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Effect of a telephonic alert system (*Healthy outlook*) for patients with chronic obstructive pulmonary disease: a cohort study with matched controls

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ABSTRACT

Background *Healthy Outlook* was a telephonic alert system for patients with chronic obstructive pulmonary disease (COPD) in the UK. It used routine meteorological and communicable disease reports to identify times of increased risk to health. We tested its effect on hospital use and mortality.

Methods Enrolees with a history of hospital admissions were linked to hospital administrative data. They were compared with control patients from local general practices, matched for demographic characteristics, health conditions, previous hospital use and predictive risk scores. We compared unplanned hospital admissions, admissions for COPD, outpatient attendances, planned admissions and mortality, over 12 months following enrolment.

Results Intervention and matched control groups appeared similar at baseline ($n = 1413$ in each group). Over the 12 months following enrolment, *Healthy Outlook* enrolees experienced more COPD admissions than matched controls (adjusted rate ratio 1.26, 95% confidence interval (CI), 1.05–1.52) and more outpatient attendances (adjusted rate ratio 1.08, 95% CI, 1.03–1.12). Enrolees also had lower mortality rates over 12 months (adjusted odds ratio 0.61, 95% CI, 0.45–0.84).

Conclusion *Healthy Outlook* did not reduce admission rates, though mortality rates were lower. Findings for hospital utilization were unlikely to have been affected by confounding.

Keywords COPD, exacerbation, forecast, health promotion, patient admission, respiratory disorders, telehealth

Introduction

Chronic obstructive pulmonary disease (COPD) is a leading cause of morbidity, with ∼800 000 diagnosed patients in England.[1] The progression of the disease is marked by exacerbations or acute periods of deterioration in respiratory symptoms.[2] These exacerbations are often caused by viruses such as influenza.[3] Further, cold weather has been linked to exacerbations, mortality and hospital admissions for COPD.[4–7] Therefore, it has been hypothesized that, if one can predict the advent of cold weather or detect rises in influenza levels, then an anticipatory care intervention might prevent exacerbations and hospital admissions.[4,8]

Approaches to managing long-term conditions such as COPD are increasingly using technology as part of the delivery of services.[9] However, sophisticated technological approaches such as automatic monitoring of blood oxygen levels can be expensive,[10] may not be suitable for all patients,[11,12] have doubtful effectiveness[13] and are comparatively rarely used.[14] Simpler solutions using familiar and readily available technology such as the home telephone may be more cost-effective, as well as more acceptable to patients.

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Healthy Outlook was developed by the UK Meteorological Office (Met Office) and combines: (i) a forecasting model to predict when the outdoor environment is likely to adversely affect the health of patients with COPD and (ii) an anticipatory care intervention package. Patients receive telephone calls during which they are reminded to keep well, asked to check their medication and advised to contact their general practice in the event of a problem. A patient survey showed that the majority of respondents found the information provided as part of the service to be useful, while 36% of respondents had been prompted by the telephone calls to seek repeat prescriptions or to check COPD medication.[15]

It is hoped that, by providing timely and effective preventive support, *Healthy Outlook* will reduce COPD exacerbations, hospital admissions and deaths. However, evidence on this point has been equivocal. A randomized controlled trial (RCT) found that fewer intervention patients had an exacerbation than controls (58 versus 68%), but this did not reach statistical significance with a sample size of only 79 patients.[16] Since the service was embedded into routine care for the population with COPD in many parts of England, there is an opportunity to conduct large, observational studies with high levels of generalizability. However, existing studies have either been small and uncontrolled[17] or have relied on aggregated analysis at the general practice level.[18] Analysis for higher level units such as general practices can miss impacts for the subset of patients that receive the intervention of interest.

The wide coverage of hospital data sets in England and the use of anonymized patient identifiers meant that it was possible to conduct a larger study exploiting these operational data sets. We tested the effect of *Healthy Outlook* on hospital admissions and deaths against a matched control group.

Methods

Intervention and eligibility

Healthy Outlook was established in November 2007 to help patients with COPD to manage their condition, keep well and avoid hospital admissions.[19] Within the populations that were provided with the service, all general practices were eligible to participate and to recruit patients.

Any patient with COPD could be referred into *Healthy Outlook* by general practice staff. Patient recruitment was usually done on an opt-in basis, with a minority of practices automatically enrolling patients. Patients who signed up for the service provided their telephone number to receive automated, interactive phone calls when the alerts were made. Patients also received two thermometers and an information pack. The information pack described the forecasting system and how cold weather could affect COPD symptoms. It also contained detailed advice on self-management of COPD.

