual participating COPD patient.

The numbers of hospital admissions for each practice and year were obtained from the Hospital Episode Statistics database: these consisted of (1) emergency admissions with a primary diagnosis of COPD (ICD-10 codes J40 to J44 (ref. 29)) and (2) emergency admissions wherein COPD was any one of the diagnosis codes, as the primary diagnosis or as co-morbid COPD (termed here as 'any diagnosis of COPD'). The years were determined from the start date of the Healthy Outlook service for each practice, defined as the date the first patient was enrolled: the year before the service is the 1-year period up to the start date, and the first year of the service is the 1-year period from the start date.

A hospital admission rate was obtained by dividing the number of admissions by the number of COPD patients registered at the practice. The COPD 1 indicator reported by practices and available on the Quality and Outcomes framework database³⁰ is the ratio of the number (numerator) of patients on the practice's COPD register against the total number (denominator) of patients registered at the practice. The COPD 1 numerator was extracted from the Quality and Outcomes framework database and provides the number of COPD patients for each practice. The COPD 1 indicator is reported at the end of each financial year such that the number of COPD patients for the previous year is taken as that last reported before the start date, and the number of patients for the first year is that first reported after the start date (e.g., a start date of 1 December

2008 means that the number of COPD patients registered at the end of March 2008 is used for the previous year and that registered at the end of March 2009 is used for the first year).

Other factors (e.g., deprivation³¹) may influence the change in admission rates from year to year for any given practice. Therefore, we matched a control practice with similar characteristics to each of the 661 participating practices, by adapting the method developed by the Eastern Region Public Health Observatory.^{32–34} Each practice was characterised according to their Index of Multiple Deprivation (IMD),³⁵ the age profile of their patients (i.e., the percentage of registered patients aged 65 years or over) and the rurality classification³⁶ of their Middle Super-Output Area given by the Office for National Statistics.

These three parameters were used as percentiles such that the control practices were chosen by finding the lowest total percentile difference between the two groups, such that the nearest available neighbour in terms of these parameters was chosen with replacement for each participating practice. If c_{IMD} , c_{age} and c_r were the percentiles for IMD, age and rurality, respectively, for participating practices, and similarly c'_{IMD} , c'_{age} and c'_r for the control practices, matched control practices were found by minimising the total percentile difference $\sum (|c_{IMD} - c'_{IMD}| + |c_{age} - c'_{age}| + |c_r - c'_r|)$.

Emergency hospital admission rates for heart failure (ICD-10 code I50) and myocardial infarction (ICD-10 codes I21 and I22) in the year before the start of the service were compared using paired *t*-tests, for participating, and control surgeries to ensure that the two groups were well matched.

RESULTS

The number of emergency hospital admissions from the Hospital Episode Statistics database and the number of COPD patients registered from the Quality and Outcomes framework database (Table 1) provide the admission rates for each participating and control practice before and after the start of the Healthy Outlook service. The mean patient participation rate in relation to the COPD patient population was 40.7% with 95% of practices, with a participation rate between 11 and 81%. The results are summarised in Table 2. Prediction intervals are provided because they are a measure of the scatter and distribution of the data.

Histograms of the characteristics for practices participating in Healthy Outlook and for all general practices in England are compared in Figure 1: the plots suggest that the distribution of

Table 1. Descriptive statistics of the data per practice: number of registered COPD patients in each practice, number of admissions with primary diagnosis and any diagnosis of COPD, number of Healthy Outlook patients and participation rate

Data	Mean with 95% confidence interval (95% prediction interval in italics)	
	Healthy Outlook	Control
Registered COPD patients previous year	119 (113 to 124) <i>(27 to 253)</i>	101 (95 to 106) <i>(19 to 246)</i>
Registered COPD patients start year	125 (119 to 131) <i>(29 to 272)</i>	105 (100 to 111) <i>(21 to 247)</i>
Primary diagnosis admissions previous year	15.4 (14.6 to 16.3) <i>(2 to 38)</i>	14.1 (13.2 to 15.0) <i>(2 to 37)</i>
Primary diagnosis admissions start year	15.2 (14.3 to 16.1) <i>(1 to 38)</i>	14.2 (13.3 to 15.2) <i>(1 to 39)</i>
Any diagnosis admissions previous year	46.6 (44.2 to 49.0) <i>(9 to 106)</i>	41.0 (38.6 to 43.5) <i>(6 to 102)</i>
Any diagnosis admissions start year	48.6 (45.8 to 51.3) <i>(8 to 114)</i>	43.3 (40.6 to 46.0) <i>(5 to 110)</i>
Number of Healthy Outlook patients	48.3 (45.1 to 51.5) <i>(9 to 123)</i>	Nil
Healthy Outlook participation rate (%)	40.7 (39.2 to 42.3) <i>(11 to 81)</i>	Nil

Abbreviation: COPD, chronic obstructive pulmonary disease.

