AUDIT, RESEARCH AND GUIDELINE UPDATE

What happens to patients with COPD with long-term oxygen treatment who receive mechanical ventilation for COPD exacerbation? A 1-year retrospective follow-up study

Negin Hajizadeh,[1] Keith Goldfeld,[2] Kristina Crothers[3]

OPEN ACCESS

▶ Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/thoraxjnl-2014-205248).

[1]Hofstra North Shore LIJ School of Medicine and North Shore LIJ Health System, Department of Medicine, Manhasset, New York, USA
[2]Department of Population Health, New York University School of Medicine, New York, New York, USA
[3]Division of Pulmonary and Critical Care, University of Washington School of Medicine, Seattle, Washington, USA

Correspondence to
Dr Negin Hajizadeh, 1985 Marcus Avenue, Suite LL 104, Lake Success, NY 11042, USA; NHajizadeh@nshs.edu

Received 19 February 2014
Revised 10 April 2014
Accepted 18 April 2014
Published Online First 14 May 2014

Open Access
Scan to access more free content

To cite: Hajizadeh N, Goldfeld K, Crothers K. *Thorax* 2015;**70**:294–296.

ABSTRACT

We performed a retrospective cohort study of patients with chronic obstructive lung disease (COPD) on long-term oxygen treatment (LTOT) who received invasive mechanical ventilation for COPD exacerbation. Of the 4791 patients, 23% died in the hospital, and 45% died in the subsequent 12 months. 67% of patients were readmitted at least once in the subsequent 12 months, and 26.8% were discharged to a nursing home or skilled nursing facility within 30 days. We conclude that these patients have high mortality rates, both in-hospital and in the 12 months postdischarge. If patients survive, many will be readmitted to the hospital and discharged to nursing home. These potential outcomes may support informed critical care decision making and more preference congruent care.

INTRODUCTION

Chronic obstructive lung disease (COPD) is the third leading cause of death in the USA. The disease follows a progressive course, and patients with advanced disease most often die from respiratory failure or cardiovascular disease. Patients hospitalised for respiratory failure due to COPD (COPD exacerbation) have a 2-year median survival, and 50% of patients who survive hospitalisation are readmitted within 6 months of discharge.[1] In addition, patients with COPD are more likely to die after receiving life-supporting technologies and less likely to receive palliative care compared with lung cancer patients.[2] Unless patients explicitly choose to forego invasive treatments, often the default is to 'do everything' to prolong survival. However, survivors of invasive treatments often have decreased functional capacity, are discharged to a nursing home and have recurrent hospitalisations that may adversely impact quality of life.

Knowledge of these potential outcomes may influence patients' informed decision making about whether to accept invasive mechanical ventilation. Unfortunately, few studies have measured outcomes beyond hospital survival for patients with COPD.

In this study, we describe outcomes for patients with COPD on LTOT who are admitted to an ICU for respiratory failure and receive invasive mechanical ventilation. The focus of our analysis is on outcomes that may inform patient-level decision making about whether to accept invasive mechanical ventilation, including in-hospital and 12-month mortality, readmissions and discharge to nursing home. Further, we describe the association between patient-level factors such as comorbidities and nursing home residence, and these outcomes.

METHODS

We conducted a cohort study of Medicare Beneficiaries who were hospitalised for a COPD exacerbation in 2008. The analytic dataset included 2007–2009 data from the following CMS data files: the Master Beneficiary Summary File Base Segments; the Medicare Provider Analysis and Review utilisation files (MEDPAR); the Home Health, Hospice and Durable Medical Equipment (DME) utilisation files; and Minimum Data Set (MDS).

Cohort selection

We confined the cohort to beneficiaries with diagnoses of COPD, with at least two claims for LTOT, admitted to non-rural ICUs, for COPD exacerbation, treated with invasive mechanical ventilation (4791 patients) (see online supplementary figure S1).

Patient characteristics

We collected data on the patient's age, race and sex, as well as nursing home or skilled nursing facility (SNF), admission before the index admission. We derived Elixhauser comorbidity measures based on the ICD-9 codes.

Patient outcomes

Primary outcomes were (1) in-hospital and 12-month mortality, (2) all-cause readmission over 12 months and (3) discharge to nursing home or SNF within 30 days. We measured discharge to nursing home using data from MDS entry dates.

Statistical analysis

We described patient characteristics using counts and proportions for all variables, except for age, for which we reported a mean (SD) value. We used bootstrap methods to estimate 95% CIs for the proportions.

We tested the association of individual patient-level factors on mortality (in-hospital and 12-month) and readmission (12-month) using simple logistic regression. Fully adjusted models were estimated using multiple logistic regression and a backwards elimination variable selection algorithm. ORs and 95% CIs were

Thorax: first published as 10.1136/thoraxjnl-2014-205248 on 14 May 2014. Downloaded from http://thorax.bmj.com/ on October 6, 2024 by guest. Protected by copyright.

estimated for each of the analyses. For additional description of methods, see online supplementary material.

RESULTS

The study cohort was defined as the 4791 COPD-LTOT patients who received invasive mechanical ventilation for COPD exacerbation. Mean age was 74.3 (SD 6.4), and 88.2% were white. 14.3% (n=687) were in a nursing home or SNF within 365 days before the index admission (defined as the first ICU admission in 2008) (see online supplementary table S1). Most patients (69.8%) had more than three comorbidities.

Mortality

Of the 4791 COPD-LTOT patients who received invasive mechanical ventilation for COPD exacerbation, 23.3% died in the hospital and 45.2% died in the 12 months after hospital discharge (figure 1). Of the total cohort, 31.5% were alive 1 year following discharge.

Readmissions

Of the 3677 index admission survivors, 67.1% were readmitted at least once in the subsequent 12 months, and 45.3% were rehospitalised two or more times (figure 1). Of those with at least one readmission (n=2466), 52.1% were readmitted due to COPD.

