Mapping inpatient care pathways for patients with COPD

Evison, Felicity; Cooper, Rachel; Gallier, Suzy; Missier, Paolo; Sayer, Avan A; Sapey, Elizabeth; Witham, Miles D.

DOI:
10.1183/23120541.00110-2023

Mapping inpatient care pathways for patients with COPD: an observational study using routinely collected electronic hospital record data

Felicity Evison [1,2], Rachel Cooper [3,4], Suzy Gallier [1,2], Paolo Missier [5], Avan A. Sayer [3,4], Elizabeth Sapey [1,6] and Miles D. Witham [3,4]

[1]PIONEER Hub, University of Birmingham, Birmingham, UK. [2]Research Informatics, Research, Development and Innovation, University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK. [3]AGE Research Group, Translational and Clinical Research Institute, Faculty of Medical Sciences, Newcastle University, Newcastle, UK. [4]NIHR Newcastle Biomedical Research Centre, Newcastle University, Newcastle upon Tyne NHS Foundation Trust and Cumbria, Northumberland, Tyne and Wear NHS Foundation Trust, Newcastle upon Tyne, UK. [5]School of Computing, Newcastle University, Newcastle upon Tyne, UK. [6]Institute of Inflammation and Ageing, University of Birmingham, Birmingham, UK.

Corresponding author: Miles D. Witham (Miles.Witham@newcastle.ac.uk)

Shareable abstract (@ERSpublications)
This study mapped pathways of inpatient care for COPD exacerbations using electronic health records. Age >70 years was associated with a lower chance of following pathways that included specialist respiratory care. https://bit.ly/3YTqeHo

Cite this article as: Evison F, Cooper R, Gallier S, *et al*. Mapping inpatient care pathways for patients with COPD: an observational study using routinely collected electronic hospital record data. *ERJ Open Res* 2023; 9: 00110-2023 [DOI: 10.1183/23120541.00110-2023].

Received: 18 Feb 2023
Accepted: 22 Aug 2023

Abstract

Introduction Respiratory specialist ward care is associated with better outcomes for patients with COPD exacerbations. We assessed patient pathways and associated factors for people admitted to hospital with COPD exacerbations.

Methods We analysed routinely collected electronic health data for patients admitted with COPD exacerbation in 2018 to Queen Elizabeth Hospital, Birmingham, UK. We extracted data on demographics, deprivation index, Elixhauser comorbidities, ward moves, length of stay, and in-hospital and 1-year mortality. We compared care pathways with recommended care pathways (transition from initial assessment area to respiratory wards or discharge). We used Markov state transition models to derive probabilities of following recommended pathways for patient subgroups.

Results Of 42 555 patients with unplanned admissions during 2018, 571 patients were admitted at least once with an exacerbation of COPD. The mean±SD age was 51±11 years; 313 (55%) were women, 337 (59%) lived in the most deprived neighbourhoods and 45 (9%) were from non-white ethnic backgrounds. 428 (75.0%) had ⩾4 comorbidities. Age >70 years was associated with higher in-hospital and 1-year mortality, more places of care (wards) and longer length of stay; having ⩾4 comorbidities was associated with higher mortality and longer length of stay. Older age was associated with a significantly lower probability of following a recommended pathway (>70 years: 0.514, 95% CI 0.458–0.571; ⩽70 years: 0.636, 95% CI 0.572–0.696; p=0.004).

Conclusions Only older age was associated with a lower chance of following recommended hospital pathways of care. Such analyses could help refine appropriate care pathways for patients with COPD exacerbations.

Introduction

COPD is a major cause of hospital admission, with over 133 000 admissions to UK hospitals in 2019–2020 [1]; the cost of National Health Service (NHS) care for COPD has been estimated at GBP 1.9 billion per annum [2]. Guidelines from the UK National Institute for Health and Care Excellence (NICE) and other similar bodies outline standards of care for the hospital treatment of patients with COPD; such guidelines typically cover a range of topics including place of care, access to specialist healthcare personnel, early assessment, monitoring, therapeutic intervention and follow-up [3]. Providing specialist inpatient care within respiratory wards is a key performance indicator in the NICE guidelines [4] as continuous access to respiratory specialist staff is associated with better outcomes for patients [5], driven in part by the structured application of key processes in respiratory care [6–8].

The impact of sociodemographic inequalities, including those based on age, sex, ethnicity and deprivation, on outcomes across many conditions is now apparent and understanding how such inequalities translate into poorer outcomes is key to mitigating the impact of these inequalities [9]. How care is delivered may constitute an important intermediate step in explaining the relationship between inequalities and outcomes. COPD disproportionately affects people from more deprived socioeconomic backgrounds, who have historically had higher rates of cigarette smoking and are known to face more barriers in accessing healthcare [10]. Patients with COPD rarely suffer from the condition in isolation; COPD is usually accompanied by comorbidities [11], and the presence of comorbidities is more common at older ages. The presence of comorbid conditions has an important impact on overall prognosis, symptom burden and quality of life; the presence of comorbidities also affects COPD treatment selection and burden [12]. Conversely, treatments used to manage other comorbidities may have adverse effects on the symptoms and prognosis of COPD. Because of this, national guidance suggests considering the impact of comorbidities during exacerbations of COPD [13] but recognises that in practice this is considered only in a proportion of patients. Neglecting comorbidities may lead to suboptimal outcomes even if COPD is managed optimally; patients with comorbidities may find that conditions other than COPD are not managed appropriately, and many readmissions after an index hospital admission (*e.g.* for COPD) are due to a health problem other than COPD [14, 15].