Table 2. Admission rates and *t*-test results with primary diagnosis and any diagnosis of COPD

Results	Mean with 95% confidence interval (95% prediction interval in italics)	
	Healthy Outlook	Control
Primary diagnosis admissions rate previous year (%)	14.0 (13.3 to 14.7) <i>(4 to 27)</i>	15.2 (14.4 to 15.9) <i>(3 to 35)</i>
Primary diagnosis admissions rate start year (%)	12.4 (11.8 to 13.0) <i>(3 to 26)</i>	14.4 (13.6 to 15.2) <i>(2 to 33)</i>
Primary diagnosis relative change Δy_{HO} , Δy_C (%)	-1.5 (-2.2 to -0.8) <i>(-16 to 9)</i>	-0.8 (-1.5 to 0.0) <i>(-15 to 14)</i>
Primary diagnosis $\Delta y_{HO} - \Delta y_C$ difference (%)	-0.8	-0.8 (-1.8 to 0.2) <i>(-19 to 17)</i>
Any diagnosis admissions rate previous year (%)	41.7 (40.2 to 43.2) <i>(18 to 75)</i>	42.9 (41.3 to 44.6) <i>(18 to 81)</i>
Any diagnosis admissions rate start year (%)	39.7 (38.3 to 41.1) <i>(12 to 70)</i>	43.2 (41.5 to 45.0) <i>(12 to 87)</i>
Any diagnosis relative change Δy_{HO} , Δy_C (%)	-2.0 (-3.5 to -0.4) <i>(-37 to 22)</i>	+0.3 (-1.3 to 1.9) <i>(-34 to 30)</i>
Any diagnosis $\Delta y_{HO} - \Delta y_C$ difference (%)	-2.3	-2.3 (-4.2 to -0.4) <i>(-43 to 33)</i>

Abbreviations: C, Control; COPD, chronic obstructive pulmonary disease; HO, Healthy Outlook.

participating practices does not differ much from that of an average English practice. From matching a control practice to each participating practice, the mean percentile difference between matched practices was 2.3% with 95% of matches with a percentile difference within 0.8–4.3%. Figure 2 shows a comparison of the IMD and age between participating and control practices, the tight clustering of the points along the diagonal suggesting a good match. Paired *t*-tests of the admission rates for heart failure and myocardial infarction in the year before the start of the service resulted in a mean difference between the two groups of -0.01‰ (95% confidence interval (CI) = -0.08 to 0.07‰; *P* = 0.9) for heart failure and -0.02‰ (95% CI = -0.09 to 0.05‰; *P* = 0.6) for myocardial infarction. This suggests that the participating practices are well matched to their controls as there were no differences in emergency hospital admission rates for these two outcomes.

For admissions with a primary diagnosis of COPD, the mean absolute change in admission rate for participating practices between the start year and the previous year was -1.5% (95% CI = -2.2 to -0.8%). For the control practices this figure was -0.8% (95% CI = -1.5 to 0.0%). The difference between participating and control practices was -0.8% (95% CI = -1.8 to 0.2%; *P* = 0.13).

For admissions with any diagnosis of COPD, there was a mean absolute reduction in admission rates for participating practices of 2.0% (95% CI = 3.5 to 0.4%) and, a corresponding increase of 0.3% (95% CI = -1.3 to 1.9%) in the control practices. The paired *t*-test yielded a difference, $\Delta y_{HO} - \Delta y_C$, of -2.3% (95% CI = -4.2 to -0.4%; *P* = 0.02).