Discharge to nursing home

Of the 3177 patients discharged alive who were not in a nursing home in the 12 months before the index admission, 26.8% were admitted to a nursing home within 30 days after hospital discharge. An additional 12.3% of survivors were admitted to a nursing home after 30 days.

Factors associated with mortality

(See online supplementary table S2). *The odds of dying in the hospital* increased by 4% for every 1 year increase in age (adjusted OR (AOR), 1.04; supplement, 95% CIs). Other factors associated with hospital death included: white race (23.8% vs 18.9%; AOR 1.42); male sex (25.3% vs 21.7%; AOR 1.17); and nursing home admission at any point in previous year (27.2% vs 22.6%; AOR 1.27). The following comorbidities were associated with hospital death: weight loss (AOR 1.30), renal failure (AOR 1.42) and metastatic cancer (AOR 1.92). Obesity was associated with reduced mortality (AOR 0.71).

Among patients discharged alive (n=3677), *the odds of dying within 12 months* increased by 1% for every 1 year increase in age (AOR 1.01; 95% CI 1.01 to 1.01). Other factors associated with dying within 12 months included white race (50.6% vs 46.5%; AOR 1.07); male sex (52.4% vs 48.5%; AOR 1.04) and nursing home admission at any point in previous year (63.6% vs 48.0%; AOR 1.10). The following comorbidities were associated with a higher likelihood of dying within 12 months: fluid and electrolyte disorders (AOR 1.05), weight loss (AOR 1.12), solid tumour without metastasis (AOR 1.20) and metastatic cancer (AOR 1.23). Obesity was associated with reduced mortality (AOR 0.91).

Factors associated with readmission

(See online supplementary table S3). The odds of readmission were increased by 14% if patients were admitted to a nursing home within 30 days of discharge from the hospital (75.6% vs 64.5%, AOR 1.14; 95% CI 1.10 to 1.18). The following comorbidities were associated with a higher likelihood of readmission within 12 months: congestive heart failure (AOR 1.06), diabetes (AOR 1.06), deficiency anemias (AOR 1.05) and depression (AOR 1.05).

DISCUSSION

We describe outcomes over 12 months for patients with COPD on LTOT who are treated with invasive mechanical ventilation for acute COPD exacerbation. Beyond mortality, we provide insights into the clinical care trajectories for patients after mechanical ventilation in terms of readmission and nursing home admission.

Patients with advanced COPD are at increased risk for severe COPD exacerbations that require critical care. Our work may be useful to inform patients' decision making about whether to accept invasive mechanical ventilation in the event of respiratory failure due to COPD exacerbation, by describing and quantifying survival and outcomes that may affect quality of life such as rehospitalisation and admission to nursing home.

In prior work, we designed a Markov decision model to simulate outcomes for patients with severe COPD who chose

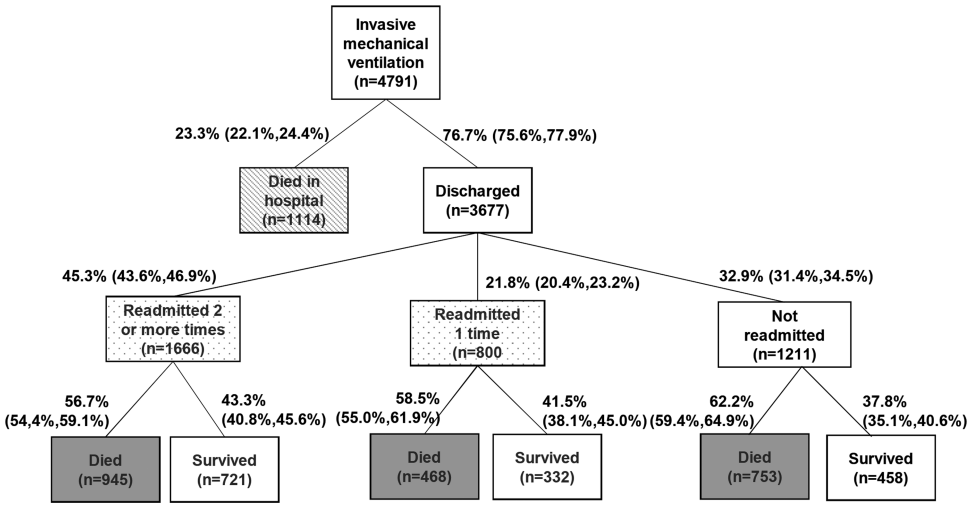


Figure 1 Outcomes over 12 months for patients with COPD-LTOT treated with invasive mechanical ventilation (with 95% CIs). COPD-LTOT, chronic obstructive lung disease–long-term oxygen treatment.

Thorax: first published as 10.1136/thoraxjnl-2014-205248 on 14 May 2014. Downloaded from http://thorax.bmj.com/ on October 6, 2024 by guest. Protected by copyright.

alternative advance directives for mechanical ventilation. We estimated 54% 12-month mortality for severe patients with COPD who chose to receive invasive mechanical ventilation (Full Code advance directives) versus 57% for patients who chose not to receive invasive mechanical ventilation.[3] However, Full Code patients had increased rehospitalisations and discharge to nursing home. Other investigators have indicated high mortality for patients with COPD who require mechanical ventilation for COPD-related respiratory failure. Breen *et al* describe 48.6% 12-month mortality in a retrospective cohort of 74 patients admitted to the ICU with acute respiratory failure due to COPD.[4]

COPD is a leading cause of hospital readmissions. Most studies report 30-day readmission because this may be more likely a marker of quality of care. The goal of our analysis was to describe outcomes that may be helpful for patients in decision making, and we therefore describe longer-term readmission rates. These readmissions likely reflect the severity of underlying chronic disease and the 'end-of-life' stage of COPD, although the proportion of potentially preventable admissions cannot be measured by this analysis.

