Home Oxygen Therapy for Patients With COPD: Time for a Reboot

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Just over 100 years ago, John Scott Haldane published a seminal report about the therapeutic potential of supplemental oxygen to treat hypoxemia. In the 1980s, a pair of clinical trials confirmed the benefit of long-term oxygen therapy in improving survival in patients with COPD associated with severe resting hypoxemia. This review provides a summary of evidence supporting long-term and short-term oxygen therapy, as well as the various types of oxygen equipment commonly used in homes to deliver supplemental oxygen. Because the majority of orders for home oxygen occur at hospital discharge following acute illness, a typical conversation between a patient and their pulmonologist following a COPD exacerbation is presented. The SHERLOCK Consortium, a multi-stakeholder group established following the publication of the COPD National Action Plan in 2017 is also detailed. Interim results of the SHERLOCK Consortium, which suggest a chain of care involving 9 steps to ensure that patients are successfully initiated on home oxygen therapy during transitions from hospital to home, are presented. Recommendations to support evidence-based policies in this high-risk population are provided. [Respir Care 2019;64(12):1574–1585. © 2019 Daedalus Enterprises]

Introduction

Home oxygen therapy has been a standard of care for COPD over the last 40 years. The process of qualifying a patient for home oxygen, determining the right prescrip-

tion, providing the right equipment, and educating caregivers, however, remains a challenge. The chain of care required to deliver appropriate and effective home oxygen therapy is complex and obfuscated by federal regulations. This challenge also is an opportunity: We believe home

oxygen therapy needs a complete re-evaluation focusing on patient needs and patient education to maximize oxygen therapy benefits.

Evidence Supporting the Use of Long-Term Oxygen Therapy

Very few individuals have contributed as much to pulmonary medicine as John Scott Haldane, considered by many to be the “father” of oxygen therapy (1860–1936; Fig. 1).^{1,2} Haldane investigated the composition of air, identified gases that led to suffocation in coal mines, researched the physiologic effects of low barometric pressure, discovered the role of carbon dioxide in the control of breathing, explored the beneficial effects of staged decompression that make it possible for deep-sea divers to return to the surface safely, and developed the precursor of modern-day blood-gas analysis.^{3–11} Just over 100 years ago, Haldane published a seminal report about the therapeutic potential of supplemental oxygen.⁷ Sixty years after this publication, a pair of randomized clinical trials in a total 290 people confirmed the survival benefits of long-term oxygen therapy (LTOT) in subjects with COPD and severe resting hypoxemia.^{12,13}

Home Oxygen Therapy for Severe Resting Room Air Hypoxemia

The Medical Research Council (MRC) multi-center clinical trial randomized 87 people with COPD to LTOT via nasal cannula for at least 15 h/d with a target P_{aO_2} of 60 mm Hg or higher versus no home oxygen.¹² To be eligible, subjects needed to be < 70 years old, have chronic bronchitis or emphysema with “irreversible airway obstruction” (defined as $FEV_1 < 1.2$ L), and resting room air

P_{aO_2} of 40–60 mm Hg. Subjects with evidence of cor pulmonale were hospitalized and needed to demonstrate stable arterial blood gas, FEV_1 , and weight over a period of at least 3 weeks to be eligible.

Once enrolled, all study subjects were urged to stop smoking and had close follow-ups that included an outpatient clinic visit every 2 months. Subjects in the home oxygen group received oxygen through various types of equipment, including a stationary oxygen concentrator, reservoir of liquid oxygen, or compressed gas tanks. Participants in the home oxygen group also received periodic home visits (frequency not specified) to assess oxygen usage and collect arterial blood gases; this information was used to promote appropriate use of home oxygen among the subjects in the intervention group. At 5 years, 19 of 42 subjects (42%) in the home oxygen therapy group had died, compared to 30 of 45 patients (66%) in the usual care (no home oxygen) group. The 5-year relative risk of death was 0.41 (95% CI 0.17–0.98) favoring the home oxygen group compared to the no home oxygen group. When interpreting these results, it is important to remember that home visits to carefully titrate the oxygen prescription and equipment to individual needs likely contributed to the survival benefits observed in the intervention group.

