## Title

Reassessment of Home Oxygen Prescription after Hospitalization for Chronic Obstructive Pulmonary Disease. A Potential Target for Deimplementation.



## Journal

Annals of the American Thoracic Society, 18(3)

## ISSN

2329-6933

## Authors

Spece, Laura J
Epler, Eric M
Duan, Kevin
et al.

## Publication Date

2021-03-01

## DOI

10.1513/annalsats.202004-364oc

Peer reviewed

# Reassessment of Home Oxygen Prescription after Hospitalization for Chronic Obstructive Pulmonary Disease

## A Potential Target for Deimplementation

Laura J. Spece[1,2], Eric M. Epler[1], Kevin Duan[1,2], Lucas M. Donovan[1,2], Matthew F. Griffith[3], Stephanie LaBedz[4], Neeta Thakur[5], Renda Soylemez Wiener[6,7], Jerry A. Krishnan[4], David H. Au[1,2*], and Laura C. Feemster[1,2*]

[1]Health Services Research and Development, Veterans Affairs Puget Sound Health Care System, Seattle, Washington; [2]Division of Pulmonary, Critical Care, and Sleep Medicine, University of Washington, Seattle, Washington; [3]Health Services Research & Development, Veterans Affairs Eastern Colorado Health System, Aurora, Colorado; [4]The Breathe Chicago Center, Division of Pulmonary, Critical Care, Sleep, and Allergy, University of Illinois at Chicago, Chicago, Illinois; [5]Department of Medicine, University of California, San Francisco, California; [6]Center for Healthcare Organization and Implementation Research, Veterans Affairs Boston Healthcare System, Boston, Massachusetts; and [7]The Pulmonary Center, Boston University School of Medicine, Boston, Massachusetts

ORCID IDs: 0000-0002-1269-5298 (L.J.S.); 0000-0001-8187-2641 (L.M.D.); 0000-0001-7679-2807 (M.F.G.); 0000-0001-7712-2135 (R.S.W.); 0000-0001-5525-4778 (J.A.K.).

## Abstract

**Rationale:** Hypoxemia associated with acute exacerbations of chronic obstructive pulmonary disease (COPD) often resolves with time. Current guidelines recommend that patients recently discharged with supplemental home oxygen after hospitalization should not have renewal of the prescription without assessment for hypoxemia. Understanding patterns of home oxygen reassessment is an opportunity to improve quality and value in home oxygen prescribing and may provide future targets for deimplementation.

**Objectives:** We sought to measure the frequency of home oxygen reassessment within 90 days of hospitalization for COPD and determine the potential population eligible for deimplementation.

**Methods:** We performed a cohort study of patients ⩾40 years hospitalized for COPD at five Veterans Affairs facilities who were prescribed home oxygen at discharge. Our primary outcome was the frequency of reassessment within 90 days by oxygen saturation ($Sp_{O_2}$) measurement. Secondary outcomes included the proportion of patients potentially eligible for discontinuation ($Sp_{O_2} > 88\%$) and patients in whom oxygen was discontinued. Our primary exposures were treatment with long-acting bronchodilators, prior history of COPD exacerbation, smoking status, and pulmonary hypertension. We used a mixed-effects Poisson model to measure the association between patient-level variables and our outcome, clustered by site. We also performed a positive deviant analysis using chart review to uncover system processes associated with high-quality oxygen prescribing.

**Results:** A total of 287 of 659 (43.6%; range 24.8–78.5% by site) patients had complete reassessment within 90 days. None of our patient-level exposures were associated with oxygen reassessment. Nearly half of those with complete reassessment were eligible for discontinuation on the basis of Medicare guidelines (43.2%; $n = 124/287$). When using the newest evidence available by the Long-Term Oxygen Treatment Trial, most of the cohort did not have resting hypoxemia (84.3%; 393/466) and would be eligible for discontinuation. The highest-performing Veterans Affairs facility had four care processes to support oxygen reassessment and discontinuation, versus zero to one at all other sites.

**Conclusions:** Fewer than half of patients prescribed home oxygen after a COPD exacerbation are reassessed within 90 days. New system processes supporting timely reassessment and discontinuation of unnecessary home oxygen therapy could improve the quality and value of care.

**Keywords:** COPD; oxygen; care quality

(Received in original form April 22, 2020; accepted in final form October 19, 2020)

*D.H.A. is Deputy Editor and L.C.F. is Associate Editor of *AnnalsATS*. Their participation complies with American Thoracic Society requirements for recusal from review and decisions for authored works.

Supported by the U.S. National Institutes of Health/National Heart, Lung, and Blood Institute grants T32HL007287-38 and 5K12HL137940. Study staff also supported by VA Puget Sound Health Services Research & Development. The views expressed here are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs. None of the funding sources was involved in the design, conduct, or analysis of this project.

