BMJ Open Respiratory Research

Specialist emergency care and COPD outcomes

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To cite: Lane ND, Brewin K, Hartley TM, *et al*. Specialist emergency care and COPD outcomes. *BMJ Open Resp Res* 2018;**5**:e000334. doi:10.1136/bmjresp-2018-000334

► Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/bmjresp-2018-000334).

Received 28 June 2018
Revised 10 August 2018

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ABSTRACT

Introduction In exacerbation of chronic obstructive pulmonary disease (ECOPD) requiring hospitalisation greater access to respiratory specialists improves outcome, but is not consistently delivered. The UK National Confidential Enquiry into Patient Outcome and Death 2015 enquiry showed over 25% of patients receiving acute non-invasive ventilation (NIV) for ECOPD died in hospital. On 16 June 2015 the Northumbria Specialist Emergency Care Hospital (NSECH) opened, introducing 24/7 specialty consultant on-call, direct admission from the emergency department to specialty wards and 7-day consultant review. A Respiratory Support Unit opened for patients requiring NIV. Before NSECH the NIV service included mandated training and competency assessment, 24/7 single point of access, initiation of ventilation in the emergency department, a door-to-mask time target, early titration of ventilation pressures and structured weaning. Pneumonia or hypercapnic coma complicating ECOPD have never been considered contraindications to NIV. After NSECH staff-patient ratios increased, the NIV pathway was streamlined and structured daily multidisciplinary review introduced. We compared our outcomes with historical and national data.

Methods Patients hospitalised with ECOPD between 1 January 2013 and 31 December 2016 were identified from coding, with ventilation status and radiological consolidation confirmed from records. Age, gender, admission from nursing home, consolidation, revised Charlson Index, key comorbidities, length of stay, and inpatient and 30-day mortality were captured. Outcomes pre-NSECH and post-NSECH opening were compared and independent predictors of survival identified via logistic regression.

Results There were 6291 cases. 24/7 specialist emergency care was a strong independent predictor of lower mortality. Length of stay reduced by 1 day, but 90-day readmission rose in both ventilated and non-ventilated patients.

Conclusion Provision of 24/7 respiratory specialist emergency care improved ECOPD survival and shortened length of stay for both non-ventilated and ventilated patients. The potential implications in respect to service design and provision nationally are substantial and challenging.

Key messages

- ► Does 7-day specialist emergency care improve outcomes in chronic obstructive pulmonary disease exacerbations requiring hospitalisation?
- ► In both ventilated and non-ventilated patients, this model of care was associated with reduced mortality and length of stay; but a small increase in 90-day readmission rates.
- ► The potential implications of wider adoption of this model of care to both patients and healthcare providers are substantial.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is one of the most common diseases in the UK, with an estimated 3 million sufferers. Approximately 13% of over 35 year-olds have COPD, and many are undiagnosed.[1 2] COPD is characterised by airflow limitation and parenchymal lung destruction, frequently resulting in breathlessness, chest tightness, sputum production and exercise limitation among other symptoms.[3] Exacerbations of COPD (ECOPD), during which symptoms acutely worsen, are common. These episodes are often triggered by infection and are the second most frequent cause of emergency hospital admission in the UK, occurring predominantly in older patients. Patients who survive to discharge have a high risk of recurrent ECOPD and readmission, particularly within 90 days of discharge.[4–7] The annual direct primary and secondary healthcare cost of COPD to the National Health Service (NHS) is approximately £1.85 billion.[8] Despite improvements in care, there is still excess COPD mortality in the UK compared with other European countries (age-standardised mortality rate: UK=58.8; EU 28=34.9 deaths/100 000).[4 9 10] In ECOPD complicated by respiratory acidaemia, non-invasive ventilation (NIV) substantially improves survival and reduces the need for invasive ventilation.[11 12] In the UK, in-hospital mortality for ECOPD requiring NIV is over 25% , substantially higher than the rates reported in clinical trials, and raises concern.[13] The 2003 national audit showed that specialist respiratory care in COPD reduced length of stay (LOS) and both inpatient and 90-day mortality.[14] Further to this, the 2014 national COPD audit report showed that patients seen by respiratory specialists received better evidence-based care and highlighted the need to improve access to respiratory physician-led care.[15] The North East of England has among the highest COPD prevalence and mortality in the UK.[16]