The multi-center Nocturnal Oxygen Therapy Trial (NOTT) sought to determine whether LTOT prescribed 24 h/d offered benefits beyond that observed when LTOT is prescribed for nighttime use only.¹³ In the NOTT study, 203 subjects with COPD were randomized to continuous LTOT (ie, 24 h/d) or nocturnal LTOT. To be eligible, individuals needed to be at least 35 years old, have COPD confirmed with post-bronchodilator $FEV_1/FVC < 0.70$, and have severe resting room air hypoxemia ($P_{aO_2} \leq 55$ mm Hg or P_{aO_2} 56–59 mm Hg with evidence of erythrocytosis or cor pulmonale). The study protocol required confirmation of severe hypoxemia twice, assessed at least 1 week apart over a 3-week COPD exacerbation-free period. Patients were excluded if they had clinically important comorbid conditions expected to affect morbidity or mortality or if there were concerns about nonadherence to therapy.

In the NOTT study, LTOT was delivered by nasal cannula at 1–4 L/min with a target P_{aO_2} of 60–80 mm Hg for all subjects. The oxygen prescription in the continuous LTOT group was increased by 1 L/min during exercise and sleep. As with the MRC study, the oxygen equipment for study participants included stationary oxygen concen-

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Fig. 1. John Scott Haldane was born May 3, 1860, in Edinburgh, Scotland, and is considered to be the father of oxygen therapy.

trators, liquid oxygen systems, and compressed oxygen tanks. Importantly, the stationary concentrators and oxygen reservoirs were outfitted with timers that recorded the duration of gas flow. This information was used to estimate adherence to LTOT, although this method underestimated total oxygen use if patients also used portable equipment for liquid oxygen or small tanks of compressed gas.

Subjects in both groups in the NOTT study appeared to have even more intensive support than those in the LTOT group in the MRC study. All NOTT subjects were assessed during home visits by a nurse practitioner once per week and were asked to attend out-patient clinic appointments once per month for 6 months; then, NOTT participants received home visits once per month and were asked to attend clinic visits every 3 months for the duration of the study.

Data from oxygen timers on stationary equipment suggested that oxygen was used for about 18 h/d in the continuous LTOT group and for about 12 h/d in the nocturnal LTOT group. The NOTT subjects were followed for a mean of 19.3 months. At 12 and 24 months, mortality in the continuous LTOT group was lower than in the nocturnal LTOT group (11.9% vs 20.6% and 22.4% vs 40.8%, respectively). Overall mortality significantly favored the continuous LTOT group compared to the nocturnal LTOT group (relative risk 0.52, 95% CI 0.31–0.85). Whether these benefits would be observed in the absence of intensive home and out-patient clinic supports is unknown. For

example, it is possible that, without such support, subjects in both groups would not know how to use the LTOT equipment properly, which would lead to no observed difference in outcomes between groups. Such support is often not available to patients prescribed LTOT today.

Home Oxygen Therapy for Moderate Resting Room Air Hypoxemia

The survival benefits of LTOT do not appear to accrue to individuals with COPD who have less than severe resting hypoxemia. In the Long-term Oxygen Therapy Trial (LOTT), 738 subjects with COPD and moderate resting hypoxemia (S_{pO_2} 89–93%), exercise-induced hypoxemia during a 6-min walk test ($S_{pO_2} < 90\%$ for at least 10 s and S_{pO_2} at least 80% for at least 5 min), or both were randomized to LTOT or no oxygen.¹⁴ LTOT was prescribed 24 h/d using stationary and portable oxygen equipment in subjects who had moderate resting hypoxemia, but with exercise and during sleep in subjects who only had exercise-induced hypoxemia. In the former group, LTOT was prescribed at 2 L/min via nasal cannula. In the latter group, the oxygen prescription was individualized (2 L/min or higher to maintain S_{pO_2} at least 90% while walking for at least 2 min) and reassessed annually. As with the MRC and NOTT studies, the assignment of oxygen was not masked to subjects or study staff.

Among all 738 subjects, there were no discernable differences in time to death or first hospitalization (primary

outcome; hazard ratio 0.94, 95% CI 0.79–1.12, $P = .52$) over 6 years in both study groups. Similar findings were noted for the primary outcome in the 133 subjects who had moderate resting hypoxemia only (prescribed LTOT vs no oxygen: hazard ratio 0.96, 95% CI 0.63–1.47) and in the 286 subjects with both moderate resting hypoxemia and exertional desaturation (hazard ratio 0.95, 95% CI 0.72–1.27). In addition, the study did not find consistent benefits with home oxygen therapy in any of the numerous secondary outcomes among all subjects (eg, components of the primary outcome, quality of life, lung function, distance walked in 6 min). Taken together, these 3 studies (NOTT, MRC, and LOTT) provide strong evidence that home oxygen prescribed for at least 15 h/d saves lives for patients with COPD and severe, but not for patients with moderate resting hypoxemia.¹⁵