*Author Contributions*: Study design and collection of data: L.J.S., E.M.E., L.M.D., M.F.G., D.H.A., and L.C.F. Analysis of data: L.J.S., E.M.E., L.M.D., and L.C.F. Interpretation of data: L.J.S., K.D., L.M.D., M.F.G., S.L., N.T., R.S.W., J.A.K., D.H.A., and L.C.F. Preparation of manuscript: L.J.S., E.M.E., K.D., L.M.D., M.F.G., S.L., N.T., R.S.W., J.A.K., D.H.A., and L.C.F.

Correspondence and requests for reprints should be addressed to Laura J. Spece, M.D., M.S., Division of Pulmonary, Critical Care, and Sleep Medicine, Health Services Research & Development, VA Puget Sound, University of Washington, 1660 South Columbian Way, 4D-125 S100, Seattle, WA 98108.
E-mail: spece@uw.edu.

Ann Am Thorac Soc Vol 18, No 3, pp 426–432, Mar 2021

DOI: 10.1513/AnnalsATS.202004-364OC
Internet address: www.atsjournals.org

Two randomized trials published in the 1980s demonstrated a survival benefit from supplemental home oxygen among patients with chronic obstructive pulmonary disease (COPD) and severe resting hypoxemia (1–3).Over the past three decades, prescription of home oxygen therapy has expanded to populations beyond those included in the original trials without evidence of efficacy (4, 5). This included patients with stable COPD and moderate and/or exercise-induced hypoxemia who were shown in the recent Long-Term Oxygen Treatment Trial (LOTT) to derive no benefit from home oxygen use (6). Home oxygen can pose harms to patients, including risk of burns, fire (7), and falls due to entanglement in tubing and equipment (8). These harms are in addition to lifestyle effects, including stigma associated with oxygen use (9). Home oxygen therapy is also expensive to the healthcare system and results in an estimated annual cost of 2-billion dollars in the United States (10, 11). Deimplementation of oxygen among patients who do not benefit from its use represents an opportunity to improve the safety and value of healthcare delivery.

Most home oxygen prescriptions for patients with COPD are initiated after hospitalization for COPD (12). The American Board of Internal Medicine and Consumer Reports "Choosing Wisely Campaign" has recommended that "for patients recently discharged on supplemental home oxygen following hospitalization, do not renew the prescription without assessing the patient for ongoing hypoxemia" because many patients improve with time (13–15). In this context, we examined reassessment of home oxygen prescriptions after hospitalization for COPD to identify potential opportunities to deimplement home oxygen when appropriate.

## Methods

### Design, Setting, Participants, and Data Sources

We performed a retrospective cohort study of Veterans admitted to hospital for COPD from 2006 to 2011 in five hospitals that make up the Veterans Integrated Service Network-20 of the Veterans Affairs (VA) in the Pacific Northwest. We included patients ⩾40 years of age with admission text and/or a primary discharge diagnosis by *International Classification of Diseases, Ninth Revision* (ICD-9), codes consistent with COPD and an oxygen prescription at discharge (16–18). We excluded patients who died during the index hospitalization or within 90 days of discharge. We also excluded those discharged to hospice because they may be prescribed oxygen therapy as palliation. In addition, we also excluded those discharged to a skilled nursing facility because this can limit the ability for timely follow-up with primary care and other providers and because oxygen is often provided to patients at these facilities even in the absence of an outpatient prescription. We defined the index date as the hospital discharge date.

We collected information from the Veterans Integrated Service Network-20 data warehouse that contains diagnoses for inpatient encounters, health factors, laboratory values, vital signs (oxygen saturation [$Sp_{O_2}$]), and prescription information. For all patients, we performed focused abstraction of the electronic medical record to confirm $Sp_{O_2}$ (ambient air vs. with supplemental oxygen), oxygen prescription, and discontinuation of oxygen. This study was approved by the VA Institutional Review Board (#00461).

### Patient Characteristics

We assessed patient characteristics hypothesized *a priori* to be exposure variables associated with reassessment, including treatment with long-acting bronchodilators (LABDs) before admission, history of COPD exacerbation, smoking status, and pulmonary hypertension. We selected the prescription of inhaled LABDs before admission as an exposure variable to reflect treatment intensity. We also included a history of COPD exacerbations in the prior year (19). We selected pulmonary hypertension because patients with evidence of cor pulmonale were included in the original Nocturnal Oxygen Treatment Trial (1). We also identified patient characteristics that were likely to confound the association between our exposures and outcome, including age, congestive heart failure (CHF), and obstructive sleep apnea (OSA).