It is therefore important to understand how patients presenting to hospital with an exacerbation of COPD progress through their hospital stay. Describing pathways of care within hospital for patients with COPD is therefore a first step in understanding what the impact of sociodemographic factors and comorbidities might be. The aim of this analysis is to describe pathways of hospital care for patients admitted with COPD, and to understand the associations of comorbidity, demographic and socioeconomic variables with pathways of care.

Methods

We conducted an analysis of routinely collected clinical data held in the electronic healthcare record (EHR) of a large teaching hospital in the United Kingdom serving a population in excess of 1.2 million people. The population served is ethnically diverse and encompasses a wide range of socioeconomic groups, from affluent to very deprived.

Hospital and data sources

The Queen Elizabeth Hospital Birmingham (QEHB) is an urban, adult NHS acute hospital in England with 1269 beds including 80 level 2/3 intensive care unit (ICU) beds, an emergency department that assesses >300 patients per day (with 100 per day admitted for further assessment), and a mixed secondary and tertiary practice that includes all major adult specialties with the exception of obstetrics and gynaecology. The EHR at QEHB (PICS, Birmingham Systems, Birmingham, UK) contains time-stamped, structured records that include demography, location, time of admission and discharge, all treatments and investigations, and physiological measurements supporting the National Early Warning Score (NEWS2). The EHR has been in place since 1999 and the Trust is a paperless environment for all care provision and planning.

For this analysis, data were extracted on all acute hospital presentations (including to the emergency department and assessment units) between 1 January 2018 and 31 December 2018 with either an International Classification of Diseases version 10 (ICD-10) discharge diagnosis of COPD exacerbation (as a primary or secondary diagnosis) or a Systematised Nomenclature of Medicine Clinical Terms (SNOMED-CT) code recorded during admission denoting exacerbation of COPD. Codes used are shown in the supplementary material. The 12-month time period during 2018 was selected to enable up to 1 year of follow-up without the data being impacted by the start of the COVID-19 pandemic in 2020. For patients with multiple eligible admissions during the study time period, only the first admission was included. The study size was determined by the number of patients with at least one admission for a COPD exacerbation in the calendar year 2018.

Outcomes

The principal outcome studied was the pathway of care through hospital, from the point of admission to discharge. All places of care (operationalised as individual wards within the hospital) were extracted with time and date of transfer to each place of care between hospital admission and discharge. Discharge was taken as the time and date of transfer out of hospital or transfer to the hospital discharge lounge. Patients who attended an inpatient ward whose speciality was not geriatric medicine, respiratory or the acute medical unit (AMU) were classified as attending a general ward. Pathways of care were constructed and analysed as described below in the Analyses section. For other outcome variables, death during hospital stay and death within 1 year of hospital admission, length of acute hospital stay (in days) and ICU admission during hospital stay, were extracted from the EHR.

Exposures

Data describing patient characteristics were extracted from the EHR using the date of each hospital admission as the index date. Data extracted included patient age, sex, index of multiple deprivation based on postcode [16], and all hospital diagnoses coded by ICD-10 discharge codes over a period of up to 10 years prior to the admission under study to improve completeness of capture of comorbidities. ICD-10 codes were mapped to diagnoses in the Elixhauser list [17] to generate information on the number of comorbidities each patient had recorded at the time of hospital admission. Previously used ICD-10 code lists were used [18], with the addition of the following codes for dementia: F00, F01, F02, F03 or F051.

Approval by PIONEER Data Trust Committee

This study was approved by the East Midlands–Derby Research Ethics Committee (reference: 20/EM/0158) and Confidentiality Advisory Group (CAG: 20/CAG/0084) as part of PIONEER, the Health Data Research (HDR)-UK Hub in Acute Care. As part of this process, the data access request and specification were reviewed and approved by the PIONEER Data Trust Committee, a group of patients and members of the public who provide oversight of all data access decisions within PIONEER [19]. Data were extracted from the electronic health record, cleaned and verified according to standard PIONEER workflows as previously described [19]; the pseudonymised study dataset was then placed in a secure Trusted Research Environment to enable access by the study team.