The Northumbria model

Northumbria Healthcare NHS Foundation Trust serves a population of 519 000 across a large geographical area in the North East of England. Previously, three district general hospitals accepted emergency admissions; one served a predominantly urban population, two included substantial rural populations and there was considerable socioeconomic diversity. Most admissions arrived in hospital via an emergency department (ED), which did not have 24/7 consultant presence. Two hospitals ran an acute medical admissions unit, and all relied on general physicians to provide acute consultant care. This broadly reflects current UK structures of care.

On 16 June 2015 the Northumbria Specialist Emergency Care Hospital (NSECH) opened as the first purpose-built specialist emergency care hospital in England,[17] receiving all emergency admissions, including primary care referrals. All patients are assessed in the ED with direct specialty ward admission. NSECH has dedicated inpatient diagnostic services, not competing with outpatient demand. Consultants in all major specialties are present at least 12 hours/day, 7 days/week and are on-call overnight. Consultants in ED are present at all times. If ongoing hospital care is needed once clinically stable, patients are transferred to an appropriate specialty ward in a different hospital within the trust. Risk-stratification tools are routinely used to inform clinical care, including Dyspnoea Eosinopenia Consolidation Acidaemia and atrial Fibrillation score (DECAF)[18 19] in ECOPD. Low-risk patients (DECAF 0–1) are considered for direct discharge from ED or formal hospital at home, while high-risk scores inform antibiotic choice among other aspects of care.[20]

NSECH houses an 11-bed Respiratory Support Unit (RSU) in which patients treated with acute NIV receive 1:2 care, with ventilation delivered by dedicated non-invasive ventilators (Respironics V60, providing controlled FiO_2 21%–100%) and a range of interfaces. There is a single point of access to acute NIV, which is provided by NIV trained and competency assessed physiotherapists who strictly adhere to our NIV pathway (online supplementary figure E1); NIV is only used outside these criteria with the approval of respiratory or intensive care consultants. On hospital arrival, and increasingly from ambulance pick-up, administering controlled oxygen to meet specified target saturations is the default; ED arrival is the start of the controlled oxygen trial. Most patients will receive nebulised bronchodilators early after arrival in the ED, or in the ambulance prior, thus other medical therapy likely to influence correction of respiratory acidaemia is included in the controlled oxygen trial period. A door-to-mask time target establishes the recognition and treatment of respiratory acidaemia as a medical emergency. NIV is commenced in the area the patient presents, normally the ED, before transfer to the RSU once the patient is stabilised. In conditions with favourable outcomes to NIV such as COPD, obesity hypoventilation syndrome and neuromuscular disease, consultant approval prior to NIV treatment is not required, but is necessary in all other cases. Hypercapnic coma and pneumonia complicating a condition with a known favourable response to NIV are considered indications for close monitoring, but not contraindications to NIV. An NIV prescription is required and includes: escalation and resuscitation plans; documentation of monitoring blood gases; and consequent changes to ventilation settings.

The NSECH RSU contains point-of-care arterial blood gas testing, dual oxygen ports, compressed air to drive nebulisers and transcutaneous CO_2 monitoring availability. There have been incremental changes to the NIV pathway since 2003 (figure 1), and it was further streamlined in 2016 where changes included:

- Limiting the role of controlled oxygen trials (maximum of 60 min from hospital arrival; but if severe acidaemia (pH <7.25) is present or the patient is rapidly deteriorating NIV can be initiated immediately).
- Removing the requirement for patients to have a pre-NIV chest radiograph in the high-risk groups above provided there is no clinical indication of pneumothorax (an urgent radiograph is still requested).
- Reduction in door-to-mask time target from 180 to 120 min.
- Introduced a structured ‘daily review’ meeting led by an experienced NIV physiotherapist to discuss and action:
  - Ventilation settings.
  - Weaning plans.
  - Consideration of/referral for home ventilation.
  - Referral to pulmonary rehabilitation.
- Expansion of NIV training to involve use of a simulation suite and wide range of cases.