We identified exacerbations as the prescription of systemic steroids and/or antibiotics with a COPD diagnosis in the outpatient setting (20). We categorized patients as smokers using validated methods from health factors data, which was collected annually at minimum (21, 22). We identified pulmonary hypertension using ICD-9 codes associated with encounters during the prior year defined by the Elixhauser comorbidity index (23). We also used the Elixhauser comorbidity index to define the confounders of CHF and OSA.

### Outcomes

We defined the primary outcome as reassessment of oxyhemoglobin saturation within 90 days of discharge. Our intent was to identify patients who were reassessed for eligibility to have oxygen discontinued using Medicare criteria. We required all patients to have $Sp_{O_2}$ measured at rest without oxygen supplementation. For patients with resting hypoxemia ($Sp_{O_2}$ ⩽88%), no further testing was required. For patients with $Sp_{O_2}$ >88% at rest, we required assessment with ambulation to demonstrate a continued need for oxygen therapy. We hereafter refer to this as "complete reassessment."

As secondary outcomes, we measured the following within 90 days of discharge: *1*) eligibility for home oxygen discontinuation by contemporary Medicare and VA requirements ($Sp_{O_2}$ > 88% at rest and with ambulation), *2*) eligibility by LOTT for discontinuation ($Sp_{O_2}$ > 88% at rest) (6), and *3*) the number of patients who had home oxygen discontinued. We assessed the proportion of patients with our outcomes at each facility to estimate a range of system-level variability.

### Statistical Analysis

We used a mixed-effects Poisson model to measure the association between patient-level variables and our outcome, clustered by facility. We estimated prevalence ratios for associations, adjusted for age, CHF, and OSA. In a *post hoc* analysis, we identified care processes using chart review at the highest-performing facility for reassessment (positive deviant) and explored whether these care processes were present at the remaining four facilities. We used Stata 16 (StataCorp) software for all analyses.

## Results

We identified 827 patients who were prescribed home oxygen at hospital discharge after a COPD exacerbation. Thirteen percent ($n$ = 109) died within 90 days of discharge and were excluded. We excluded an additional 20 patients who were prescribed

home oxygen for hospice use and 39 patients who were discharged to a skilled nursing facility. Of the 659 patients remaining in the cohort, 96.1% ($n = 633$) were male, 81.3% ($n = 536$) were white, and over half (54.2%; $n = 357$) were active smokers (Table 1).

### Oxygen Reassessment

Of the 659 patients included in the study cohort, 287/659 (43.6%) had complete reassessment. Of the 287, 59 (20.6%) patients had resting hypoxemia and did not require testing with ambulation. Only 13 (4.5%) had resting hypoxemia and were also tested with ambulation. Most patients (215/287; 74.9%) did not have resting hypoxemia and underwent testing with ambulation. Most of the study cohort was reassessed at rest within 90 days of discharge (466/659; 70.7%).

### Hypoxemia and Potential for Discontinuation

Among those with complete reassessment, 43.2% ($n = 124/287$) did not demonstrate hypoxemia and were therefore eligible for discontinuation by contemporary Medicare guidelines (Figure 1). Of note, among those with an assessment with ambulation, no patients demonstrated an $Sp_{O_2} \leqslant 80\%$ when tested with ambulation (an exclusion for LOTT). Among those eligible for discontinuation, most patients (86.3%; $n = 107/124$) had oxygen discontinued. Five patients elected to discontinue oxygen therapy despite demonstrated hypoxemia.

If using LOTT criteria, reassessment needs to occur only at rest. Of the 466 patients who were reassessed at rest, few patients demonstrated resting hypoxemia (73/466; 15.7%). Therefore, the population eligible for discontinuation by LOTT doubled in size (393/466; 84.3%).

### Patient Factors Associated with Oxygen Reassessment

Patient-level exposures of smoking status, treatment with LABDs, and a prior history of a COPD exacerbation were not associated with complete reassessment in our model. Pulmonary hypertension trended toward an inverse relationship with reassessment, but the estimate was imprecise (Table 2).

### Variation of Oxygen Reassessment by Facility

The proportion of patients with complete reassessment ranged from 24.8% to 78.5% across the five facilities (Table 3). Among those patients who were reassessed, the proportion who would be potentially eligible for discontinuation using Medicare guidelines ranged from 31.5% to 54.6%. Discontinuation of oxygen ranged from 35.3% to 100% of those patients eligible for discontinuation across the sites. The highest-performing site for home oxygen reassessment (78.5%) was also a site with a high proportion of appropriately discontinued home oxygen prescriptions after reassessment (100%). This site was identified as a positive deviant for our *post hoc* analysis.