Decisions about whether to signal a telephonic alert were made weekly by the Met Office during winter, which used meteorological and influenza virus data to determine whether there was an increased risk of COPD exacerbation. Consideration was given to indicators relating to calendar week, temperature, influenza virus levels (based on communicable disease reports)[20] and a forecaster evaluation of the overall synoptic situation and air quality. Decisions about whether to signal alerts were made on a regional basis, with the regions corresponding to the 10 former Strategic Health Authorities in England.

When alerts were made, patients were telephoned up to three times at their preferred time of day. Once the patient with COPD had been reached, a message was given informing the patient that people with COPD might become more unwell in the following two weeks. The automated telephone call then worked through a script based on patients' replies to a series of questions. This covered the patients' COPD symptoms and medication, and is described in more detail elsewhere.[18] If a repeat prescription was needed or symptoms had worsened, patients were advised to contact their practice or respiratory nurse.

Study endpoints

We assessed the total number of urgent and unplanned ('emergency') hospital admissions, as well as hospital admissions for COPD, identified from hospital administrative data by the principal diagnosis, using *International Classification of Diseases*, *tenth revision* (*ICD-10*) codes J43 (emphysema) and J44 (other COPD). Secondary metrics were numbers of planned ('elective') admissions and outpatient attendances. Finally, we examined mortality rates.

A preliminary sample size calculation was based on detecting a 20% change in emergency admissions over the 12 months following enrolment into *Healthy Outlook*, at 90% power and a two-sided P-value <0.05. We assumed that emergency admission rates would be 0.8 per year for control patients, based on national rates (standard deviation 1.7; correlation between intervention and matched control groups 0.15). This produced a target sample size of 2019 intervention patients.

Data linkage

We studied the anonymized hospital care histories of a sample of *Healthy Outlook* patients recruited in England between the start of the service (November 2007) and a cut-off point of September 2011. The sample was taken from the operational system used to manage participants' data for *Healthy Outlook* and was primarily based on the availability of the unique patient identifier ['National Health Service (NHS) number'] needed for data linkage.

Hospital data were obtained from a national administrative database of inpatient and outpatient care paid for by the NHS at all acute hospitals in England, the Hospital Episode Statistics (HES). We also obtained a linked mortality file that contained the date of death for patients with an HES record, regardless of whether death occurred inside or outside the hospital.

Study cohorts

From the set of linked intervention patients, we excluded those without an HES inpatient admission between 2001 and the date of enrolment. This was done because HES inpatient data were our richest source of data, and so we could not as accurately characterize patients who had not been admitted. We also required that the prior inpatient admission contained a primary or secondary diagnosis of COPD (ICD-10 codes J43–J44).

A matched control group was selected retrospectively from a group of potential controls that was sourced from the same regions as the intervention patients. Like intervention patients, potential controls had a previous inpatient admission with a diagnosis of COPD. We excluded as controls all patients who had ever been registered at a general practice that offered *Healthy Outlook*. Thus, potential controls met the eligibility criteria for *Healthy Outlook* but were not registered at a general practice at which the service was offered.

For intervention patients, baseline variables were calculated at the date of enrolment into *Healthy Outlook* (see Table 1). These baseline variables have been shown to be predictive of future emergency hospital admissions.[21] Potential control patients were randomly assigned eight index dates, corresponding to months during the study period (November 2007 to September 2011); baseline variables were then created at each of these index dates. However, we removed records where the index date was after the date of death or before the date of the first diagnosis of COPD in inpatient data.

A matching algorithm was used to select from the potential control records (up to eight per potential control patient), a subset that was similar to the intervention patients with respect to the baseline variables. To do this, we used genetic matching,[22] which is a computer-intensive search algorithm that has been shown to produce more closely balanced groups than more traditional methods.[23] The matching was conducted separately by region (thus ensuring that controls were resident in the same broad geographical location as intervention patients) and on a 1:1 basis.