In contrast to mortality and readmission rates, few studies have described discharge to nursing home after mechanical ventilation for COPD respiratory failure. Although our current analysis does not include data to assess functional capacity, more than 60% of nursing home residents who have COPD require extensive assistance, or are totally dependent for activities of daily living in other studies.[5] In addition, many patients are unable to be liberated from mechanical ventilation[1] and many of the 26.8% of patients we identified as being discharged to nursing home within 30 days may have remained on mechanical ventilation. Understanding the likelihood of nursing home admission after mechanical ventilation for COPD exacerbation, described in our study, may be valuable for patients' decision making.

Our study has several limitations. Most notably, we used LTOT as a marker of COPD severity. We chose this method as a surrogate marker of advanced/severe COPD because CMS data files do not contain lung function tests. We believe oxygen supplementation is a valid surrogate marker of COPD severity because patients with COPD typically require oxygen supplementation once their lung disease is very advanced. Second, there are limits on the generalisability of our outcomes because the cohort was predominantly white and did not include patients admitted to rural hospitals where practice patterns are likely different. Third, because this was a course-of-disease study, we did not compare outcomes from another group, such as an exacerbated COPD cohort who did not receive invasive mechanical ventilation. A meaningful comparison would require the groups to have similar characteristics (eg, health status and acuity of illness) at the time of ICU admission, which we could not ascertain with the available data.

The outcomes we report have important implications for doctor–patient discussions about prognoses in the event of acute COPD exacerbation and could be useful to patients making informed decisions about whether to accept invasive mechanical ventilation. Future work will describe the quality of life for patients discharged to a nursing home in an attempt to further inform advance care planning in patients with advanced COPD.

Contributors NH conceived and designed the study, acquired data and drafted the manuscript; NH and KF analysed and interpreted data; all authors critically revised the manuscript for important intellectual content.

Funding This work was supported in part by a grant from the U.S. Agency for Healthcare Research and Quality (K12 HS019473-01).

Competing interests None.

Ethics approval New York University School of Medicine Institutional Review Board.

Provenance and peer review Not commissioned; externally peer reviewed.

Open Access This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 3.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/3.0/

REFERENCES

1 Connors AF Jr, Dawson NV, Thomas C, *et al*. Outcomes following acute exacerbation of severe chronic obstructive lung disease. The SUPPORT investigators (Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments). *Am J Respir Crit Care Med* 1996;154(4 Pt 1):959–67.

2 Claessens MT, Lynn J, Zhong Z, *et al*. Dying with lung cancer or chronic obstructive pulmonary disease: insights from SUPPORT. Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments. *J Am Geriatr Soc* 2000;48(5 Suppl):S146–53.

3 Hajizadeh N, Crothers K, Braithwaite RS. Using modeling to inform patient-centered care choices at the end of life. *J Comp Effectiveness Res* 2013;2:497–508.

4 Breen D, Churches T, Hawker F, *et al*. Acute respiratory failure secondary to chronic obstructive pulmonary disease treated in the intensive care unit: a long term follow up study. *Thorax* 2002;57:29–33.

5 Zarowitz BJ, O'Shea T. Chronic obstructive pulmonary disease: prevalence, characteristics, and pharmacologic treatment in nursing home residents with cognitive impairment. *J Manag Care Pharm* 2012;18:598–606.

Thorax: first published as 10.1136/thoraxjnl-2014-205248 on 14 May 2014. Downloaded from http://thorax.bmj.com/ on October 6, 2024 by guest. Protected by copyright.

What Happens To COPD Patients with Long Term Oxygen Treatment Who Receive Mechanical Ventilation for COPD exacerbation? A One-Year Retrospective Follow up Study.

Negin Hajizadeh, MD, MPH, Keith Goldfeld, DrPH, Kristina Crothers, MD

Abstract

We performed a retrospective cohort study of COPD patients on long-term oxygen treatment (LTOT) who received invasive mechanical ventilation for COPD exacerbation. Of the 4791 patients, 23% died in the hospital, and 45% died in the subsequent 12 months. 67% of patients were readmitted at least once in the subsequent 12 months, and 23% were discharged to a nursing home or SNF within 30 days. We conclude that these patients have high mortality rates, both in-hospital and in the 12 months post-discharge. If patients survive, many will be readmitted to the hospital and discharged to nursing home. These potential outcomes may support informed critical care decision making and more preference-congruent care.

INTRODUCTION

Chronic obstructive lung disease (COPD) is the third leading cause of death in the United States, and affects 6% of the general population.[1,2] Once established, the disease follows a progressive course, and patients with advanced disease most often die from respiratory failure or cardiovascular disease.[3] Patients hospitalized for respiratory failure due to COPD (COPD exacerbation) have a 2-year median survival, and 50% of patients who survive hospitalization are readmitted within 6 months of discharge. In addition, COPD patients are more likely to die after receiving life supporting technologies, and less likely to receive palliative care when compared to lung cancer patients. Unless patients choose to explicitly forego invasive treatments, often the default is to "do everything" in order to prolong survival. However, survivors of invasive treatments often have decreased functional capacity, are discharged to a nursing home, and have recurrent hospitalizations that may adversely impact quality of life.[4-6]

Knowledge of these potential outcomes may influence patients' informed decision-making about whether to accept invasive mechanical ventilation. Unfortunately, few studies have measured outcomes beyond hospital survival for patients with COPD. Connors et al. prospectively followed a cohort of SUPPORT patients (The Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments) hospitalized with an acute exacerbation of severe COPD and found 11% in-hospital mortality and 43% 1-year mortality. At 6 months, only 26% of the cohort was both alive and able to report a good, very good, or excellent quality of life.[6] This study did not however focus only on invasive mechanical ventilation, and in fact only 35% required mechanical ventilation.