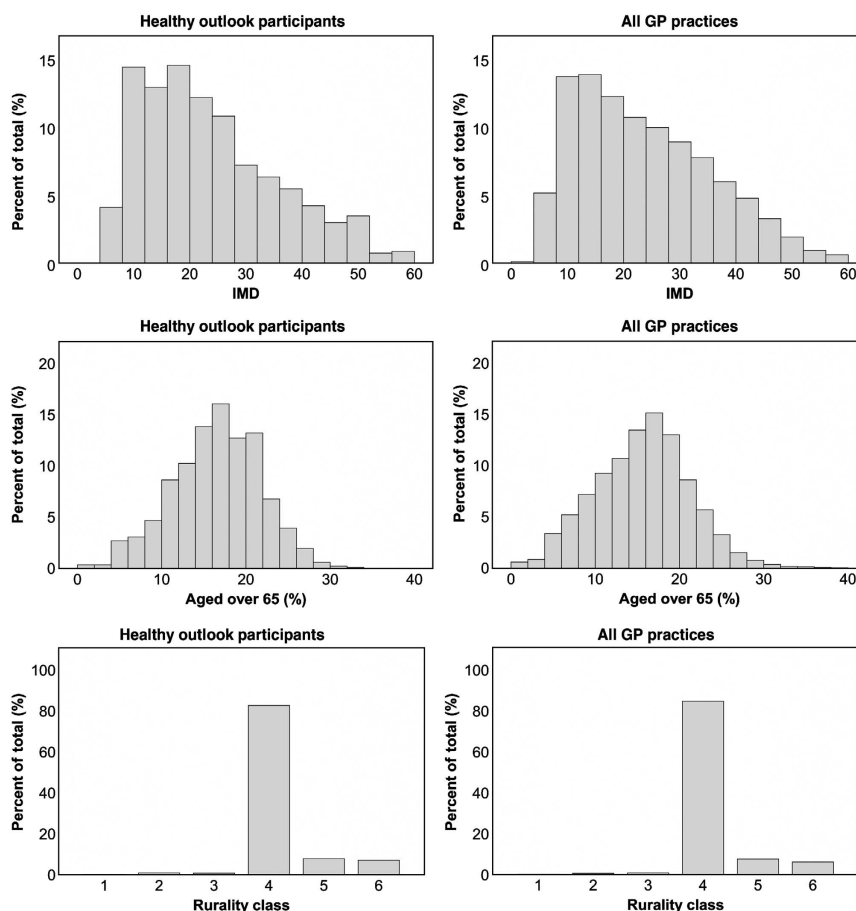


Figure 1. Distributions of Index of Multiple Deprivation (IMD), percentage of patients aged over 65 and rurality class for practices participating in Healthy Outlook and for all practices in England. (Rurality classes are: 1—urban > 10 K—sparse; 2—town and fringe—sparse; 3—village, hamlet and isolated dwellings—sparse; 4—urban > 10 K—less sparse; 5—town and fringe—less sparse; 6—village, hamlet and isolated dwellings—less sparse.)

For the regression of the $\Delta y_{HO} - \Delta y_C$ difference against participation rate, the regression coefficient is -0.023 (95% CI = -0.045 to -0.002 ; $P=0.04$) for admissions with a primary diagnosis of COPD. This equates to an estimated difference in admission rate of -2.3% for the participating COPD patient.

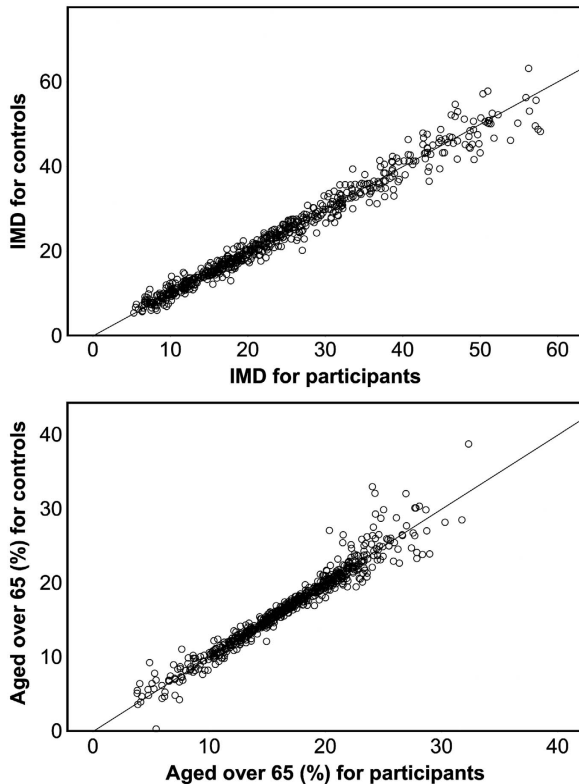


Figure 2. Index of Multiple Deprivation (IMD) and percentage of registered patients aged over 65 of matched control practices against participating practices. An equivalent plot for rurality class is not shown because its categorical nature makes the plot unhelpful.