We assessed the similarity of intervention and matched control groups at baseline using the standardized difference (defined as the difference in sample means as a percentage of pooled standard deviation).[24] A threshold of 10% has been used to denote a meaningful imbalance.[25] As the standardized difference only measures a difference in means, we also assessed the ratio of variances in the two groups.[26]

Statistical methods

We estimated the effects of *Healthy Outlook* on hospital use and mortality over the year following enrolment. Analysis was done at the patient level, regardless of subsequent death. Counts of hospital activity were compared using Poisson regression, adjusting for the baseline variables, with coefficients presented as rate ratios. Analogously, mortality rates were compared using logistic regression, with coefficients presented as odds ratios. Models contained random effects for the matched pair to account for the expected correlation structure of the data.[24]

Additional analyses

Two further analyses are presented in the Supplementary data. First, we examined the meteorological data that were used to determine when the telephonic alerts were made and confirmed that these were predictive of hospital admissions and mortality. Secondly, we examined short-term changes in hospital utilization over the 7, 14 and 28 days following the telephone alerts (rather than over the year following enrolment).

Results

Figure 1 shows the flow of patients into the study. In total, 3946 patient spells contained an NHS number and 3581 were mapped to the hospital data, giving a linkage rate of 90.7%. A prior diagnosis of COPD was recorded on inpatient data for 40.1% of linked patients, leaving a sample of 1425 patients. Our sample was registered at 102 general practices, with a median number of study patients per practice of 10 (range 1–66).

HES provided 697 095 potential controls from 8736 general practices. Compared with the potential controls, intervention patients were younger, less likely to have co-morbidities and had experienced fewer emergency hospital admissions (see Table 1 and Fig. 1).

All except 12 intervention patients were matched to a control ($n = 1413$). Matched controls and intervention

Table 1 Baseline characteristics (data are the percentage of group unless otherwise stated)

	Intervention patients (n = 1425)	*Potential controls (n = 697 095)*[a]	*Matched controls (n = 1413)*	*Before matching standardized difference (variance ratio)*	*After matching standardized difference (variance ratio)*[b]
Mean age in years (SD)	71.2 (9.9)	72.6 (12.5)	71.6 (10.1)	−12.9 (0.62)	−4.0 (0.95)
Female	44.8	48.3	45.0	−7.0	−0.4
Mean socioeconomic score (SD)[c]	25.0 (13.1)	24.5 (12.6)	25.0 (13.0)	4.0 (1.09)	−0.4 (1.01)
Mean number of chronic conditions (SD)[d]	2.0 (1.5)	2.3 (1.7)	1.9 (1.5)	−16.2 (0.87)	4.3 (1.01)
Mean index date (SD)[e]	18199.4 (285.3)	18193.8 (357.3)	18200.3 (288.6)	1.8 (0.64)	−0.3 (0.99)
Health conditions recorded inpatient data over 3 years					
COPD	79.0	80.0	76.9	−2.4	5.0
Hypertension	39.4	43.8	38.8	−8.9	1.2
Ischaemic heart disease	21.3	24.5	20.7	−7.5	1.6
Asthma	18.2	20.5	16.6	−5.7	3.9
Angina	14.7	16.5	14.2	−4.9	1.2
Injury	14.3	21.9	14.5	−19.9	−0.2
Diabetes	11.7	15.4	10.9	−10.7	2.2
Atrial fibrillation	11.2	16.5	10.7	−15.4	1.6
Respiratory infection	9.8	13.7	9.2	−12.1	1.9
Peripheral vascular disease	8.8	10.4	7.5	−5.4	4.9
Cancer	8.3	13.0	7.5	−15.2	3.1
Mental health	8.1	14.2	8.0	−19.7	0.5
Congestive heart failure	7.6	12.6	7.7	−16.7	−0.3
Anaemia	6.6	9.8	6.4	−11.7	0.9
Falls	6.5	11.0	7.1	−15.9	−2.2
Cerebrovascular disease	5.8	7.7	5.0	−7.6	3.7
Iatrogenic	4.1	6.4	4.2	−10.2	−0.4
Renal failure	3.2	6.0	3.3	−13.1	−0.4
Drug abuse	0.3	0.5	0.2	−3.7	1.4
Mean numbers of secondary care contacts per head, 1−360 days before enrolment (SD)[f]					
Emergency admissions	0.58 (1.10)	0.93 (1.53)	0.56 (1.06)	−26.5 (0.52)	2.1 (1.08)
COPD admissions	0.17 (0.59)	0.19 (0.64)	0.15 (0.51)	−2.8 (0.87)	3.4 (1.34)
Elective admissions	0.56 (1.40)	0.68 (1.75)	0.47 (1.14)	−7.3 (0.64)	7.3 (1.50)
Outpatient attendances	4.19 (4.81)	4.29 (5.84)	3.79 (4.55)	−1.9 (0.68)	8.2 (1.11)
Mean numbers of secondary care contacts per head, 361−720 days before enrolment (SD)					
Emergency admissions	0.53 (1.00)	0.60 (1.25)	0.49 (0.99)	−6.1 (0.63)	4.6 (1.02)
COPD admissions	0.17 (0.53)	0.12 (0.50)	0.14 (0.51)	9.3 (1.16)	4.2 (1.11)
Elective admissions	0.45 (1.00)	0.50 (1.49)	0.39 (0.89)	−4.0 (0.45)	6.1 (1.27)
Outpatient attendances	3.83 (4.56)	3.54 (5.08)	3.40 (4.26)	6.1 (0.81)	9.7 (1.15)