In this current study, we describe outcomes for COPD patients on LTOT who are admitted to an ICU for respiratory failure and receive invasive mechanical ventilation. The focus of our analysis is on outcomes that may inform patient-level decision making about whether to accept invasive mechanical ventilation, including in-hospital and 12-month mortality, readmissions and discharge to nursing home. Further, we describe the association between patient-level factors such as comorbidities and nursing home residence, with these outcomes.

METHODS

We conducted a cohort study of Medicare Beneficiaries who were hospitalized for a COPD exacerbation in 2008. The analytic dataset included 2007-2009 data from the following CMS data files: the Master Beneficiary Summary File Base Segments;[7] the Medicare Provider Analysis and Review utilization files (MEDPAR);[8] the Home Health, Hospice and Durable

Medical Equipment (DME) utilization files; and Minimum Data Set (MDS). The study was approved by the New York University Institutional Review Board (R# 11-02351) and conducted under a data use agreement with the CMS.

Cohort selection: Our study cohort included patients with COPD on long-term oxygen treatment (LTOT) who were admitted to an intensive care unit (ICU) for COPD exacerbation. We first selected beneficiaries with a diagnosis of COPD, hospitalized in 2008 (Figure S1).[9,10] We then selected patients who were admitted for COPD exacerbation. We limited our analysis to beneficiaries who were in non-rural patterns to try to control for variability in practice between non-rural and rural hospitals.[11,12] We then limited this cohort to patients who were receiving LTOT as defined by at least two claims for oxygen in the 12 months prior to the index admission. We further limited this cohort to patients who were admitted to the ICU. This was identified as the index admission for our COPD cohort (25,032 patients) and the starting point for analyzing repeat hospital visits. We then identified patients who received any mechanical ventilation and limited the analysis to those receiving invasive mechanical ventilation (4,791 patients).[13]

Patient characteristics: We collected data on the patients' age, race, and sex, as well as nursing home or skilled nursing facility (SNF) admission before the index admission. We derived Elixhauser comorbidity measures based on the ICD-9 codes[14] which is an extensively validated risk-adjustment tool for hospital length of stay and mortality.[15,16] We modified the comorbidity measure to include all diagnoses during the year prior to the index admission.

Patient outcomes: Primary outcomes were 1) in-hospital and 12-month mortality, 2) all-cause readmission over 12 months, and 3) discharge to nursing home or SNF within 30 days. We identified all readmissions in the following 365 days after discharge, and classified them as being COPD admissions versus "other" based on the same criteria as the index admission. We measured discharge to nursing home using data from MDS entry dates.

Statistical analysis: We described patient characteristics using counts and proportions for all variables, except for age, for which we reported a mean (SD) value. We used bootstrap methods to estimate 95% confidence intervals for the proportions.

We tested the association of individual patient-level factors on mortality (in-hospital and 12-month) and readmission (12-month) using simple logistic regression. Fully adjusted models were estimated using multiple logistic regression and a backwards elimination variable selection algorithm. Odds ratios and 95% confidence intervals were estimated for each of the analyses. All analyses were conducted using R, version 3.0.2 (R Foundation for Statistical Computing; http://r-project.org).

RESULTS

The study cohort was defined as the 4791 COPD-LTOT patients who received invasive mechanical ventilation for COPD exacerbation. Mean age was 74.3 (SD 6.4) and 88.2% were white. 14.3% (n=687) were in a nursing home or SNF within 365 days before the index

admission (defined as the first ICU admission in 2008) (Table S1). Most patients (69.8%) had more than three comorbidities.

Mortality: Of the patients who received invasive mechanical ventilation (n=4791), 23.3% died in the hospital, and 45.2% died in the 12 months after hospital discharge (Figure). Of the total cohort, 31.5% were alive one year following discharge.

Readmissions: Of the 3677 index admission survivors, 67.1% were readmitted at least once in the subsequent 12 months, and 45.3% were re-hospitalized two or more times (Figure). Of those with at least one readmission (n=2466), 52.1% were readmitted due to COPD.

Discharge to nursing home: Of the 3177 patients discharged alive who were not in a nursing home in the 12 months before the index admission, 26.8% were admitted to a nursing home within 30 days after hospital discharge. An additional 14.2% of survivors were admitted to a nursing home after 30 days.

Factors associated with mortality (Table S2): The odds of dying in the hospital increased by 4% for every one year increase in age (adjusted OR [AOR], 1.04; 95% CI: 1.03-1.05). Other factors associated with hospital death included: white race (23.8% vs. 18.9%; AOR, 1.42; 95% CI: 1.13-1.79); male sex (25.3% vs. 21.7%; AOR, 1.17; 95% CI: 1.02-1.35); and nursing home admission at any point in previous year (27.2% vs. 22.6%; AOR, 1.27; 95% CI: 1.05-1.55). The following comorbidities were associated with hospital death: weight loss (AOR, 1.30; 95% CI: 1.09-1.55),

renal failure (AOR, 1.42; 95% CI: 1.16-1.74), and metastatic cancer (AOR, 1.92; 95% CI: 1.30-2.84). Obesity was associated with reduced mortality (AOR, 0.71; 95% CI: 0.55-0.92).

Among patients discharged alive (n=3677), the odds of dying within 12 months increased by 1% for every one year increase in age (AOR, 1.01; 95% CI: 1.01-1.01). Other factors associated with dying within 12 months included: white race (50.6% vs. 46.5%; AOR, 1.07; 95% CI: 1.02-1.13); male sex (52.4% vs. 48.5%; AOR, 1.04; 95% CI: 1.01-1.08); and nursing home admission at any point in previous year (63.6% vs. 48.0%; AOR, 1.10; 95% CI: 1.05-1.16). The following comorbidities were associated with a higher likelihood of dying within 12months: fluid and electrolyte disorders (AOR, 1.05; 95% CI: 1.01-1.08), weight loss (AOR, 1.12; 95% CI: 1.07-1.17), solid tumor without metastasis (AOR, 1.20; 95% CI: 1.12-1.28), and metastatic cancer (AOR, 1.23; 95% CI: 1.10-1.38). Obesity was associated with reduced mortality (AOR, 0.91; 95% CI: 0.87-0.96).