Analyses

We generated descriptive statistics for patient characteristics and outcomes and compared outcomes between prespecified subgroups (age ⩽70 or >70 years approximating the median age of the study population, men *versus* women, white *versus* non-white ethnic group, Index of multiple deprivation score in bottom fifth of UK values *versus* all others, and number of comorbidities). Groups with small numbers were suppressed in line with the PIONEER data governance stipulations [19]. Between-group comparisons were performed using Pearson's chi-squared test for categorical variables, t-test for normally distributed continuous variables and Mann–Whitney U-test for non-normally distributed continuous variables. Analyses were performed using R Statistical Software (v4.1.2; R Core Team 2021, Vienna, Austria) and a two-sided p-value of <0.05 was taken as statistically significant for all analyses. We generated graphical maps (Sankey diagrams) to show transfers between wards and departments. We developed Markov state transition diagrams to depict transfers between wards and other states (including death or discharge) to enable the probability of transition between individual states to be mapped. Each transition (*e.g.* a move between one place of care and another) on the Markov diagram is given a value between 0 and 1, depicting the probability of an individual patient undergoing that transition. Using national and local guidelines supplemented by clinical expertise, we identified which pathways of care (equivalent to a sequence of states) could be construed as recommended pathways [4, 5]. Probabilities for each patient pathway were calculated by multiplying individual state transition probabilities along each pathway, and the probability of following a recommended pathway was then calculated by summing all of the possible recommended pathway variants. 95% confidence intervals around the probability point estimates were generated assuming a binomial distribution.

Results

A total of 571 patients admitted to hospital with an exacerbation of COPD were included in analyses; a flowchart showing patient selection for inclusion in the analysis is shown in figure 1, and details of included patients are shown in table 1. The mean±SD age of included patients was 51±11 years; 313 (55%) were women and 45 (8%) were from non-white ethnic backgrounds. The majority of patients (337; 59%) were in the "most deprived" fifth of the index of multiple deprivation and the median number of comorbidities was 5 (IQR 3.5–7). The median length of stay was 4 days (IQR 2–8) and 28 (4.9%) died during their admission. Patients spent time in a median of 3 places of care (IQR 2–4) during their admission.

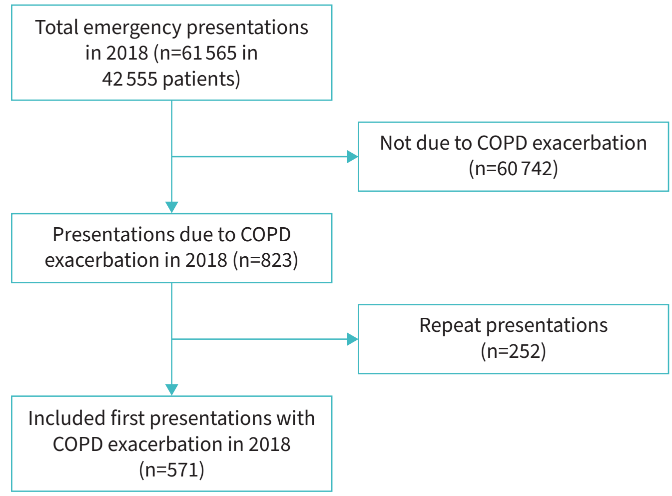

FIGURE 1 Selection of participants for inclusion in analysis.

Associations of age, sex, ethnicity and deprivation with indices of hospital stay

Table 2 shows differences in key outcomes (in-hospital death and death by 1 year, length of stay, number of places of care that patients were cared for in and admission to ICU) by age, sex, ethnicity and deprivation. The proportion of those dying in hospital was higher in the older age group than in the younger group, but was similar by sex, ethnicity, deprivation and comorbidities. The proportion dying within 1 year was higher in those aged >70 years than those ⩽70 years (29.8% *versus* 15.1%) and in those with four or more comorbidities compared to those with 0 to three comorbidities (25.9% *versus* 15.4%). 1-year death rates were similar between subgroups for sex, ethnicity and deprivation. The older subgroup had longer length of stay than the younger subgroup (median 5 days (IQR 2–9), *versus* median 4 days (IQR 1–7)) and those with four or more comorbidities stayed longer than those with 0 to three comorbidities (median 5 days (IQR 2–9), *versus* median 3 days (IQR 1–6)). Length of stay was similar by sex, ethnicity and deprivation. The median number of places of care was similar in all subgroups although those aged >70 years were cared for in statistically significantly more areas (median 3 (IQR 2–4), *versus* median 3 (IQR 2–3) for those aged ⩽70 years, p=0.04). The proportion admitted to ICU was similar between all subgroups.

Complexity of care pathways

Figure 2 depicts how patients moved through wards or other clinical departments during their hospital stay. 11 patients were admitted straight to a medical ward rather than to the AMU or the emergency department and have been excluded from the pathways analysis. Figure 3 shows the transition probabilities between a simplified set of places of care and other states for all patients during their hospital stay. When applying these probabilities to the set of pathways defined as recommended care (supplementary figure S1), the overall probability of a patient with COPD following a recommended pathway of care was 0.568 (95% CI 0.527–0.609). Probabilities of following a recommended care pathway for different patient subgroups are shown in table 3. The probability estimate for those aged >70 years was 0.514 (95% CI 0.458–0.571), compared with 0.636 (95% CI 0.572–0.696) for those aged ⩽70 years; this difference was statistically significant (p=0.004). Subgroup analysis of patients with COPD exacerbation as their main (primary) diagnosis showed a non-significant difference between this group and patients with COPD exacerbation as a secondary diagnosis (0.604 (95% CI 0.547–0.659) *versus* 0.524 (95% CI 0.460–0.587); p=0.06). No statistically significant difference was found between other pairs of groups on subgroup analyses.