For admissions with any diagnosis of COPD (i.e., when COPD was the primary diagnosis or a co-morbid condition), the regression coefficient was -0.07 (95% CI = -0.11 to -0.03 ; $P=0.001$). This equates to an estimated difference in admission rate of -7% for the participating patient.

DISCUSSION

Main findings

In the year after recruitment, the difference between participating and control practices was -0.8% for admissions with a primary diagnosis of COPD. Therefore, for an average practice with a primary diagnosis admission rate of 15% (see Table 2), the effect of the Healthy Outlook service was a 5% drop in admissions with a primary diagnosis of COPD (i.e., 0.8% is 5% of 15%). Furthermore, the difference between practices equates to a difference in admission rate of -2.3% for participating patients. Taking the primary diagnosis mean admission rate of 14% (see Table 2) before the start of the service for participating practices, the admission rate difference is equivalent to an average reduction in primary diagnosis admissions of 16% (95% CI = 1 to 32% ; c.f. Figure 3). This average reduction appears significant, whereas the difference of -0.8% between participating and control practices was not, because a further assumption was made that no participation means no effect, thus constraining the result to a narrower interval.

The difference was -2.3% for admissions with any diagnosis of COPD. Therefore, for an average practice with an admission rate of 43% for any diagnosis (see Table 2), the effect of the service was a 5% drop in admissions with any diagnosis of COPD (i.e., 2.3% is 5% of 43%). Furthermore, the difference between practices equates to a difference in admission rate of -7% for participating patients. Taking the mean admission rate of 42% for any diagnosis (see Table 2) before the start of the service for participating practices, the admission rate difference was found to be equivalent to an average reduction in any diagnosis admissions of 16% (95% CI = 6 to 26%).

Strengths and limitations of this study

This study is the first to examine the impact of the Healthy Outlook service in England by examining the admission rates for

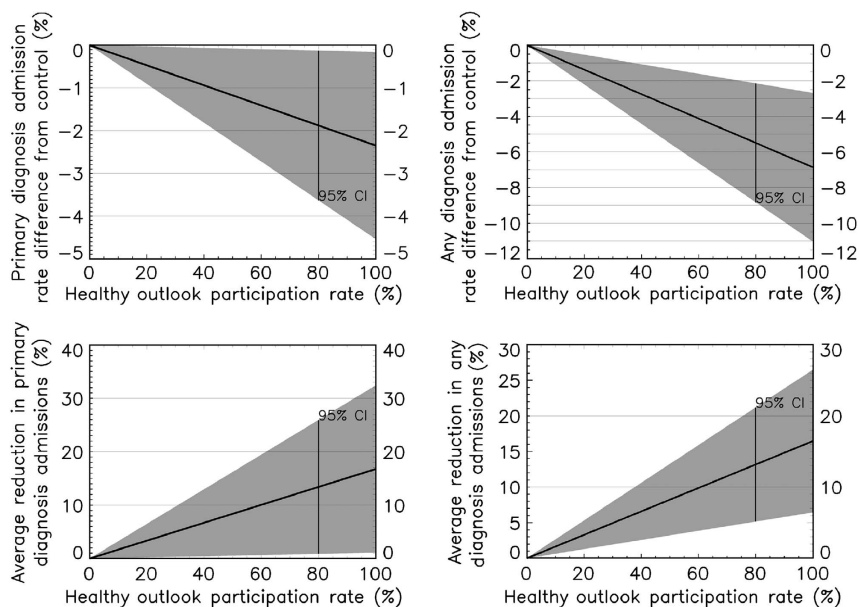


Figure 3. Regression lines with 95% confidence intervals (CIs) for the linear regression of the $\Delta y_{HO} - \Delta y_C$ difference against Healthy Outlook participation rate for primary and any (secondary) diagnosis of COPD, and the equivalent regression lines for average reductions in admissions assuming a mean admission rate of 14% and 42% for primary and any diagnosis of COPD, respectively.

all of the 661 participating practices where the participating COPD patients were registered. Not all COPD patients registered at a participating practice received the Healthy Outlook service. Therefore, the effect of the Healthy Outlook service on the admission rates is expected to be dependent on the patient participation rate within each practice. Admission rates per practice are also dependent on the severity of COPD of the patients registered in the practice as well as on other efforts made by the practice to address COPD admissions. Furthermore, the risk to COPD patients and therefore the risk of an emergency hospital admission will vary from year to year because of factors such as changes in levels of circulating viruses. While participating practices were clustered by commissioning organisation, usually Primary Care Trusts, they present a wide geographical distribution illustrated in Figure 4, such that it is unlikely that participating practices were climatically biased compared with the controls.