Factors associated with readmission (Table S3): The odds of readmission were increased by 14% if patients were admitted to a nursing home within 30 days of discharge from the hospital (75.6% vs. 64.5%, AOR, 1.14; 95% CI: 1.10-1.18). The following comorbidities were associated with a higher likelihood of readmission within 12 months: congestive heart failure (AOR, 1.06; 95% CI: 1.03-1.10), diabetes (AOR, 1.06; 95% CI: 1.03-1.10), deficiency anemias (AOR, 1.05; 95% CI: 1.01-1.09), and depression (AOR, 1.05; 95% CI: 1.00-1.10).

DISCUSSION

We describe outcomes over 12-months for patients with COPD on LTOT who are treated with invasive mechanical ventilation for acute COPD exacerbation. Although other investigators have described outcomes for patients with COPD who receive mechanical ventilation,[6,17-21] ours is the first study that describes outcomes for a large representative sample of non-rural COPD patients, focusing in particular on patients with LTOT who received invasive mechanical ventilation. Beyond mortality, we provide insights into the clinical care trajectories for patients after mechanical ventilation in terms of readmission and nursing home admission.

Patients with advanced COPD are at increased risk for severe COPD exacerbations that require critical care. Unfortunately patients are often not informed about the progressive nature of COPD or the potential need for life-supporting technologies.[3] Our work may be useful to inform patients' decision making about whether to accept invasive mechanical ventilation in the event of respiratory failure due to COPD exacerbation, by describing and quantifying survival and outcomes that may affect quality of life such as re-hospitalization and admission to nursing home, after invasive mechanical ventilation.

In prior work we designed a Markov decision model synthesizing available clinical data to simulate outcomes for patients with severe COPD who chose alternative advance directives for mechanical ventilation. We estimated 54% 12-month mortality for severe COPD patients who chose to receive invasive mechanical ventilation (Full Code advance directives) versus 57% for patients who chose not to receive invasive mechanical ventilation (Do Not Intubate/DNI advance directives). However, Full Code patients had increased re-hospitalizations and discharge to

nursing home. Other investigators have indicated high mortality for patients with COPD who require mechanical ventilation for COPD related respiratory failure. For example, Breen et al. describe a 48.6% (95% CI: 61%–37%) 12-month mortality measured in a retrospective cohort analysis of 74 patients admitted to the ICU with acute respiratory failure due to COPD. Their cohort had a mean FEV1 of 0.74L corresponding to advanced stage COPD,[22] and 85% received invasive mechanical ventilation. Our analysis measures a higher death rate of 68% within 12-months of ICU admission, which is likely because we selected patients with more advanced COPD as indicated by LTOT and only patients who were treated with invasive mechanical ventilation. Our cohort was also older with a mean age of 74 as opposed to 64.

COPD is a leading cause of hospital readmissions[23]. Most studies report 30-day readmission because this is more likely a marker of quality of care. The goal of our analysis was to describe outcomes that may be helpful for patients in decision making, and we therefore describe longer term readmission rates. Although the proportion of potentially preventable admissions cannot be measured by this analysis, and it is feasible that quality of care improvement measures focusing on transitions at hospital discharge would decrease some of these readmissions, these readmissions also reflect the severity of underlying chronic disease and the 'end-of-life' stage of COPD.

In contrast to mortality and readmission rates, few studies have described discharge to nursing home after mechanical ventilation for COPD respiratory failure. Although our current analysis does not include data to assess functional capacity, more than 60% of nursing home residents who have COPD require extensive assistance, or are totally dependent for activities of daily

living in other studies. In addition, many patients are unable to be liberated from mechanical ventilation and many of the 26.8% of patients we identified as being discharged to nursing home within 30 days, may have remained on mechanical ventilation. Understanding the likelihood of nursing home admission after mechanical ventilation for COPD exacerbation, described in our study, may be valuable for patients' decision making.

Our study has several limitations. First, we used LTOT as a marker of COPD severity. We chose this method as a surrogate marker of advanced/severe COPD because CMS data files do not contain lung function tests. We believe oxygen supplementation is a valid surrogate marker of COPD severity because patients with COPD typically require oxygen supplementation once their lung function is very advanced.[18,24] Second, we excluded patients who had a claim for heart failure at the index hospitalization in an attempt to keep the cohort restricted as much as possible to COPD as a cause of respiratory failure. Because of this exclusion we are not able to describe outcomes for patients with advanced COPD who were hospitalized for both COPD exacerbation and heart failure. Third, as with all studies using claims-based data, although the definition of COPD exacerbation classically excludes respiratory failure in patients with COPD due to pneumonia and heart failure[25,26] misclassification is still possible. Fourth, because we did not have access to the full set of Medicare claims data we were unable to distinguish between long-term care and short term SNF care in the nursing home. Fifth, there are limits on the generalizability of our outcomes because the cohort was predominantly white and did not include patients admitted to rural hospitals where practice patterns are likely different. Finally, because this was a course-of-disease study, we did not compare outcomes from another group, such as an exacerbated COPD cohort who did not receive invasive mechanical ventilation. A meaningful

comparison would require the groups to have similar characteristics (e.g., health status and acuity of illness) at the time of ICU admission, which we could not ascertain with the available data.

The outcomes we report have important implications for doctor-patient discussions about prognoses in the event of acute COPD exacerbation, and could be useful to patients making informed decisions about whether to accept invasive mechanical ventilation. Patients may choose to use this information to prepare for possible outcomes, or to decide whether to accept invasive mechanical ventilation. Future work will describe the quality of life for patients discharged to a nursing home in an attempt to further inform advance care planning in patients with advanced COPD.