The NIV protocol includes ventilator settings and a weaning strategy specific to the condition being treated, closely maps to the 2018 BTS NIV Quality Standards[21] and is subject to continuous rolling audit.

We aimed to assess whether the major changes in the structure of care following the opening of NSECH were associated with an improvement in outcomes following hospital admission for ECOPD, in both patients requiring and not requiring assisted ventilation. Outcomes assessed include mortality (inpatient, 30 days after discharge and combined inpatient plus 30 days after discharge), LOS and readmission rate at both 30 and 90 days after discharge.

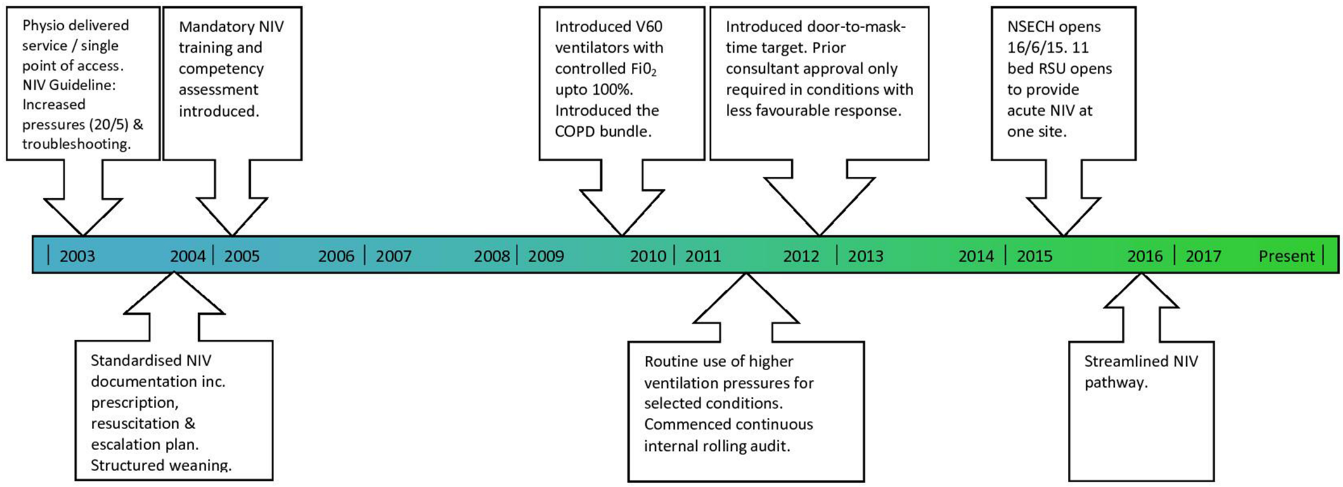

Figure 1 Timeline of changes to the Northumbria non-invasive ventilation pathway between 2003 and 2017. COPD, chronic obstructive pulmonary disease; NIV, non-invasive ventilation; NSECH, Northumbria Specialist Emergency Care Hospital; RSU, Respiratory Support Unit.

METHODS

Patients hospitalised with ECOPD between 1 January 2013 and 31 December 2016 were identified from coding data using either a primary diagnosis code of J44 (which captures COPD exacerbation) or J96 (respiratory failure) with a secondary code of J44. Patients under 35 years old were excluded. Inpatients prior to, and at the time of, NSECH opening were categorised as pre-NSECH. Patients admitted from 16 June 2015 were considered post-NSECH. Patients requiring assisted ventilation at any point during this admission (defined as NIV or invasive mechanical ventilation (IMV), but not continuous positive airway pressure (CPAP)), were identified through our internal rolling NIV audit data and the coding search, with discrepancies resolved through case note review. Coding data do not differentiate between CPAP and NIV; a problem highlighted in the recent National Confidential Enquiry into Patient Outcome and Death (NCEPOD) report on NIV.[13]

Age, sex, admission from residential/nursing home, revised Charlson Index (as used in the Summary Hospital-Level Mortality Indicator (SHMI),[22] but with COPD scoring removed), key comorbidities including dementia, cardiovascular disease, stroke and active malignancy (for full list see online supplementary file 1), and whether the patient was under the care of a respiratory physician or admitted to the critical care unit during their hospital stay were collected. Chest radiograph reports were reviewed and presence of pneumonia or heart failure (such as pulmonary congestion, bilateral effusions, pulmonary oedema) was recorded.