### Supportive Processes at the High-Performing Site

We identified four processes of care at the highest performing site that appeared to support home oxygen reassessment at the system-level. These included *1*) an automated alert to schedule an $Sp_{O_2}$ measurement within 90 days of the initial home oxygen prescription, *2*) a dedicated home oxygen clinic, *3*) a dedicated home oxygen coordinator who documented in the patient record, *4*) a respiratory therapist (RT)-generated home oxygen discontinuation order when appropriate that was forwarded to a prescribing provider for signature. Two of the remaining facilities had one of these processes in place, and the other facilities did not have any (Table 4).

**Table 1.** Characteristics of the cohort prescribed home oxygen at hospital discharge

| | Cohort ($n = 659$) |
|---|---|
| Demographics | |
| Age at index admission, yr, mean (SD) | 68.0 (10.5) |
| Sex, M, *n* (%) | 633 (96.1) |
| White race, *n* (%) | 536 (81.3) |
| Body mass index, *n* (%) | |
| Obese | 236 (35.8) |
| Smoking status, *n* (%) | |
| Current | 357 (54.2) |
| COPD severity, *n* (%) | |
| LABD | 204 (31.0) |
| ICS | 250 (37.9) |
| Systemic steroids in year prior | 262 (39.8) |
| Comorbidities, *n* (%) | |
| Congestive heart failure | 150 (22.8) |
| Obstructive sleep apnea | 43 (6.5) |
| Pulmonary hypertension | 41 (6.2) |

*Definition of abbreviations*: COPD = chronic obstructive pulmonary disease; ICS = inhaled corticosteroid; LABD = long-acting bronchodilator; SD = standard deviation.

## Discussion

We found that many patients discharged after a COPD exacerbation with home oxygen did not have complete reassessment within 90 days. Nearly half were eligible for discontinuation when complete reassessment did occur. When applying the newest evidence provided by LOTT, the population eligible for discontinuation doubled. If new system processes could be implemented to support reassessment and apply current evidence, a large population of patients with COPD would be eligible for deadoption of this high-cost therapy.

This is the first multicenter cohort study of home oxygen reassessment after hospitalization for COPD in the United States that included $Sp_{O_2}$ results to evaluate for potential overuse and develop plans for deimplementation programs. When compared with prior single-site studies, we found that a similar proportion of patients were reassessed for home oxygen (24–26) and had home oxygen discontinued (27).

There are several potential reasons why home oxygen was not reassessed in our cohort. Most patients in our cohort had an appointment with a primary care provider within 90 days, and therefore, patient access does not explain this care gap. One potential