Table S1. Baseline Characteristics of ICU Admissions for Exacerbated COPD with Mechanical Ventilation in 2008 (n=4,791).

Measure	Count (%)
Age, mean (standard deviation)	74.3 (6.4)
White	4,226 (88.2)
Female	2,764 (57.7)
Previous admission for COPD	2,466 (51.5)
In nursing home prior to admission	687 (14.3)
Comorbidities	
Hypertension	3,104 (64.8)
Fluid and electrolyte disorders	2,872 (59.9)
Congestive heart failure	2,265 (47.3)
Diabetes w/o chronic complications	1,435 (30.0)
Deficiency anemias	1,229 (25.7)
Weight loss	838 (17.5)
Pulmonary circulation disorder	796 (16.6)
Renal failure	670 (14.0)
Depression	643 (13.4)
Peripheral vascular disorder	583 (12.2)
Obesity	525 (11.0)
Valvular disease	473 (9.9)
Neurological disease	458 (9.6)
Solid tumor without metastasis	342 (7.1)
Diabetes w/ chronic complications	325 (6.8)
Metastatic cancer	124 (2.6)

Table S2. Factors Associated with Dying in the ICU and Dying within 1 Year of Discharge for Severe COPD Patients Treated with Invasive Mechanical Ventilation for COPD Exacerbation in 2008.

	Died in hospital (n=4,791)		Died following discharge (n=3,677)	
Factor	**Unadjusted Odds Ratio (95% CI)**	**Adjusted Odds Ratio (95% CI)**	**Unadjusted Odds Ratio (95% CI)**	**Adjusted Odds Ratio (95% CI)**
Age	1.04 (1.03,1.05) **	1.04 (1.03, 1.05) **	1.05 (1.04,1.06) **	1.01 (1.01, 1.01) **
White	1.34 (1.07,1.67) **	1.42 (1.13, 1.79) **	1.18 (0.97,1.43)*	1.07 (1.02, 1.13) **
Male	1.22 (1.06,1.39) **	1.17 (1.02, 1.35) **	1.16 (1.02,1.33) **	1.04 (1.01, 1.08) **
Had previous admission for COPD	0.95 (0.88,1.02)		1.15 (1.07,1.23) **	1.05 (1.02, 1.09) **
In nursing home prior to admission	1.28 (1.07,1.54) **	1.27 (1.05, 1.55) **	1.90 (1.56,2.30) **	1.10 (1.05, 1.16) **
Hypertension	0.81 (0.70,0.93) **	0.83 (0.71, 0.96) **	1.03 (0.90,1.18)	
Fluid and electrolyte disorders	0.88 (0.77,1.01)*	0.89 (0.77, 1.02)	1.32 (1.16,1.51) **	1.05 (1.01, 1.08) **
Congestive heart failure	0.89 (0.78,1.02)*	0.86 (0.74, 1.00) **	1.21 (1.06,1.38) **	1.03 (1.00, 1.06)*
Diabetes w/o chronic complications	0.71 (0.61,0.82) **	0.76 (0.65, 0.90) **	0.92 (0.80,1.06)	
Deficiency anemias	0.98 (0.84,1.15)		1.24 (1.07,1.43) **	
Weight loss	1.39 (1.18,1.65) **	1.30 (1.09, 1.55) **	1.83 (1.53,2.19) **	1.12 (1.07, 1.17) **
Pulmonary circulation disorder	1.15 (0.96,1.37)	1.25 (1.04, 1.51) **	1.08 (0.90,1.29)	
Renal failure	1.35 (1.12,1.62) **	1.42 (1.16, 1.74) **	1.37 (1.13,1.66) **	1.04 (0.99, 1.09)
Depression	0.77 (0.63,0.95) **	0.84 (0.68, 1.04)	1.00 (0.83,1.20)	
Peripheral vascular disorder	1.09 (0.90,1.34)		1.17 (0.96,1.43)	
Obesity	0.59 (0.46,0.75) **	0.71 (0.55, 0.92) **	0.65 (0.53,0.80) **	0.91 (0.87, 0.96) **
Valvular disease	0.95 (0.76,1.19)		1.26 (1.02,1.57) **	
Neurological disease	0.78 (0.61,0.99) **	0.77 (0.60, 0.98) **	1.19 (0.96,1.47)	
Solid tumor without metastasis	1.38 (1.08,1.76) **	1.23 (0.94, 1.59)	2.73 (2.05,3.64) **	1.20 (1.12, 1.28) **
Diabetes w/ chronic complications	1.08 (0.83,1.41)	1.32 (0.99, 1.75)*	1.08 (0.83,1.40)	
Metastatic cancer	2.06 (1.42,2.98) **	1.92 (1.30, 2.84) **	3.89 (2.24,6.78) **	1.23 (1.10, 1.38) **

Note: Adjusted odds ratios are only reported for variables with significant associations at the $p<0.05$ level.
**$p<0.05$
*$p<0.01$

Table S3. Factors Associated with Readmission within 12 months for COPD-LTOT patients surviving index admission (n=3677).