A limitation of the Eastern Region Public Health Observatory method for matching practices is that it does not take into account factors that might be linked to the take-up of the service, such as practices with a larger number of registered patients being more engaged in offering the service to patients. This would account for the significant difference in the number of COPD patients registered in participating and control practices, with 18 more patients in participating practices (95% CI=11 to 25; $P < 0.001$). The number of patients per practice could have been an additional matching criterion. Because it is already used as the denominator to measure the admission rate as outcome, the number of patients per practice was not used as a criterion for matching.

Interpretation of findings in relation to previously published work
A cohort study was carried out by Steventon *et al.*³⁷ for 1,413 COPD patients matched to controls and enrolled in the Healthy Outlook service in 102 participating practices: they concluded that Healthy Outlook did not reduce admission rates but found lower mortality rates. A significant difference in their approach is in not

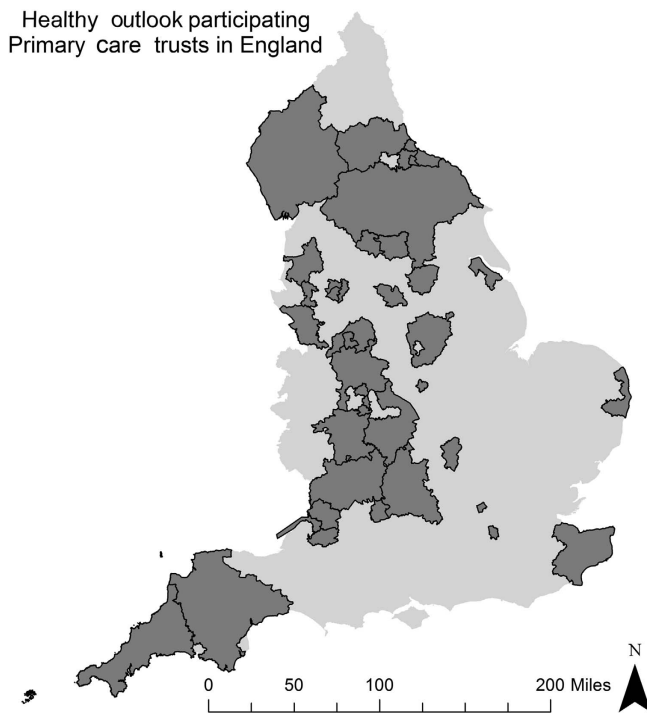


Figure 4. Locations of the Primary Care Trusts (PCT) in England with practices participating in the Healthy Outlook service.

having included unspecified and chronic bronchitis in the counts of COPD hospital admissions. A possible explanation is that mild-to-moderate COPD sufferers avoid hospitals following a telephone alert, whereas more severe sufferers will need emergency care in any case and despite the alert.

Although anticipatory care interventions are often well received,³⁸ COPD disease management can yield significant direct health-care costs³⁹ including the use of telemedicine.⁴⁰ Although we have demonstrated a small but statistically significant reduction in hospital admissions for participating practices, it is unclear how the cost-benefit of the Healthy Outlook can be quantified. Economic evaluation depends on the analytic approach adopted.⁴¹ Modelling the natural history of COPD linked with health economics may provide a more precise cost-benefit assessment.^{42–44}

Implications for future research, policy and practice

We found a 5% reduction in primary COPD diagnosis hospital admission rates when comparing participating and control practices in the year following adoption of the Healthy Outlook service. While the difference was not statistically significant, this may be explained by the range of uptake of the service within the participating practices (11 and 81%). However, and possibly more importantly, we have demonstrated a small, statistically significant net reduction in hospital admission rates in patients with any primary or co-morbid diagnosis of COPD. The importance of this finding emphasises the contribution of co-morbid COPD on overall hospital admissions, which has a knock-on effect when planning health-care provision.

Furthermore, when allowing for differences in participation rates (or 'exposure' to the service), changes in admission rates for those with a primary or co-morbid diagnosis of COPD are statistically significant and equivalent to a 16% drop in admissions.

Conclusions

We have demonstrated that participation in the Healthy Outlook service of the Met Office reduces hospital admission rates for patients coded on discharge with a primary or co-morbid diagnosis of COPD. This has major implications for patient well-being as well as for NHS resources.

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CONTRIBUTIONS

All authors together designed the study and reviewed the results; Christophe Sarran carried out the analysis; the manuscript was written by MLL and CS with contributions from DH; all authors reviewed drafts of the manuscript.

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