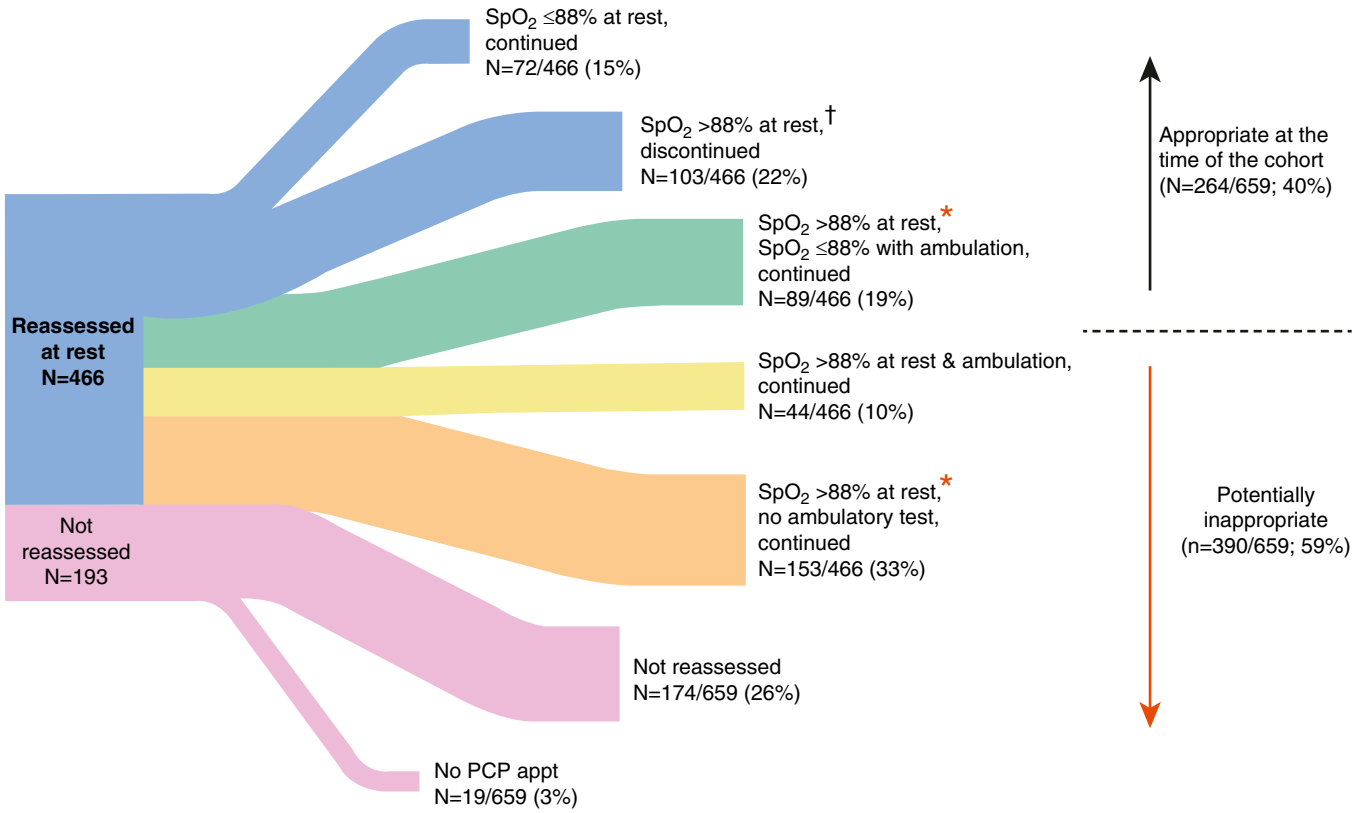


**Figure 1.** Flow diagram of cohort depicting oxygen discontinuation within 90 days of discharge. Values are given as *n* (%) with denominators. The flow tracts in blue depict the proportion of the cohort who had oxygen continued or discontinued in alignment with recommended practice. The flow tract in green represents the proportion of the cohort with oxygen continued for ambulatory hypoxemia, which is no longer recommended practice after the Long-Term Oxygen Treatment Trial (LOTT), and these patients would now be eligible for discontinuation. The flow tract in yellow represents a group that was inappropriately continued at the time of the cohort and is eligible for discontinuation. The flow tract in orange was incompletely reassessed based on recommendations at the time of the cohort but would be eligible for discontinuation based on LOTT. The flow tracts in red demonstrate the proportion of the cohort who did not have reassessment at rest or with ambulation. Five patients requested to discontinue home oxygen despite demonstrated hypoxemia and were not included in the flow diagram. *Eligible populations for oxygen discontinuation based on the new evidence provided by LOTT. †This flow tract includes 80 patients who underwent testing with ambulation and 23 without testing with ambulation. appt = appointment; PCP = primary care provider; $Sp_{O_2}$ = peripheral oxygen saturation.

barrier to reassessment is that oxygen therapy is dogmatically believed to be beneficial, not harmful, and therefore, reassessment is felt to be unnecessary by both providers and patients (28). Furthermore, the lack of evidence of efficacy does not translate into reimbursement constraints. At the health system level, limited time and effort to review and discontinue therapies during a clinic visit has been cited as a barrier to deprescribing in the primary care setting (29). In addition, finding time and staff to assess for hypoxemia with ambulation could be prohibitive in a busy clinic setting. Some sites within the Veterans Health Administration require home oxygen prescriptions to be managed by pulmonary specialists and this may be another barrier to high-quality home oxygen use.

Our patient-level exposures were not associated with reassessment for home oxygen. Pulmonary hypertension trended toward an inverse association, which may be due to difficulties identifying pulmonary hypertension using administrative codes and because pulmonary hypertension is often mild when secondary to COPD. Overall, our finding that patient-level exposures

**Table 2.** Multivariable model for home oxygen reassessment in 90 days

| Variable | PR (95% CI) |
|---|---|
| Smoking | 1.01 (0.82–1.92) |
| Prior COPD exacerbation | 0.76 (0.56–1.23) |
| LABD | 0.95 (0.66–1.48) |
| Pulmonary hypertension | 0.37 (0.20–1.00) |

*Definition of abbreviations*: CI = confidence interval; COPD = chronic obstructive pulmonary disease; LABD = long-acting bronchodilator; PR = prevalence ratio.
Mixed effects Poisson model adjusted for age, congestive heart failure, and obstructive sleep apnea and clustered by site.