	Odd Ratios (95% CI) Readmission	
Factor	Unadjusted	Adjusted
Age	0.98 (0.97,0.99) **	0.99 (0.99, 1.00) **
White	0.75 (0.60,0.93) **	0.94 (0.90, 0.98) **
Male	0.92 (0.80,1.05)	
In nursing home prior to index admission	0.99 (0.81,1.20)	
Admitted to nursing home within 30 days	1.70 (1.43,2.03)	1.14 (1.10, 1.18) **
Hypertension	1.30 (1.13,1.50) **	1.03 (0.99, 1.06)
Fluid and electrolyte disorders	1.09 (0.95,1.25)	
Congestive heart failure	1.44 (1.25,1.66) **	1.06 (1.03, 1.10) **
Diabetes w/o chronic complications	1.55 (1.33,1.81) **	1.06 (1.03, 1.10) **
Deficiency anemias	1.33 (1.13,1.56) **	1.05 (1.01, 1.09) **
Weight loss	0.79 (0.66,0.94) **	0.95 (0.91, 0.99) **
Pulmonary circulation disorder	1.28 (1.06,1.56) **	1.03 (0.99, 1.07)
Renal failure	1.37 (1.11,1.69) **	1.07 (1.02, 1.12) **
Depression	1.47 (1.19,1.81) **	1.05 (1.00, 1.10) *
Peripheral vascular disorder	1.33 (1.07,1.66) **	
Obesity	1.19 (0.96,1.48)	
Valvular disease	1.18 (0.93,1.49)	
Neurological disease	1.16 (0.92,1.46)	
Solid tumor without metastasis	0.98 (0.74,1.29)	
Diabetes w/ chronic complications	1.67 (1.23,2.27) **	
Metastatic cancer	1.02 (0.63,1.65)	

Note: Adjusted odds ratios are only reported for variables with significant associations at the $p<0.05$ level.
**$p<0.05$
*$p<0.01$

References

1 Centers for Disease Control and Prevention. National Center for Health Statistics. National Vital Statistics Report. Deaths: Final Data for 2009. June 2012; 60(03).

2 Mannino DM, Homa DM, Akinbami LJ, *et al*. Chronic obstructive pulmonary disease surveillance--United States, 1971-2000. *Respir Care.* 2002;**47** (suppl 10):1184-1199.

3 Heffner JE. Advance care planning in chronic obstructive pulmonary disease: barriers and opportunities. *Curr Opin Pulm Med.* 2011;**17** (suppl 2):103-109.

4 Barnato AE, Albert SM, Angus DC, *et al*. Disability among Elderly Survivors of Mechanical Ventilation. *Am J Respir Crit Care Med.* 2011;**183** (suppl 8):1037-1042.

5 Hopkins RO, Jackson JC. Short- and long-term cognitive outcomes in intensive care unit survivors. *Clin Chest Med.* 2009;**30** (suppl 1):143-53, ix.

6 Connors AF,Jr, Dawson NV, Thomas C, *et al*. Outcomes following acute exacerbation of severe chronic obstructive lung disease. The SUPPORT investigators (Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments). *Am J Respir Crit Care Med.* 1996;**154** (suppl 4 Pt 1):959-967.

7 Centers for Medicare and Medicaid Services. Denominator File. 2012; Available at: http://www.cms.gov/Research-Statistics-Data-and-Systems/Files-for-Order/IdentifiableDataFiles/DenominatorFile.html. Accessed September 23, 2013.

8 Lauderdale DS, Furner SE, Miles TP, *et al*. Epidemiologic uses of Medicare data. *Epidemiol Rev*. 1993;**15** (suppl 2):319-327.

9 CMS Chronic Condition Data Warehouse Condition Categories . Available at: https://www.ccwdata.org/cs/groups/public/documents/document/ccw_conditioncategories.pdf.

10 Rothberg MB, Pekow PS, Lahti M, *et al*. ANtibiotic therapy and treatment failure in patients hospitalized for acute exacerbations of chronic obstructive pulmonary disease. *JAMA*. 2010;**303** (suppl 20):2035-2042.

11 Centers for Medicare and Medicaid Services. Details for Title: FY 2013 Proposed Rule Data Files. Available at: http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/FY-2013-IPPS-Proposed-Rule-Home-Page-Items/FY-2013-Proposed-Rule-Data-Files-CMS-1588-P.html. Accessed August 10, 2013.

12 Centers for Disease Control and Prevention. NCHS Urban-Rural Classification Scheme for Counties. 2013; Available at: http://www.cdc.gov/nchs/data_access/urban_rural.htm. Accessed August 10, 2013.

13 Tsai CL, Lee WY, Delclos GL, *et al*. Comparative effectiveness of noninvasive ventilation vs invasive mechanical ventilation in chronic obstructive pulmonary disease patients with acute respiratory failure. *J Hosp Med*. 2013;**8** (suppl 4):165-172.

14 HCUP Comorbidity Software. Healthcare Cost and Utilization Project (HCUP). Agency for Healthcare Research and Quality, Rockville, MD. September 2013; Available at: www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp. Accessed September 25, 2013.

15 Elixhauser A, Steiner C, Harris DR, *et al*. Comorbidity measures for use with administrative data. *Med Care.* 1998;**36** (suppl 1):8-27.

16 Austin PC, Stanbrook MB, Anderson GM, *et al*. Comparative ability of comorbidity classification methods for administrative data to predict outcomes in patients with chronic obstructive pulmonary disease. *Ann Epidemiol.* 2012;**22** (suppl 12):881-887.

17 Wildman MJ, Sanderson CFB, Groves J, *et al*. Survival and quality of life for patients with COPD or asthma admitted to intensive care in a UK multicentre cohort: the COPD and Asthma Outcome Study (CAOS). *Thorax.* 2009;**64** (suppl 2):128-132.

18 Anon JM, Garcia de Lorenzo A, Zarazaga A, *et al*. Mechanical ventilation of patients on long-term oxygen therapy with acute exacerbations of chronic obstructive pulmonary disease: prognosis and cost-utility analysis. *Intensive Care Med.* 1999;**25** (suppl 5):452-457.

19 Garcia-Aymerich J, Farrero E, Felez MA, *et al*. Risk factors of readmission to hospital for a COPD exacerbation: a prospective study. *Thorax.* 2003;**58** (suppl 2):100-105.

20 Bahadori K, FitzGerald JM, Levy RD, *et al*. Risk factors and outcomes associated with chronic obstructive pulmonary disease exacerbations requiring hospitalization. *Can Respir J.* 2009;**16** (suppl 4):e43-9.