In-hospital and 30-day postdischarge mortality, LOS and readmission rates pre-NSECH and post-NSECH opening were captured. We examined changes in mortality rates (combined 30 days and inpatient) by day of admission (weekday/weekend), and the proportions of weekday versus weekend discharges pre-NSECH and post-NSECH.

Data are presented as mean (SD), median (IQR) and absolute number (percentage), while bivariate comparisons were made using Student's t-test, Mann-Whitney U test and Fisher's exact test for parametric, non-parametric and categorical variables, respectively. NSECH, age, gender, season, consolidation, dementia, cardiovascular disease, revised Charlson Index[22] and admission from institutional care (nursing or residential home) were included in a stepwise logistic regression model using backward elimination techniques and checked for collinearity. The final regression model was checked for robustness, fit with reference to tolerance and residual and eigenvalue patterns. This was performed for both ventilated and non-ventilated subgroups. In the regression models, the term 'full model' refers to all variables of interest, not restricted to those significantly related to mortality, and the term 'independent predictors model' refers to a reduced model showing only those variables which were independent predictors of mortality. The full model is shown to illustrate the interaction between all possible variables of interest.

A variable life adjusted display (VLAD) chart was plotted. This is a graphical method to demonstrate observed versus expected mortality, adjusted for the baseline mortality risk. It demonstrates the cumulative number of excess deaths (below the x-axis) or lives saved (above the x-axis) compared with expected outcome. The baseline risk was set as the SHMI January 2013 to December 2013 model; chosen as this is the first year of our data. Analyses were performed using IBM SPSS V.24.

RESULTS

A total of 3943 ECOPD episodes were identified before NSECH opening and 2348 afer NSECH opening. Eight patients were coded as having received NIV but records

Table 1 Key demographics and outcomes split by ventilation status pre-NSECH and post-NSECH

	Pre-NSECH	Post-NSECH	P values
All patients: demographics			
Age mean (SD)	72.64 (10.7)	72.01 (10.5)	0.023
NIV (%)	521 (13.2)	339 (14.4)	0.17
NIV+IMV/IMV alone	10/19	6/7	–
% ventilated patients who received IMV	5.4	3.8	0.33
Under respiratory consultant (%)	1994 (50.6)	1638 (69.8)	<0.0001
Critical care admission (%)	73 (1.9)	38 (1.6)	0.55
CXR with pneumonia (%)	782 (19.8)	402 (17.1)	0.0077
Charlson Index median (IQR)	3.00 (0–10)	3.00 (0–12)	0.011
Admitted from institutional care (%)	217 (5.5)	133 (5.7)	0.82
Non-ventilated patients: outcomes			
Mortality: IP+30 days after discharge (%)	211 (6.2)	87 (4.3)	0.0037
Mortality: IP only (%)	152 (4.5)	58 (2.9)	0.0035
Mortality: OP ≤30 days after discharge (%)	59 (1.7)	29 (1.4)	0.50
Median LOS (IQR)	4 (1–7)	3 (1–7)	0.0023
Readmission: 30 days (%)	865 (25.4)	522 (26.1)	0.61
Readmission: 90 days (%)	1343 (39.5)	854 (42.7)	0.022
Ventilated patients: outcomes			
Mortality: IP+30 days after discharge (%)	98 (18.1)	36 (10.4)	0.0015
Mortality: IP only (%)	71 (13.1)	32 (9.2)	0.086
Mortality: OP ≤30 days after discharge (%)	27 (5)	4 (1.2)	0.0022
Median LOS (IQR)	9 (6–15)	8 (5–13)	0.0015
Readmission: 30 days (%)	127 (23.5)	101 (29.2)	0.070
Readmission: 90 days (%)	200 (37)	165 (47.7)	0.0021