Discussion

We have shown that it is possible to use routinely collected data from hospital EHR to describe pathways of care for patients admitted with COPD, and to compare both simple descriptive care pathway variables across subgroups of interest, but also more complex probabilities of following a particular pathway of care across subgroups of interest. Older patients and those with four or more comorbidities had a longer length of hospital stay and higher mortality rates during inpatient stay and by 1 year. In addition, older patients had more ward moves and were less likely to follow a pathway (based on admission to a respiratory ward)

TABLE 1 Descriptors and outcomes for patients admitted to hospital during 2018 with an exacerbation of COPD

Factor	n (%) or median (IQR)
Age group	
⩽70 years	252 (44.1)
>70 years	319 (55.9)
Female sex	313 (54.8)
Ethnicity	
White	485 (84.9)
Non-white	45 (7.9)
Unknown/preferred not to say	41 (7.2)
IMD fifth	
1 (most deprived)	337 (59.0)
2 to 5 (less deprived)	232 (41.0)
Number of comorbidities	
0–3	143 (25.0)
4 or more	428 (75.0)
Most common comorbidities	
Hypertension	396 (69.4)
Cardiac arrhythmia	308 (53.9)
Fluid or electrolyte disorder	308 (53.9)
Chronic heart failure	231 (40.5)
Depression	184 (32.2)
Diabetes mellitus	158 (27.7)
Valvular heart disease	144 (25.2)
Renal failure	140 (24.5)
Anaemia due to deficiency	120 (21.0)
Any cancer (solid tumour, metastatic, lymphoma)	115 (20.1)
Outcomes	
Number of places of care during admission	3 (2–4)
Admitted to intensive care unit during admission	26 (4.6)
Length of stay days	4 (2–8)
Death during hospital admission	28 (4.9)
Death within a year of admission	133 (23.3)

IQR: interquartile range; IMD: index of multiple deprivation.

that is recommended by current guidelines. It is not possible to determine from our data whether this finding represents a limitation of current care or a limitation of current guidelines, and complementary research designs including qualitative enquiry are likely to be needed to investigate this issue further.

TABLE 2 Comparison of outcome measures in patients admitted to hospital during 2018 with an exacerbation of COPD by age, sex, ethnicity, index of multiple deprivation and comorbidities

	n[#]	Died during hospital admission, n (%)	Died within 1 year of admission, n (%)	Length of stay days, median (IQR)	Number of places of care, median (IQR)	Intensive care unit admission, n (%)
Age >70 years	319	**21 (6.6)**	**95 (29.8)**	**5 (2–9)**	**3 (2–4)**	13 (4.1)
Age ⩽70 years	252	**<10[¶]**	**38 (15.1)**	**4 (1–7)**	**3 (2–3)**	13 (5.2)
Men	258	14 (5.4)	61 (23.6)	4 (2–8)	3 (2–3)	12 (4.7)
Women	313	14 (4.5)	72 (23.0)	4 (2–8)	3 (2–3)	14 (4.5)
White ethnicity	485	22 (4.5)	112 (23.1)	4 (2–8)	3 (2–3)	22 (4.6)
Non-white ethnicity	45	<10[¶]	<10[¶]	4 (1–7)	3 (2–3)	<10[¶]
Lowest fifth of IMD	337	19 (5.6)	83 (24.6)	4 (2–8)	3 (2–3)	18 (5.4)
Higher four-fifths of IMD	232	<10[¶]	50 (21.6)	4 (2–8)	3 (2–3)	<10[¶]
0–3 comorbidities	143	<10[¶]	**22 (15.4)**	**3 (1–6)**	3 (2–3)	<10[¶]
4 or more comorbidities	428	<10[¶]	**111 (25.9)**	**5 (2–9)**	3 (2–3)	19 (4.5)

Bold denotes p<0.05 for comparison between subgroups. IQR: interquartile range; IMD: index of multiple deprivation. #: denominator for percentages in each row; ¶: small numbers suppressed.