**Table 3.** Reassessment, eligibility for, and discontinuation of home oxygen by site

| Facility | Patients | Complete Reassessment | Eligible to Discontinue | Discontinuation |
|---|---|---|---|---|
| A | 183 (27.8) | 54 (29.5) | 17 (31.5) | 6 (35.3) |
| B | 181 (27.5) | 142 (78.5) | 63 (44.4) | 64 (100)* |
| C | 107 (16.2) | 34 (31.8) | 14 (41.2) | 18 (100)* |
| D | 121 (18.4) | 30 (24.8) | 18 (54.6) | 9 (50.0) |
| E | 67 (10.1) | 27 (40.3) | 12 (44.4) | 11 (91.7) |
| Total | 659 | 287 (43.6) | 124 (43.2) | 107 (86.3) |

All values are listed as *n* (%). The percentage for each column is given using a denominator of the column to the right.
*Five patients declined home oxygen therapy despite demonstrating hypoxemia.

are not associated with oxygen reassessment may be because the barriers to reassessment occur at the clinician or health system level.

There was a wide range of reassessment and discontinuation practices for home oxygen across the five facilities in our study. We identified four care processes at a high-performing facility that likely facilitated timely home oxygen reassessment and appropriate use. In particular, the RT-generated order to discontinue home oxygen when appropriate is an example of task-shifting that could improve care quality and increase efficiency (30, 31). Much of the current evidence for task-shifting has focused on the shift from doctor to nurse; however, protocols that rely on RTs have been successful in weaning patients from mechanical ventilation (32) and delivering treatment protocols for bronchodilators (33). A small pilot study found that the implementation of an RT-managed oxygen clinic significantly decreased inappropriate home oxygen use (34). A crude extrapolation of cost savings for the 130 patients in the pilot was estimated to be >500,000 U.S. dollars. It is possible that incorporating RTs and/or the other processes identified in our study could improve the quality and value of home oxygen services and should be confirmed in future studies with formal cost analyses.

Extrapolation of clinical trial data beyond the studied population, such as home oxygen therapy for moderate hypoxemia in COPD, leads to potential overuse of therapies and services. As medical studies progress, therapies and services that were previously thought to be beneficial will commonly evolve; those found to be ineffective should be targets for reversal or deadoption (35, 36). While deimplementing therapies and medications is uncomfortable in our healthcare system, unintended consequences may result if we allow overuse to persist. In 2016, the Centers for Medicare and Medicaid Services Durable Medical Equipment Competitive Bidding Program significantly reduced payment rates for home oxygen concentrators and supplies by 50–80% relative to 2015 payments in an effort to contain Medicare programmatic spending (37). This made it more difficult for vulnerable patients with COPD and severe resting hypoxemia—who actually benefit from home oxygen—to receive this service (38). New policies hope to rectify this problem, but guidance from providers, patients, and other stakeholders is needed to shape the Centers for Medicare and Medicaid Services indications and reimbursement requirements for home oxygen services in the post-LOTT era.

Our study has limitations. First, this study used administrative data from oxygen prescriptions at the time of hospital discharge; therefore, we do not know whether patients received home oxygen therapy before hospitalization. It is also possible that outpatient providers were not aware that home oxygen was prescribed at the time of discharge. Patients may have home oxygen prescribed through Medicare or an alternative payor from a hospitalization outside of the VA, although this is less likely given the significant cost savings to veterans from the use of VA home oxygen services. We did not have detailed oxygen prescription data or adherence data to discern oxygen flow rates. We also do not know how many patients were prescribed home oxygen for nocturnal use, which may limit the ability to fully discontinue oxygen if no longer required while awake. Pulmonary function data were not available, and patients with COPD were identified by

**Table 4.** Health system processes for oxygen prescribing at each facility

| Facility | Majority of Patients Reassessed | Automated Alert for Scheduling | Home Oxygen Clinic | Home Oxygen Coordinator | RT-generated Order for Discontinuation |
|---|---|---|---|---|---|
| A | − | − | + | − | − |
| B | + | + | + | + | + |
| C | − | − | − | − | − |
| D | − | − | − | − | − |
| E | − | − | − | − | + |

*Definition of abbreviations*: − = system process absent; + = system process present; RT = respiratory therapist.
Facility B is a positive deviant identified during the study. Four processes were identified at this facility that may facilitate appropriate and timely oxygen prescriptions.

ICD codes, but the goal of this pragmatic study was to understand healthcare delivery. Pulmonary hypertension was also identified using ICD codes, which may not capture all patients with cor pulmonale and may inadvertently include patients with pulmonary arterial hypertension (39). This study was conducted within the VA, which predominantly serves men of lower socioeconomic means. This may limit the generalizability of findings, although we do not expect that this should impact patterns of care delivery. Finally, this study was also performed before the Choosing Wisely campaign and LOTT, and there may be changes in practice since that time, although our findings are largely unchanged from studies that are 20 years old, suggesting this is unlikely.

This study had several important strengths. The VA is an ideal system in which to study clinical patterns of home oxygen prescription because the prescription can be tracked using the electronic health record. Also, we had a complete assessment of all hospital admissions for a COPD exacerbation across a large geographic region, enhancing generalizability and making idiosyncratic practices less likely to impact our findings. We also conducted chart review to enhance administrative data.