Data are mean (SD), median (IQR) or absolute number (%).
IMV, invasive mechanical ventilation;IP, inpatient;LOS, length of stay;NIV, non-invasive ventilation;NSECH, Northumbria Specialist Emergency Care Hospital;OP, outpatient.

could not be obtained. These patients have been classified as having had NIV. Sixty radiographs with unclear reports were reviewed, and a further 45 cases without a chest X-ray were assumed not to have pneumonia or heart failure. Patient characteristics were broadly similar between the pre-NSECH and post-NSECH groups although, as expected, post-NSECH patients were more likely to be under respiratory consultant care and had slightly lower rates of coexistent radiographic consolidation. Fewer than 2% of all patients with ECOPD were admitted to critical care, and among ventilated patients there was a non-significant reduction in the proportion receiving IMV from 5.4% pre-NSECH to 3.8% post-NSECH (table 1).

After NSECH, inpatient plus 30-day mortality and LOS were lower in both ventilated and non-ventilated patients. However, the 90-day readmission rate was higher in both groups. In ventilated patients there was a substantial fall in 30-day postdischarge mortality, with a trend towards a higher 30-day readmission rate (table 1). The VLAD plot (figure 2) showed sustained improvement in observed versus expected mortality. Our median (IQR) door-to-mask times were 109 (99) min before NSECH and 114 (114) min after NSECH.

NSECH was a strong predictor of reduced mortality in both ventilated (OR 0.52; 95% CI 0.34 to 0.78) and non-ventilated (OR 0.68; 95% CI 0.52 to 0.89) patients. The independent predictors identified in the regression analysis for both ventilated and non-ventilated patients are shown in table 2.

The opening of NSECH did not impact the pattern of mortality based on weekday versus weekend admissions. Mortality in patients admitted over a weekend was non-significantly lower compared with those admitted on a weekday, both pre-NSECH and post-NSECH. The proportion of patients discharged at the weekend increased following the opening of NSECH (table 3).

Details of the remaining bivariate comparisons between pre-NSECH and post-NSECH groups (online supplementary table E1), as well as the full regression analysis tables (online supplementary tables E2 and E3) are available online supplementary file 1.