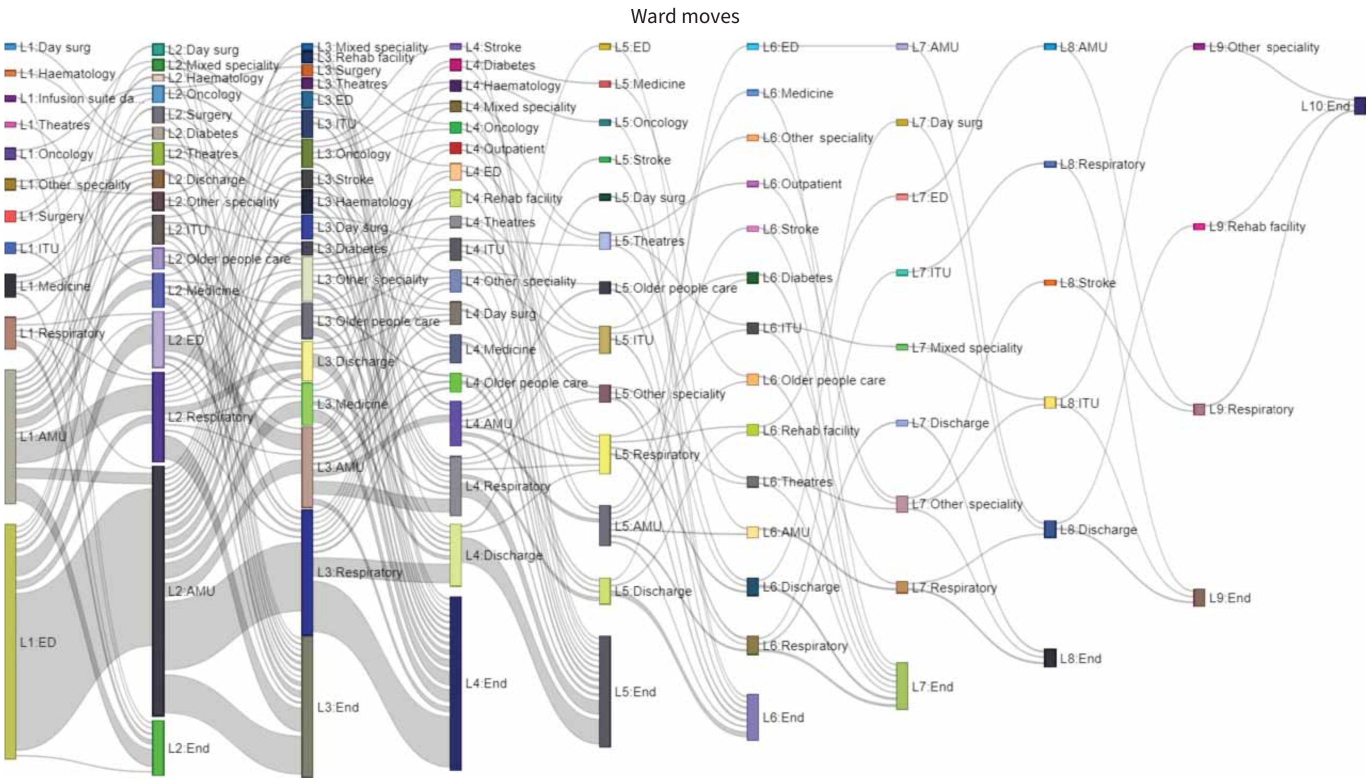

FIGURE 2 Pathways through different places of care during hospital stay. AMU: acute medical unit; Day surg: day surgery unit; Discharge: discharge lounge; ED: emergency department; End: discharged or died; ITU: intensive care unit; Rehab facility: off-site rehabilitation ward.