## Conclusions

Most patients prescribed home oxygen are not reassessed within 90 days after hospital discharge after a COPD exacerbation. When reassessed, >80% are potentially eligible for discontinuing home oxygen based on new evidence. Review of a high-performing site sheds light onto systems-level processes that may facilitate deadoption of this low-value therapy, which could result in considerable cost savings to health systems and reduced harm to patients. ■

## References


1 The Nocturnal Oxygen Therapy Trial Group. Continuous or nocturnal oxygen therapy in hypoxemic chronic obstructive lung disease: a clinical trial. *Ann Intern Med* 1980;93:391–398.
2 Medical Research Council Working Party. Long term domiciliary oxygen therapy in chronic hypoxic cor pulmonale complicating chronic bronchitis and emphysema: report of the Medical Research Council Working Party. *Lancet* 1981;1:681–686.
3 Lacasse Y, Tan AM, Maltais F, Krishnan JA. Home oxygen in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2018;197: 1254–1264.
4 Drummond MB, Blackford AL, Benditt JO, Make BJ, Sciurba FC, McCormack MC, *et al*.; NETT Investigators. Continuous oxygen use in nonhypoxemic emphysema patients identifies a high-risk subset of patients: retrospective analysis of the National Emphysema Treatment Trial. *Chest* 2008;134:497–506.
5 Nishi SP, Zhang W, Kuo YF, Sharma G. Oxygen therapy use in older adults with chronic obstructive pulmonary disease. *PLoS One* 2015; 10:e0120684.
6 Albert RK, Au DH, Blackford AL, Casaburi R, Cooper JA Jr, Criner GJ, *et al*.; Long-Term Oxygen Treatment Trial Research Group. A randomized trial of long-term oxygen for COPD with moderate desaturation. *N Engl J Med* 2016;375:1617–1627.
7 Ahrens M. Fires and burns involving home medical oxygen. Quincy, MA: National Fire Protection Association, Fire Analysis and Research Division; 2008.
8 Murabit A, Tredget EE. Review of burn injuries secondary to home oxygen. *J Burn Care Res* 2012;33:212–217.
9 Breaden K, Collier A, Litster C, Allcroft P, Currow DC, Phillips JL. Stigma and the in(visible) perspectives and expectations of home oxygen therapy among people with chronic breathlessness syndrome: a qualitative study. *Palliat Med* 2019;33:82–90.
10 O'Donohue WJ Jr, Plummer AL. Magnitude of usage and cost of home oxygen therapy in the United States. *Chest* 1995;107:301–302.
11 Ward MM, Javitz HS, Smith WM, Bakst A. Direct medical cost of chronic obstructive pulmonary disease in the U.S.A. *Respir Med* 2000;94: 1123–1129.
12 Eaton TE, Grey C, Garrett JE. An evaluation of short-term oxygen therapy: the prescription of oxygen to patients with chronic lung disease hypoxic at discharge from hospital. *Respir Med* 2001;95: 582–587.
13 Cassel CK, Guest JA. Choosing wisely: helping physicians and patients make smart decisions about their care. *JAMA* 2012;307:1801–1802.
14 Wiener RS, Ouellette DR, Diamond E, Fan VS, Maurer JR, Mularski RA, *et al*. An official American Thoracic Society/American College of Chest Physicians policy statement: the Choosing Wisely top five list in adult pulmonary medicine. *Chest* 2014;145:1383–1391.
15 Levi-Valensi P, Weitzenblum E, Pedinielli JL, Racineux JL, Duwoos H. Three-month follow-up of arterial blood gas determinations in candidates for long-term oxygen therapy: a multicentric study. *Am Rev Respir Dis* 1986;133:547–551.
16 Cooke CR, Joo MJ, Anderson SM, Lee TA, Udris EM, Johnson E, *et al*. The validity of using ICD-9 codes and pharmacy records to identify patients with chronic obstructive pulmonary disease. *BMC Health Serv Res* 2011;11:37.
17 Ginde AA, Tsai CL, Blanc PG, Camargo CA Jr. Positive predictive value of ICD-9-CM codes to detect acute exacerbation of COPD in the emergency department. *Jt Comm J Qual Patient Saf* 2008;34: 678–680.
18 Gershon AS, Wang C, Guan J, Vasilevska-Ristovska J, Cicutto L, To T. Identifying individuals with physcian diagnosed COPD in health administrative databases. *COPD* 2009;6:388–394.
19 Global Initiative for Chronic Obstructive Lung Disease (GOLD). Global strategy for the diagnosis, management and prevention of COPD. 2018 [accessed 2018 May 20]. Available from: www.goldcopd.org.
20 Joo MJ, Lee TA, Weiss KB. Geographic variation in chronic obstructive pulmonary disease exacerbation rates. *J Gen Intern Med* 2007;22: 1560–1565.
21 McGinnis KA, Brandt CA, Skanderson M, Justice AC, Shahrir S, Butt AA, *et al*. Validating smoking data from the Veteran's Affairs Health Factors dataset, an electronic data source. *Nicotine Tob Res* 2011;13: 1233–1239.
22 Melzer AC, Feemster LC, Collins MP, Au DH. Predictors of pharmacotherapy for tobacco use among veterans admitted for COPD: the role of disparities and tobacco control processes. *J Gen Intern Med* 2016;31:623–629.
23 Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care* 1998;36:8–27.
24 Oba Y, Salzman GA, Willsie SK. Reevaluation of continuous oxygen therapy after initial prescription in patients with chronic obstructive pulmonary disease. *Respir Care* 2000;45:401–406.
25 Guyatt GH, Nonoyama M, Lacchetti C, Goeree R, McKim D, Heels-Ansdell D, *et al*. A randomized trial of strategies for assessing eligibility for long-term domiciliary oxygen therapy. *Am J Respir Crit Care Med* 2005;172:573–580.
26 Macnee W. Prescription of oxygen: still problems after all these years. *Am J Respir Crit Care Med* 2005;172:517–518.
27 Savani R, Patil M, Tariq A, Mador MJ. A retrospective observational study of domiciliary oxygen usage in a subset of veterans. *Respir Care* 2020:65:1694–1701.
28 Anderson K, Stowasser D, Freeman C, Scott I. Prescriber barriers and enablers to minimising potentially inappropriate medications in adults: a systematic review and thematic synthesis. *BMJ Open* 2014;4: e006544.