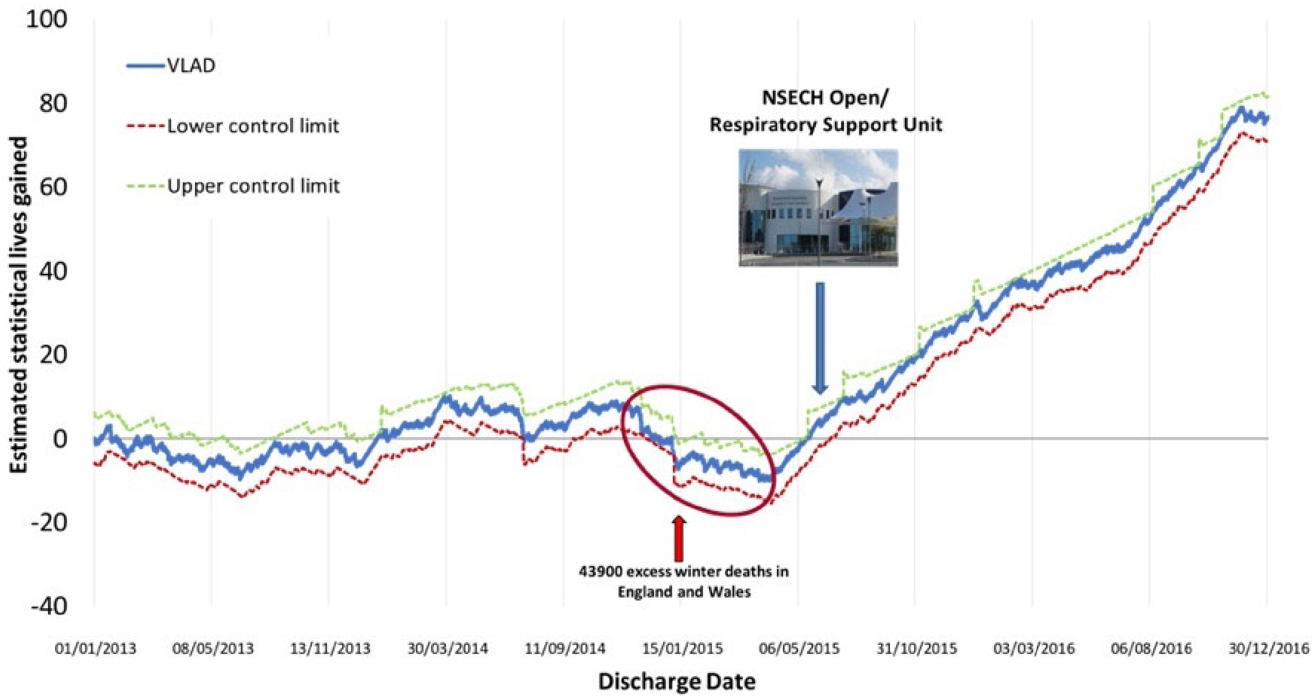

Figure 2 Variable life adjusted display (VLAD chart) showing observed versus expected mortability with cumulative lives lost below the x-axis and cumulative lives saved above the x-axis. NSECH, Northumbria Specialist Emergency Care Hospital.

DISCUSSION

The NSECH model of 24/7 specialist emergency care was associated with lower ECOPD mortality and LOS, both in ventilated and non-ventilated patients. Improvements were seen from a strong baseline; NIV mortality rates pre-NSECH were lower than the NCEPOD Inspiring Change report and the 2013 BTS NIV audit.[13 23] In a logistic regression model including the available potential prognostic indices, NSECH was independently associated with survival for both ventilated and non-ventilated

Table 2 Backward regression analysis showing our independent predictors only. Results displayed for ventilated and non-ventilated patients

Independent predictors	B	OR (95% CI)	P values
Non-ventilated patients			
Age (years)	0.052	1.05 (1.04 to 1.07)	<0.0001
Any cardiovascular disease	0.315	1.37 (1.05 to 1.80)	0.022
CXR evidence of pneumonia	0.284	1.33 (1.01 to 1.76)	0.046
Post-NSECH	–0.383	0.68 (0.52 to 0.89)	0.0042
Charlson score 0			<0.0001
Charlson score 1–5	–0.137	0.87 (0.57 to 1.32)	0.52
Charlson score >5	0.802	2.23 (1.65 to 3.02)	<0.0001
Admission from nursing home	0.624	1.87 (1.29 to 2.70)	0.0010
Ventilated patients			
Age (years)	0.050	1.05 (1.03 to 1.07)	<0.0001
Male	–0.489	1.63 (1.10 to 2.41)	0.014
Post-NSECH	–0.663	0.52 (0.34 to 0.78)	0.0018
Charlson score 0			0.0083
Charlson score 1–5	–0.840	0.43 (0.24 to 0.78)	0.0054
Charlson score >5	0.031	1.03 (0.67 to 1.58)	0.89

Full list of cardiovascular diseases and/or stroke diseases is found in the online supplementary file 1.
B, beta coefficient;CXR, chest X-ray;NSECH, Northumbria Specialist Emergency Care Hospital.

Table 3 Weekday and weekend discharges and mortality. Outcomes pre-NSECH and post-NSECH opening have been compared by Fisher's exact test

	Weekday (Monday to Friday)	Weekend (Saturday and Sunday)	P values
Day of discharge (% of all discharges)			
Pre-NSECH	87.8	12.2	0.0019
Post-NSECH	84.9	15.1	
Combined inpatient and 30-day postdischarge mortality (based on day of admission)			
Pre-NSECH % (n=3943)	8.1	7.0	0.28
Post-NSECH % (n=2348)	5.5	4.6	0.46

NSECH, Northumbria Specialist Emergency Care Hospital.

patients. Key strengths of this study include a large sample size, broad inclusion criteria and verification of ventilation status and chest radiograph appearance from patient records. There was no significant difference in mortality based on weekday or weekend admission, but rather a global improvement across 7 days.