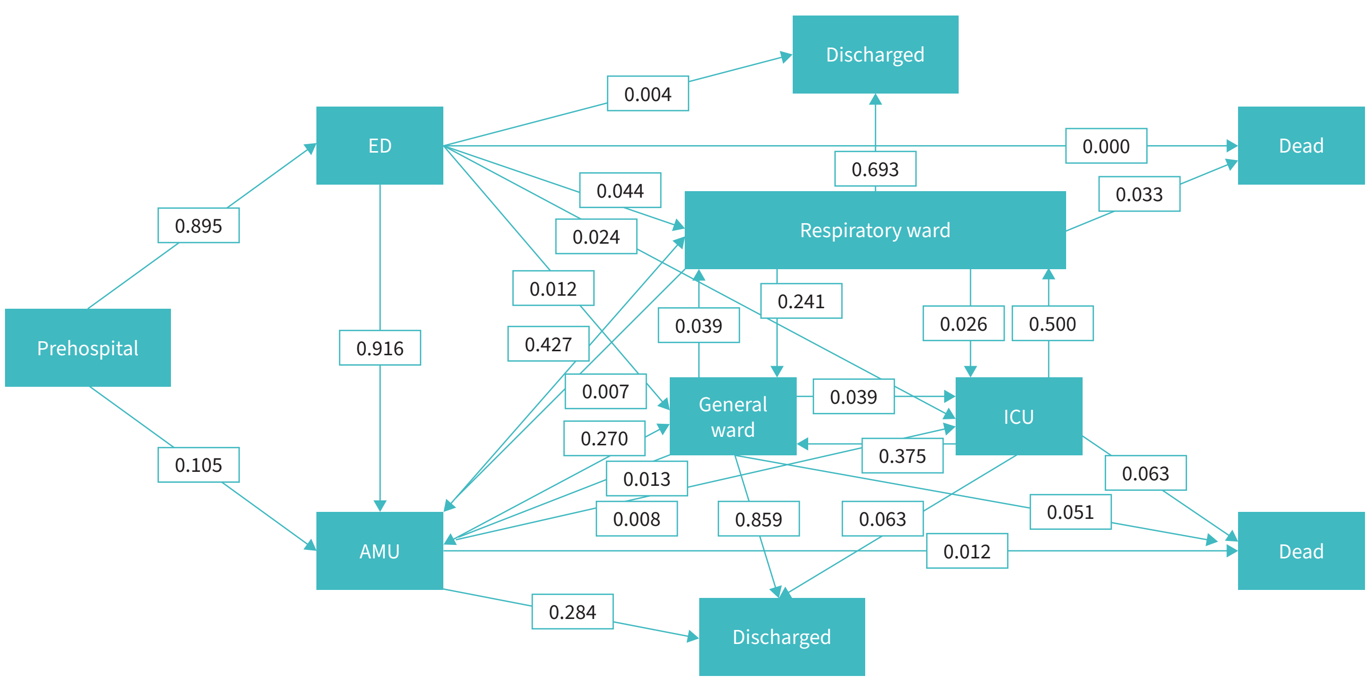

FIGURE 3 Transition probabilities between places of care or states during hospital admission. AMU: acute medical unit; ED: emergency department; ICU: intensive care unit.

TABLE 3 Probabilities of following a recommended care pathway by patient subgroup

Patient group	n	Probability (95% CI[#])	p-value[¶]
Whole group	560	0.568 (0.526–0.609)	-
Age ⩽70 years	247	0.636 (0.572–0.696)	0.004
Age >70 years	313	0.514 (0.458–0.571)	
Women	308	0.532 (0.475–0.589)	0.18
Men	252	0.588 (0.524–0.649)	
White ethnicity	476	0.562 (0.516–0.607)	0.50
Non-white ethnicity	43	0.615 (0.454–0.759)	
Lowest fifth of IMD	329	0.589 (0.534–0.643)	0.62
Higher four-fifths of IMD	230	0.610 (0.543–0.673)	
0–3 comorbidities	142	0.626 (0.541–0.706)	0.10
4 or more comorbidities	418	0.547 (0.498–0.596)	
COPD exacerbation as primary diagnosis	308	0.604 (0.547–0.659)	0.06
COPD exacerbation as secondary diagnosis	252	0.524 (0.460–0.587)	

IMD: index of multiple deprivation. [#]: by binomial distribution. [¶]: p-value for comparison between subgroups.

There have been few attempts to describe the complexity of care pathways for patients with COPD beyond simple descriptions of length of stay [20] and admission to critical care facilities. One paper elicited views of healthcare professionals from five European countries on pathways of care for patients with COPD but did not use patient-level data to map care pathways [21]. Existing work on care pathways has tended to focus on pathways as written, structured processes of delivering key components of care, rather than as pathways that describe the journey of patients through their hospital stay. Such structured approaches to care have however been shown to improve some outcomes of care for people admitted to hospital with exacerbations of COPD [6–8] and may help to explain the beneficial impact of specialist care on respiratory wards. It is unsurprising that older patients take longer to recover; this is the group most likely to be living with other long-term conditions/comorbidities and with frailty [22, 23], adding to the complexity of care, the likelihood of complications and the ability to recover from an illness. There are several possible explanations for why those aged 70 and over are less likely to be cared for on a pathway that is currently recommended by guidelines; this group is at higher risk of death and they may be cared for on a non-respiratory ward (*e.g.* a geriatric medicine ward) if the mix of long-term conditions with which they present to hospital makes this an appropriate choice of place to deliver care. However, it is also possible that patients who are older (and thus tend to have more long-term conditions) are inappropriately cared for on non-respiratory wards when specialist respiratory care would enhance the chances of survival and a rapid recovery. A lack of capacity on respiratory wards may also explain why not all patients were admitted to a specialist respiratory ward; UK hospital wards typically run very close to maximum capacity [24] and thus space may not have been available for all patients to be transferred to a respiratory ward. It is not possible to choose between these explanations based on our current data, but our findings provide a starting point for further enquiry.

Our analysis has a number of strengths. The use of routinely collected data enables inclusion of a wide range of patients, including those with severe illness or with cognitive impairment that would not be able to give consent for research. It is reassuring that the median length of stay and the inpatient mortality rate for our sample are very similar to those found in the 2018/2019 national COPD clinical audit [10], where the median length of stay was 4 days and the inpatient mortality was 3.9%, suggesting that our findings may be generalisable to admissions with exacerbation of COPD across the UK. Our approach to analysing care pathways highlights the complexity of pathways, and the use of Markov state transition models enables this complexity to be made tractable, allowing comparisons between subgroups. We chose to study a time period before the COVID-19 pandemic to ensure that our analyses were not affected by changes to either the presentation of patients with COPD exacerbation, or to the way that hospital care was organised.