SD, standard deviation.

[a]For the purpose of this table, one index date was selected randomly for the potential control patients.

[b]Compared with the 1413 intervention patients matched to controls.

[c]Based on the index of multiple deprivation score (2004) attributed to general practice.[33] $n = 1327$ (intervention group and matched controls); 692 520 (potential controls).

[d]Based on inpatient diagnoses and including angina, asthma, cerebrovascular disease, congestive heart failure, COPD, diabetes, hypertension, ischaemic heart disease and renal failure.

[e]Expressed as number of days since an arbitrary index date (1 January 1960).

[f]Inpatient activity was restricted to ordinary admissions, and excluded transfers, regular ward attendances and maternity events. Admissions were classified by defined admission methods into emergency (unplanned) and elective (planned) activity. Outpatient activity was restricted to appointments that were attended.

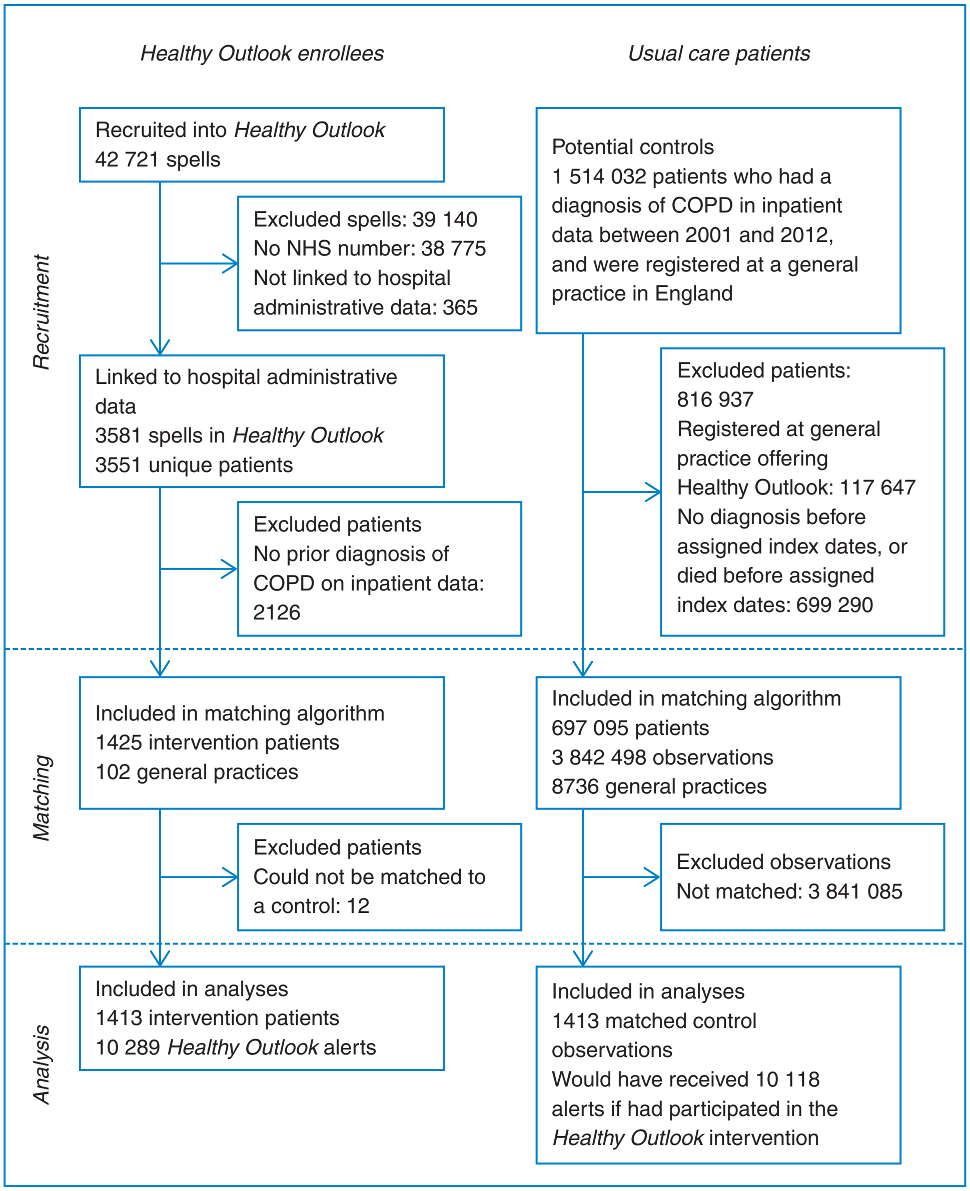

Fig. 1 Flow diagram showing recruitment into the study.

patients were similar, with all standardized differences less than the 10% threshold (Table 1).

Differences following enrolment

In the year following enrolment, intervention patients experienced more COPD admissions per head than matched controls (0.20 versus 0.16) (see Fig. 2). This difference reached statistical significance with an adjusted rate ratio of 1.26 [95% confidence interval (CI), 1.05–1.52]. The intervention group also experienced more outpatient attendances than matched controls (adjusted rate ratio 1.08, 95% CI, 1.03–1.12). However, only 5.6% of intervention patients died during the year following enrolment, compared with 8.5% of matched controls (adjusted odds ratio 0.61, 95% CI, 0.45–0.84) (see Table 2).

Discussion

Main findings of this study

There was no evidence of lower admission rates amongst the intervention than matched control patients. In fact, during the year following enrolment into *Healthy Outlook*, intervention patients experienced more COPD admissions per head than matched controls, along with more outpatient attendances. When we analysed utilization in the days immediately

Table 2 Estimated effect of Healthy Outlook over 1 year before and after enrolment ($n = 1413$ in each group)