Survival improved after NSECH and compares favourably to similar populations nationally and internationally.[23–26] The model of care is a complex intervention and it is impossible to identify the relative contribution of individual components. Nevertheless, we consider early access to specialist respiratory care important, complementing the findings and recommendations of the 2014 national audit.[15] Provision of specialist care has been shown to improve outcomes in other conditions. In heart failure, patients managed by cardiologists have better in-hospital and 1-year survival compared with those under other physicians.[27–29] This pattern is similar in other conditions such as inpatient treatment of myasthenia gravis, Parkinson's disease and end-stage liver disease.[30–32] The proportion of patients under a respiratory consultant increased; we have not captured respiratory review of patients on other medical wards, but who are not under the direct care of a respiratory consultant, a limitation of coding data. The respiratory specialist nurses review all such patients identified. Changes in care are common and likely to influence outcomes, but not captured by coding. The case mix, or severity of illness, cannot be measured from coding data and thus comparisons of case mix between patients under respiratory or other care are not examined.

Provision of 1:2 care during the acute period of NIV was introduced with the opening of the RSU in NSECH. Other elements of NIV provision described were already in place, but delivery is likely to have been more consistent in NSECH. Use of controlled oxygen to target saturations is encouraged from ambulance pick-up and is the default from ED arrival. Austin *et al* showed that in patients with suspected ECOPD, controlled oxygen from ambulance pick-up improved survival in those subsequently confirmed to have airflow obstruction, while other patients were not harmed.[33] Furthermore, the UK National COPD Resources and Outcomes Project data show that use of high-flow oxygen is associated with higher rates of ventilation (high-flow oxygen: used=22%; not used=9%) and mortality (high-flow oxygen: used=11.1%; not used=7.2%).[34] This supports provision of controlled oxygen to target saturations by default in all patients with COPD, rather than reliance on oxygen alert cards or selection by other means. We initiate NIV in the setting in which the patient first presents (normally the ED) to reduce delays in treatment. The NCEPOD report showed that 28% of patients were transferred to the ward before starting treatment with NIV, and 24% of these had an unnecessary delay to their treatment.[13] Delay in life-saving treatment while awaiting ward transfer is a common and avoidable problem; both NCEPOD and the BTS NIV Quality Standards recommend our approach.[13 21] While NIV was consistently provided by NIV-trained and competency-assessed clinicians (predominantly physiotherapists) throughout, before NSECH monitoring and review were more robust. Structured daily progress review led by a senior respiratory physiotherapist was introduced, including ventilation and weaning plans, and consideration for home ventilation. The NCEPOD report highlights that provision of NIV by staff without training and competency assessment and inadequate monitoring during provision of NIV are common failings. We provide our NIV guideline and wall chart as an online supplementary file 1, and direct clinicians to the BTS Quality Standards[21] and NCEPOD self-assessment checklist (http://www.ncepod.org.uk/2017niv.html). Rates of IMV vary markedly between hospitals and countries,[35] and the relatively low rates in the UK may in part reflect fewer critical care beds and nihilism.[36] However, the outcome from IMV following failure of NIV is poor.[37] One possibility is that this reflects inappropriately delayed intubation, but it may be that a population failing despite high-quality NIV and appropriate medical therapy represent a distinct group in whom IMV is unlikely to improve outcome due to the severity of their underlying lung disease and acute insult. These patients may have a poor outcome regardless of how ventilation is provided and should be differentiated from those failing due to poor tolerance of the non-invasive interface, in whom escalation to IMV is more appropriate. Of relevance, before and after NSECH, patient characteristics and the proportion ventilated per day (pre-NSECH=0.60; post-NSECH=0.61) were similar, yet the NSECH model of care was associated with a substantial fall in inpatient and 30-day mortality among ventilated patients (18.1% vs 10.4%) despite a non-significant fall in the proportion receiving IMV (5.4% vs 3.8%).