Our analysis also has a number of limitations. The sample size was relatively small and was derived from a single year in a single hospital; this limited our power to find between-group differences (for instance between those with four or more comorbidities and those with fewer comorbidities). We limited our analyses to univariate approaches; there is a high degree of collinearity between variables such as age and the number of comorbid conditions, and dissecting out the contribution of each of these in a dataset of this size is challenging. It is possible though that some clinically significant associations could be missed as they would only become apparent on multivariable analysis when controlling for other variables (*i.e.* positive confounding), or would become statistically significant with larger sample sizes, and it would be premature to conclude that sex, deprivation or ethnicity are not associated with pathways of care. We chose not to try and include time spent in each ward within the Markov models for this analysis; such an approach would add additional granularity but at the expense of a more complex analysis, and this is an area of focus for future work. Similarly, we chose to map our care pathways based on place of treatment (wards) and did not attempt to include additional information (for instance investigations and therapies) that would provide a richer description of a care pathway; this too provides the foundation for future work. Complete information on cause of death was not available for this analysis; such information may have shed further light on the appropriateness of different pathways of care.

Although we have defined a "recommended" pathway of care for the purposes of this analysis, it is contestable whether such a pathway is most appropriate for some groups of patients admitted with COPD exacerbation. For a patient living with frailty and dementia, admitted with a mild COPD exacerbation not requiring ventilatory support, a respiratory ward may not provide the best environment to deliver care for all other comorbidities. Nevertheless, current guidelines for COPD care do not fully reflect these nuances, and the use of a recommended care pathway as we define it for this analysis serves to highlight these issues. It is of interest that there was some evidence to suggest that patients with a primary discharge diagnosis of COPD exacerbation were slightly more likely to follow the recommended care pathway, suggesting that the relative importance of different diagnoses may indeed influence choices around pathways of care as described. We suggest that qualitative enquiry, seeking the views of patients with COPD and of clinicians making care decisions, will be needed to better understand how choices are made about which pathway of care to follow, and hence how to adapt guidelines to meet the individual needs of different patients with COPD.

Pathways of care for patients in hospital are complex, and the work we present here is intended to lay the foundations for more sophisticated analyses in future. Such analyses should aim to incorporate time and other activities of care such as treatment and investigation. Measures that reflect the quality of care rather than simply place and time of care and could usefully explore whether different groups or clusters of long-term conditions have different impacts on which pathway of care is chosen. Whilst some of these analyses are achievable using routinely collected EHR data, there is also a pressing need for qualitative work to understand both the lived experience of these care pathways for patients with COPD with and without comorbidities, and also to understand barriers and drivers to decision-making by clinical staff around pathways of care.

In conclusion, we have demonstrated a method to characterise pathways of care for patients admitted to hospital with COPD in a way that enables comparison of pathways between different subgroups of patients. Older age was associated with a lower chance of following a guideline recommended hospital pathway of care, but there was no evidence that other sociodemographic factors were associated with differences in following a recommended pathway. This analysis provides a starting point for further enquiry using complementary research methods to better understand pathways of care and the factors that influence these pathways, with the ultimate aim of designing more appropriate pathways that meet the needs of individual patients and deliver the most appropriate care for different groups of patients with COPD exacerbations.

Provenance: Submitted article, peer reviewed.

Acknowledgements: This work used data provided by patients and collected by the NHS as part of their care and support. M.D. Witham, R. Cooper and A.A. Sayer acknowledge support from the National Institute for Health and Care Research Newcastle Biomedical Research Centre based at Newcastle upon Tyne Hospitals NHS Foundation Trust and Newcastle University. E. Sapey acknowledges funding from the UK Medical Research Council and Health Data Research UK to support the PIONEER programme.

Data access: Data and code are held by the HDRUK PIONEER acute care hub and may be accessible on completion of an appropriate data access agreement with PIONEER.

Ethics approval: This study was approved by the East Midlands Derby Research Ethics Committee (reference 20/EM/0158) and Confidentiality Advisory Group (20/CAG/0084) as part of PIONEER, the Health Data Research UK Hub in Acute Care. As part of this process, the data access request and specification were reviewed and approved by the PIONEER Data Trust Committee, a group of patients and members of the public who provide oversight of all data access decisions within PIONEER.

Conflicts of interest: E. Sapey is director of the PIONEER acute data hub, funded by Health Data Research-UK. The other authors have no conflicts of interest to declare.

Support statement: This research was conducted as part of the ADMISSION research collaborative, funded by the Strategic Priority Fund "Tackling multimorbidity at scale" programme (grant number MR/V033654/1) delivered by the Medical Research Council and the National Institute for Health and Care Research in partnership with the Economic and Social Research Council and in collaboration with the Engineering and Physical Sciences Research Council. The views expressed in this publication are those of the authors and not necessarily those of UK Research and Innovation, the National Institute for Health and Care Research, or the Department of Health and Social Care. Funding information for this article has been deposited with the Crossref Funder Registry.