	Year before enrolment: mean (SD)			*Year after enrolment: mean (SD)*			*Rate ratio (95% CI)*
	Intervention patients	*Matched controls*	*Difference*	*Intervention patients*	*Matched controls*	*Difference*	*Adjusted rate ratio following enrolment*
Emergency admissions per head	0.58 (1.10)	0.56 (1.06)	0.02	0.59 (1.22)	0.61 (1.46)	−0.02	0.95 (0.86, 1.04) $P = 0.271$
COPD admissions per head	0.17 (0.59)	0.15 (0.51)	0.02	0.20 (0.66)	0.16 (0.56)	0.05	1.26 (1.05, 1.52) $P = 0.012$
Elective admissions per head	0.56 (1.40)	0.47 (1.14)	0.09	0.47 (1.51)	0.41 (1.06)	0.06	0.97 (0.87, 1.09) $P = 0.656$
Outpatient attendances per head	4.18 (4.80)	3.79 (4.55)	0.39	4.13 (5.03)	3.56 (4.74)	0.57	1.08 (1.03, 1.12) $P = 0.003$

following the alerts (see Supplementary data), we found similar trends, though generally these did not reach statistical significance.

Mortality rates were significantly lower among intervention patients than matched controls during the year following enrolment. It is possible that the intervention reduced rates of COPD exacerbation and thereby prevented deaths; however, this seems unlikely given the trends towards increased admissions. Alternatively, the intervention might have prompted patients or healthcare professionals to respond differently to risks to health. For example, the intervention might have increased awareness of threats to health, thereby producing more inpatient and outpatient care but reducing deaths. The positive finding for mortality needs to be understood in relation to the limitations of this study as detailed below.

What is already known on this subject?

To our knowledge, *Healthy Outlook* is the only telephonic intervention developed to prevent hospital admissions for COPD patients on the basis of routine meteorological data. Previous evaluations of *Healthy Outlook* have not satisfactorily addressed the potential impacts of the service on hospital admissions. For example, a previous observational study found that *Healthy Outlook* patients showed reductions in admissions over time,[17] but, in the absence of a control group, it was not possible to say whether these reductions might have occurred anyway.[27] Another study relied on analysis at the general practice level.[18] This failed to find a statistically significant impact on admissions, but unobserved impacts might have existed at the individual level.