21 Seneff MG, Wagner DP, Wagner RP, *et al*. Hospital and 1-year survival of patients admitted to intensive care units with acute exacerbation of chronic obstructive pulmonary disease. *JAMA.* 1995;**274** (suppl 23):1852-1857.

22 From the *Global Strategy for the Diagnosis, Management and Prevention of COPD*, Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2011. Available from: http://www.goldcopd.org/.

23 Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. *N Engl J Med.* 2009;**360** (suppl 14):1418-1428.

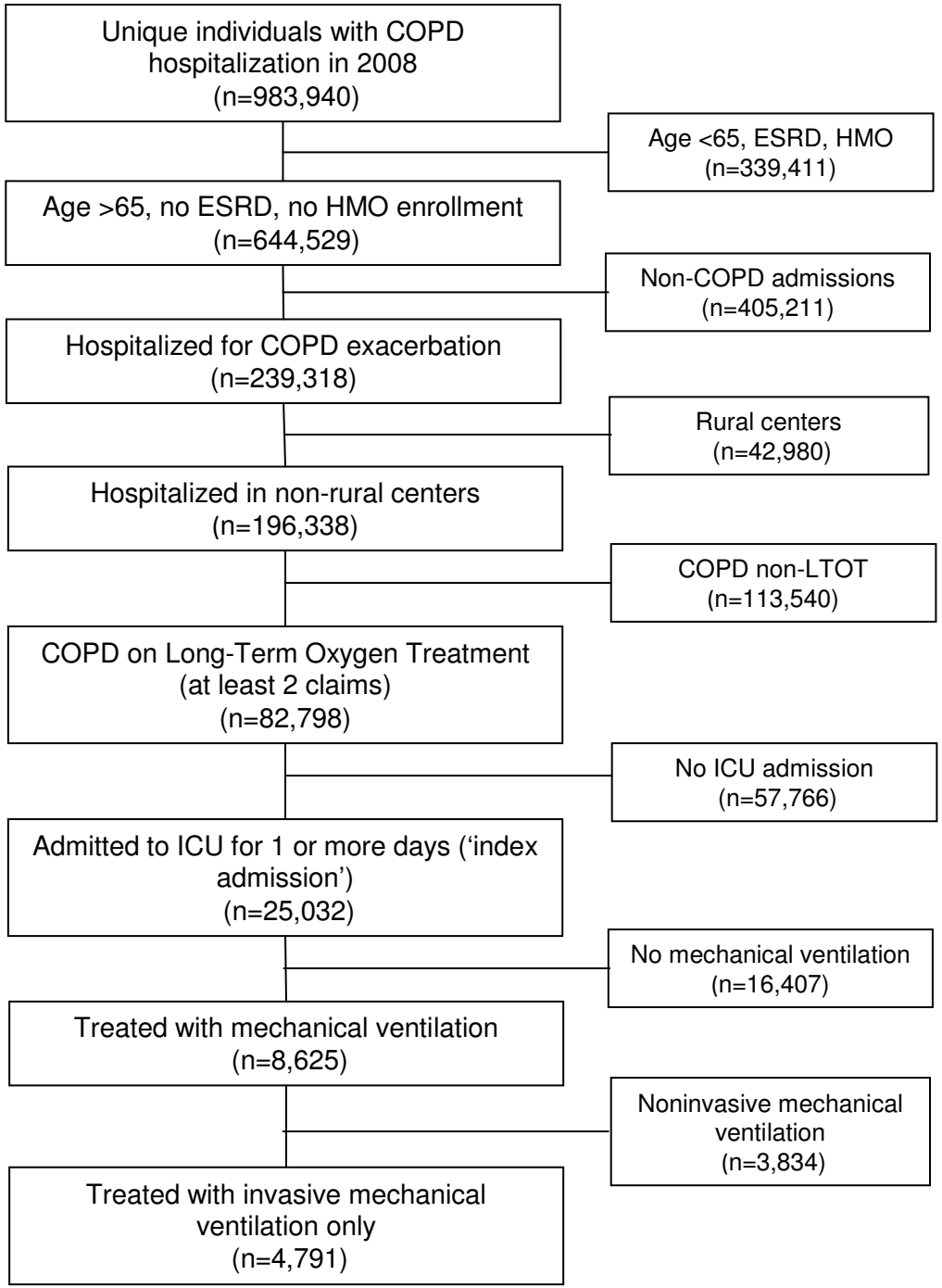
24 Rabe KF, Hurd S, Anzueto A, *et al*. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary. *Am J Respir Crit Care Med.* 2007;**176** (suppl 6):532-555.

25 Global Initiative for Chronic Obstructive,Lung Disease. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease. (Updated 2009).

26 Hurst JR, Wedzicha JA. What is (and what is not) a COPD exacerbation: thoughts from the new GOLD guidelines. *Thorax.* 2007;**62** (suppl 3):198-199.

Figure legend

Figure S1. Consort diagram showing the definition of the study sample.


Unique individuals with COPD hospitalization in 2008 (n=983,940)
Age <65, ESRD, HMO (n=339,411)
Age >65, no ESRD, no HMO enrollment (n=644,529)
Non-COPD admissions (n=405,211)
Hospitalized for COPD exacerbation (n=239,318)
Rural centers (n=42,980)
Hospitalized in non-rural centers (n=196,338)
COPD non-LTOT (n=113,540)
COPD on Long-Term Oxygen Treatment (at least 2 claims) (n=82,798)
No ICU admission (n=57,766)
Admitted to ICU for 1 or more days ('index admission') (n=25,032)
No mechanical ventilation (n=16,407)
Treated with mechanical ventilation (n=8,625)
Noninvasive mechanical ventilation (n=3,834)
Treated with invasive mechanical ventilation only (n=4,791)