References

1 Office for Health Improvement & Disparities. UK Interactive Health Atlas of lung conditions. www.gov.uk/government/statistics/interactive-health-atlas-of-lung-conditions-in-england-inhale-2022-update/interactive-health-atlas-of-lung-conditions-in-england-inhale-february-2022-update Date last updated: 1 February 2022. Date last accessed: 16 August 2022.
2 British Lung Foundation. Estimating the economic burden of respiratory illness in the UK. 2017. https://allcatsrgrey.org.uk/wp/wpfb-file/pc-1601_-_economic_burden_report_final_8cdaba2a-589a-4a49-bd14-f45d66167795-pdf/ Date last updated: 3 December 2019. Date last accessed: 7 July 2023
3 National Institute for Health and Care Excellence. NICE guideline NG115: Chronic obstructive pulmonary disease in over 16s: diagnosis and management. 2019. https://www.nice.org.uk/guidance/ng115 Date last updated: 26 July 2019.
4 National Institute for Health and Care Excellence. Quality Standard QS10. NICE Quality Standards: Chronic Obstructive Pulmonary Disease in adults. www.nice.org.uk/guidance/qs10/ Date last accessed: 18 September 2023. Date last updated: 2016.
5 Lane ND, Brewin K, Hartley TM, *et al.* Specialist emergency care and COPD outcomes. *BMJ Open Respir Res* 2018; 5: e000334.
6 Lodewijckx C, Sermeus W, Panella M, *et al.* Impact of care pathways for in-hospital management of COPD exacerbation: a systematic review. *Int J Nurs Studies* 2011; 48: 1445–1456.
7 Vanhaecht K, Lodewijckx C, Sermeus W, *et al.* Impact of a care pathway for COPD on adherence to guidelines and hospital readmission: a cluster randomized trial. *Int J COPD* 2016; 11: 2897–2908.
8 Seys D, Bruyneel L, Sermeus W, *et al.* Teamwork and adherence to recommendations explain the effect of a care pathway on reduced 30-day readmission for patients with a COPD exacerbation. *COPD* 2017; 15: 157–164.
9 Pleasants RA, Riley IL, Mannino DM. Defining and targeting health disparities in chronic obstructive pulmonary disease. *Int J Chron Obstruct Pulmon Dis* 2016; 11: 2475–2496.
10 Gershon AS, Dolmage TE, Stephenson A, *et al.* Chronic obstructive pulmonary disease and socioeconomic status: a systematic review. *COPD* 2012; 9: 216–226.
11 Carmona-Pírez J, Poblador-Plou B, Ioakeim-Skoufa I, *et al.* Multimorbidity clusters in patients with chronic obstructive airway diseases in the EpiChron Cohort. *Sci Rep* 2021; 11: 4784.
12 Hanlon P, Nicholl BI, Jani BD, *et al.* Examining patterns of multimorbidity, polypharmacy and risk of adverse drug reactions in chronic obstructive pulmonary disease: a cross-sectional UK Biobank study. *BMJ Open* 2018; 8: e018404.
13 Hurst J, Legg M, Shanahan L, *et al.* National Asthma and Chronic Obstructive Pulmonary Disease Audit Programme (NACAP). COPD clinical audit 2018/19 (people with COPD exacerbations discharged from acute hospitals in England, Scotland and Wales between September 2018 and 2019. Clinical audit report. London, Royal College of Physicians, July 2020.
14 Hughes LD, Witham MD. Causes and correlates of 30 day and 180 day readmission following discharge from a Medicine for the Elderly Rehabilitation unit. *BMC Geriatr* 2018; 18: 197.
15 Jencks SF, Williams MV, Coleman EA. Rehospitalisations among patients in the Medicare fee-for service program. *N Engl J Med* 2009; 360: 1418–1428.
16 Ministry of Housing, Communities and Local Government. English Indices of Multiple Deprivation. https://www.gov.uk/government/statistics/english-indices-of-deprivation-2019 Date last updated: 26 September 2019. Date last accessed: 5 August 2022.
17 Elixhauser A, Steiner C, Harris DR, *et al.* Comorbidity measures for use with administrative data. *Med Care* 1998; 36: 8–27.
18 Quan H, Sundararajan V, Halfon P, *et al.* Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care* 2005; 43: 1130–1139.
19 Gallier S, Price G, Pandya H, *et al.* Infrastructure and operating processes of PIONEER, the HDR-UK Data Hub in Acute Care and the workings of the Data Trust Committee: a protocol paper. *BMJ Health Care Inform* 2021; 28: e100294.

20 Hurst JR, Quint JK, Stone RA, *et al.* National clinical audit for hospitalised exacerbations of COPD. *ERJ Open Res* 2020; 6: 00208-2020.

21 Kayyali R, Odeh B, Frerichs I, *et al.* COPD care delivery pathways in five European Union countries: mapping and health care professionals' perceptions. *Int J COPD* 2016; 11: 2831–2838.

22 Barnett K, Mercer SW, Norbury M, *et al.* Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. *Lancet* 2012; 380: 37–43.

23 Hanlon P, Lewsey J, Quint JK, *et al.* Frailty in COPD: an analysis of prevalence and clinical impact using UK Biobank. *BMJ Open Respir Res* 2022; 9: e001314.

24 British Medical Association. NHS Hospital Beds Data Analysis. 2022. www.bma.org.uk/advice-and-support/nhs-delivery-and-workforce/pressures/nhs-hospital-beds-data-analysis Date last updated: 20 December 2022. Date last accessed: 24 July 2023.