What this study adds

From this study, it appears that *Healthy Outlook* may have increased COPD admissions and outpatient attendances. One possible explanation is that the additional information provided about risks to health prompted patients or their healthcare professionals to seek more care in hospital settings. Health benefits may have resulted, but the intended reductions in utilization and concomitant cost seem not to have occurred. Although the observed mortality difference is promising, this is the first evaluation of *Healthy Outlook* to identify such an effect, and we consider that further studies are needed to confirm it.

The meteorological data used by *Healthy Outlook* successfully identified times of increased risk of COPD admissions and death (see Supplementary data). Therefore, the algorithms used by *Healthy Outlook* may still be valuable, even though the intervention itself may require refinement. For example, as some *Healthy Outlook* patients reported that they were already sufficiently aware of prevailing weather conditions,[15] other activities might be needed alongside the telephone calls to reduce utilization. These activities might include more personalized support aimed at engaging patients in their care[28] or initiatives to improve housing conditions.[7] The absence of reductions in admissions might also be due to insufficient integration of *Healthy Outlook* with other services, including pharmacies and specialist care.

Limitations of this study

When interpreting the results from this study, it is important to be mindful that, in the absence of randomization, there may have been systematic differences between intervention and matched control groups.[29] This study was designed to reduce this risk. For example, the focus on patients with a previous COPD admission standardized the inclusion criteria across intervention and control groups, while a matching algorithm balanced observed baseline characteristics.