29 Fried TR, Tinetti ME, Iannone L. Primary care clinicians' experiences with treatment decision making for older persons with multiple conditions. *Arch Intern Med* 2011;171:75–80.
30 Niezen MG, Mathijssen JJ. Reframing professional boundaries in healthcare: a systematic review of facilitators and barriers to task reallocation from the domain of medicine to the nursing domain. *Health Policy* 2014;117:151–169.
31 World Health Organization, U.S. President's Emergency Plan for AIDS Relief, Joint United Nations Programme on HIV and AIDS. Task shifting: rational redistribution of tasks among health workforce teams: global recommendations and guidelines. Geneva: World Health Organization; 2007 [accessed 2019 Sep 9]. Available from: https://apps.who.int/iris/bitstream/handle/10665/43821/9789241596312_eng.pdf?sequence=1&isAllowed=y.
32 Ely EW, Bennett PA, Bowton DL, Murphy SM, Florance AM, Haponik EF. Large scale implementation of a respiratory therapist-driven protocol for ventilator weaning. *Am J Respir Crit Care Med* 1999;159:439–446.
33 Kollef MH, Shapiro SD, Clinkscale D, Cracchiolo L, Clayton D, Wilner R, *et al*. The effect of respiratory therapist-initiated treatment protocols on patient outcomes and resource utilization. *Chest* 2000;117:467–475.
34 Chaney JC, Jones K, Grathwohl K, Olivier KN. Implementation of an oxygen therapy clinic to manage users of long-term oxygen therapy. *Chest* 2002;122:1661–1667.
35 Elshaug AG. Over 150 potentially low-value health care practices: an Australian study. Reply. *Med J Aust* 2013;198:597–598.
36 Niven DJ, Mrklas KJ, Holodinsky JK, Straus SE, Hemmelgarn BR, Jeffs LP, *et al*. Towards understanding the de-adoption of low-value clinical practices: a scoping review. *BMC Med* 2015;13:255.
37 Centers for Medicare & Medicaid Services. Revised DME 16-C Fee Schedule, 50/50 blend DMEPOS adjustment. Baltimore, MD: Centers for Medicare & Medicaid Services; 2016 [accessed 2018 Jan 5]. Available from: www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/DMEPOSFeeSched/DMEPOS-Fee-Schedule-Items/DME16-C.html.
38 Jacobs SS, Lindell KO, Collins EG, Garvey CM, Hernandez C, McLaughlin S, *et al*. Patient perceptions of the adequacy of supplemental oxygen therapy: results of the American Thoracic Society Nursing Assembly Oxygen Working Group Survey. *Ann Am Thorac Soc* 2018;15:24–32.
39 Link J, Glazer C, Torres F, Chin K. International Classification of Diseases coding changes lead to profound declines in reported idiopathic pulmonary arterial hypertension mortality and hospitalizations: implications for database studies. *Chest* 2011;139:497–504.