The proportion of our patients discharged at the weekend has increased but, in both groups, 90-day readmission rates were higher after the opening of NSECH, following a national trend. The largest increase in readmissions following NSECH opening was between 30 and 90 days after discharge, suggesting that this was not primarily due to suboptimal acute management. The Previous admissions, Extended MRCD score, Age, Right and Left-sided heart failure (PEARL) score highlights that frailty and comorbidities are important drivers of readmission,[7] and thus potential targets for intervention that are easily overlooked if excessive focus is placed on the respiratory features alone. While reducing readmission rates in ECOPD is a priority,[15] it is important to consider that readmission may not universally be an adverse event. For example, before NSECH, the ventilated population experienced a substantial fall in 30-day postdischarge mortality and a corresponding trend towards more frequent readmission. The national trend in readmissions for ECOPD is multifactorial; reasons may include a lower threshold for referral to hospital, an ageing and more comorbid population and a change in attitude to risk. However, our data suggest that for some individuals, early hospital readmission may be protective.

The main weaknesses of this study are reliance on a single centre, its retrospective nature and the use of coding data which may misattribute diagnoses or miss patients. Compared with a population with spirometry confirmed COPD, outcomes based on coding data may be better. Change in coding practice or diagnostic terms used by clinicians could also influence results; there was no change in coding definitions or the seasonally adjusted number of patients admitted with ECOPD over the study period. Population characteristics were similar; minor differences in age and pneumonia rates, both lower in the NSECH population, were balanced by greater comorbidity. Survival data are also for events rather than unique patients, relevant to those experiencing recurrent admissions. This study is unable to identify the precise cause(s) of reduced mortality. Given the use of coding data, some clinical information with known prognostic implications, such as DECAF or Extended Medical Research Council Dyspnoea score (eMRCD),[19 38] was not available in the study. Additionally, arterial blood gas measurements were unavailable to ensure all patients treated with NIV were appropriate; however, we have included our NIV guideline in the online supplementary file 1, and NIV is only initiated by the Respiratory Team or Critical Care. The onset of the sustained improvement in the VLAD survival chart predated the opening of NSECH. This could be as a result of there being 43 900 excess winter deaths nationally[39] (reflected in our local data) immediately prior to the pre-NSECH survival improvement; mortality rates may have transiently fallen due to regression to the mean. Additionally, where possible planned system changes were implemented at the pre-existing acute receiving hospitals in advance of NSECH opening; this may have impacted survival. It is also noteworthy that mortality has fallen in national COPD audits, with an inpatient mortality of 4.3% in 2014 compared with 7.8% in 2008.[15] We have not assessed whether similar improvements were seen in other conditions and specialities and it may be that our results in part reflect improving national outcomes.

Provision of 24/7 respiratory specialist emergency care was associated with improved ECOPD survival and shortened LOS in both non-ventilated and ventilated patients. The potential implications in respect to service design and provision nationally are substantial and challenging; confirmation of improved outcome in other conditions and NHS trusts is first required. Provision of this model of care did not stem the increase in the 90-day readmission rate, which may at least in part reflect lower acute mortality. Effective strategies to reduce the risk of readmission are urgently required.

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Contributors SCB conceived and obtained support to conduct the study. NDL, JS and SCB designed the study. MB performed the coding searches and produced the VLAD graph. NDL, KB and TMH obtained additional patient data. NDL and WKG performed statistical analysis. NDL, JS and SCB undertook data interpretation. NDL drafted the original manuscript, revised by TMH, JS and SCB. All authors approved the final version.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests SCB, JS, NDL and TMH are currently undertaking a 10-centre NIV Outcomes trial, funded in part by Philips Respironics and Pfizer Open Air (outside the submitted work). SCB reports grants from the National Institute of Health Research, Philips Respironics and Pfizer Open Air, personal fees from ResMed, Pfizer and from AstraZeneca, and non-financial support from GSK and Boehringer Ingelheim outside the submitted work. NDL and TMH are employed and funded by Northumbria Healthcare NHS Foundation Trust Research Fellowship programme.

Patient consent Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement Any individuals or parties interested in accessing our data should contact SCB.

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