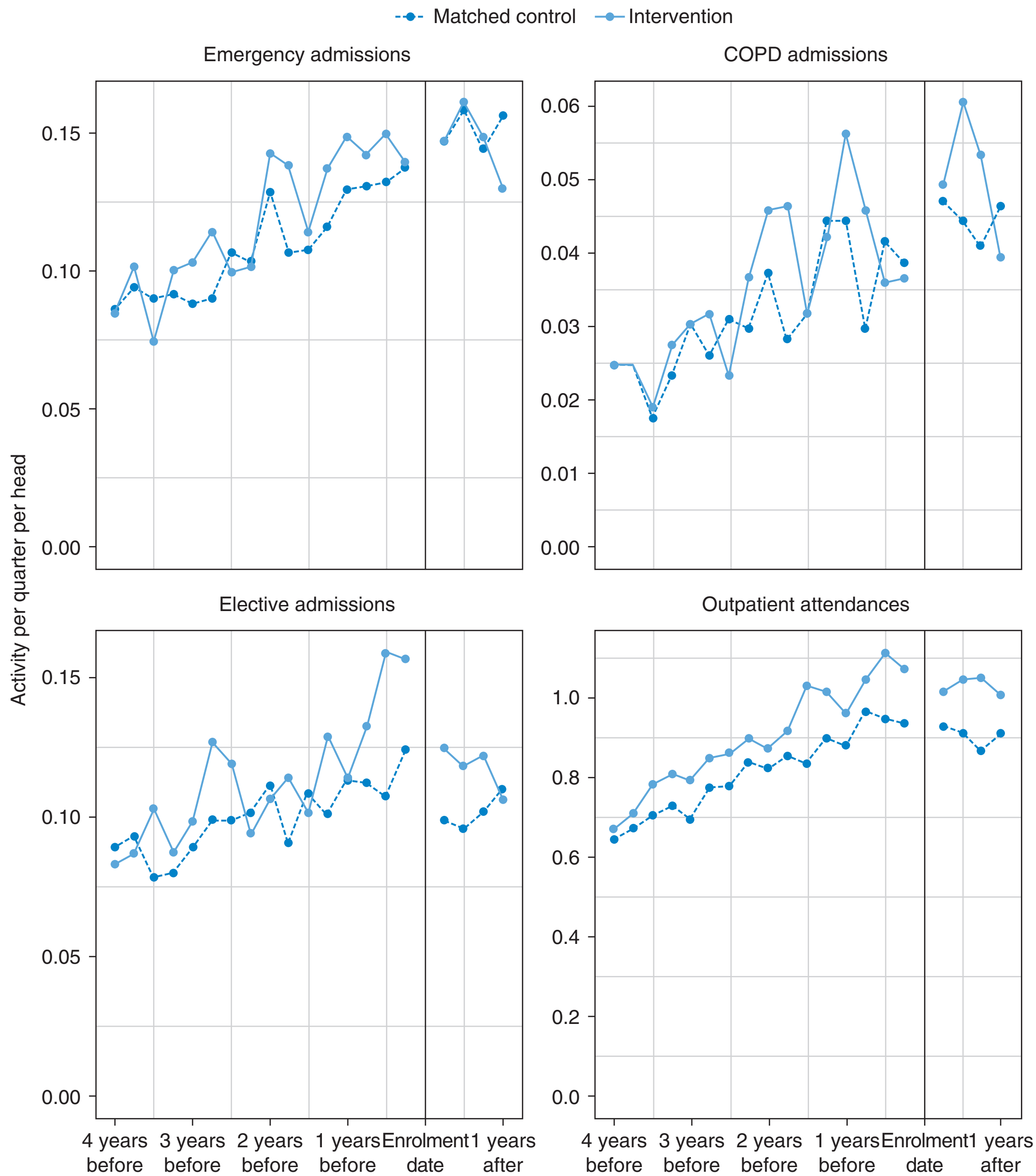

Fig. 2 Trends in hospital activity before and after enrolment.

Despite these efforts, it is nonetheless possible that unobserved differences existed between groups. For example, there may have been differences in people's abilities to manage their own health and healthcare, factors that are not currently recorded in administrative data.[28] Intervention patients might have already been more likely than matched controls to seek care when concerned about their health, even before enrolment into *Healthy Outlook*. Also, although the intervention and matched control groups were similar in terms of socioeconomic deprivation score, these scores were defined at an area level. It may be that the intervention patients tended to live in more affluent households within their area and so tended to be better prepared to respond to cold conditions. Other unobserved variables include smoking status and disease severity.

While confounding will always be a threat in observational studies, we were able to control for an established set of prognostic variables. The patients at risk of rehospitalization model, on which our variable selection was based, has good predictive ability.[21] Many of the unobserved variables (including attitudes towards using emergency care and disease severity) will be correlated with variables that were controlled for, such as prior hospital utilization. Furthermore, based on the variables in Table 1, *Healthy Outlook* patients were generally less severely ill at the point of enrolment than the general admitted population with COPD. Therefore, if there were unobserved differences between the groups, these might also point towards intervention patients being less severely ill than matched controls. Despite this possibility, we still found more COPD admissions and more outpatient attendances among intervention patients than matched controls. Overall, it seems unlikely that we missed reductions in hospital utilization.

Despite their limitations, observational studies are useful to examine interventions that are already embedded into routine health care, which often cannot be examined in RCTs. The effect of an intervention may well be different in routine settings than in an RCT due to differences in the intervention design, implementation, selection of patients or context.[30] Our study, which included a large number of general practices ($n = 102$) across seven English regions, should have high generalizability. Although our findings only apply to COPD patients with a previous hospital admission, these patients are at highest individual risk of experiencing admissions in future.[31]

In this study, we focussed on patients with an NHS number (~10% of all enrolled patients); limited information was available on patients not linked to HES and so we could not check empirically for the representativeness of the sample. As the decision to enter NHS numbers was made by general practice staff, it is reasonable to suppose that our sample was more complete in some general practices than others.

Our target number of patients was 2019, but data for only 1413 patients were available. However, the difference in emergency admissions observed (−5%) was notably smaller than the amount that was considered meaningful (20%) and the 95% CI (−14 to +4%) excluded a meaningful effect (Table 2).

Administrative data enable a retrospective analysis on large samples, without some of the problems of self-reported data such as non-response and recall bias.[32] They also meant that the hospital utilization of patients could be tracked even if the patients moved between areas of England. However, the quality of the data was not directly under our control and there was limited insight about the appropriateness of the care provided. This study examined impacts on hospital use and mortality, but *Healthy Outlook* may have affected numbers of emergency department visits, COPD exacerbations, patient experience, quality of life or use of primary care. These were beyond the scope of this study, but could be examined in future.

Authors' Contributions

A.S., M.B. and N.M. designed the study. A.S. oversaw the data linkage, conducted the analyses and prepared the first draft of the manuscript. All authors contributed towards the preparation of the manuscript and approved the final version. A.S. is a guarantor.

Ethics and Transparency

Ethical approval was not needed for this study as it was a retrospective analysis of pseudonymized routine data. A.S. affirms that the manuscript is an honest, accurate and transparent account of the study being reported; that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

Data Sharing

No additional data available.

Supplementary Data

Supplementary data are available at the *Journal of Public Health* online.

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