Ambulatory Oxygen Therapy for Exertional Desaturation

Ambulatory oxygen therapy refers to oxygen delivered during exercise or other activities of daily living. The LOTT study adds to the existing literature about the benefits of ambulatory oxygen therapy. Prior to LOTT, there were 4 randomized clinical trials of ambulatory oxygen therapy in total of 237 subjects (26–143 participants subjects per study) with COPD and exertional dyspnea or desaturation without evidence of severe resting hypoxemia.^{16–19} All 4 studies compared portable oxygen or identical appearing compressed air over a 2–12-week period; subjects and study staff were masked to treatment assignment. A meta-analysis of these studies suggests the potential to improve dyspnea and fatigue with exertion.²⁰ The LOTT study results indicated no significant difference among the those prescribed LTOT versus no oxygen for the primary outcome (death or first hospitalization) in the 286 subjects who had exertional desaturation with moderate resting hypoxemia (results presented above) and in the 319 subjects with exertional desaturation without moderate hypoxemia (hazard ratio 0.95, 95% CI 0.73–1.24).¹⁴ These 5 randomized clinical trials involving a total of nearly 850 people with COPD suggest the need for a more nuanced approach to treating exertional desaturation in the absence of severe resting hypoxemia. Such individuals may benefit from a discussion with their health care provider to understand their preferences and values for the treatment of dyspnea and fatigue (ie, shared decision making),²¹ rather than routinely prescribing ambulatory oxygen therapy in this population.

Short-Term Oxygen Therapy

Short-term oxygen therapy refers to initiating oxygen during a period of severe hypoxemia that is likely to be

temporary (eg, during a COPD exacerbation). Studies in subjects who are prescribed home oxygen during a respiratory exacerbation (most of whom have COPD or are hospitalized for a COPD exacerbation) suggest that 30–50% of such individuals no longer have severe resting hypoxemia within 3 months.^{22,23} Guidelines therefore recommend re-assessing home oxygen requirements after hospital discharge to modify the oxygen prescription (eg, reductions or increases in oxygen flow, prescribing portable equipment) or to discontinue it altogether in patients who no longer have a clinical indication.^{15,24} Dedicated oxygen clinics that re-assess a patient's need for continuing home oxygen after hospital discharge and provide patient education can help implement these guideline recommendations.²² However, dedicated home oxygen clinics are not routine in most health systems; findings from a multicenter qualitative study suggest that patients who are prescribed home oxygen are not routinely re-assessed for their home oxygen need, which may lead some to use home oxygen even when they do not need it.²⁵

Description of Home Oxygen Equipment

Several types of equipment deliver oxygen for home use: stationary equipment to be used at home (eg, stationary concentrator), portable equipment to be used outside the home (eg, portable oxygen concentrators, compressed oxygen tank, liquid oxygen system), and accessories for use with portable and stationary equipment (eg, home trans-fill unit, oxygen-conserving device) (Fig. 2). Most patients need a combination of stationary and portable oxygen equipment. In some cases, patients use an oxygen-conserving device on their compressed oxygen tanks; such devices provide oxygen only during inspiration to extend the time that each tank can be used.

Compressed oxygen tanks are time-limited sources of oxygen; the duration of use varies across different compressed oxygen tanks according to the size of the tank (in order of size: M4, M6, D, E), filling pressure, oxygen flow, and whether an individual is using continuous flow oxygen or an oxygen conserving device. According to information provided to patients by a home health provider, a D-cylinder filled to 2,000 pounds per square inch and used at 2, 3, and 4 L/min continuous flow will last approximately 2, 1.25, and 1 h, respectively; corresponding durations of use for a E-cylinder are approximately 4.5, 3, and 2 h, respectively.²⁶ Information published by a durable medical equipment (DME) provider suggests slightly different information (ie, a D-cylinder at 4 L/min continuous flow will last 1.7 h, whereas an E-cylinder used at 4 L/min continuous flow will last 2.8 h).²⁷ A reliable resource developed and maintained by an independent group without commercial interests in the home oxygen equipment is needed.

HOME OXYGEN THERAPY FOR PATIENTS WITH COPD

Type of equipment	Description
Oxygen concentrator <i>Stationary</i>	<ul style="list-style-type: none"> - Device that concentrates oxygen from ambient air - Designed to be used in the home - Requires constant power supply
Oxygen concentrator <i>Portable</i>	<ul style="list-style-type: none"> - Device that concentrates oxygen from ambient air - Lightweight; designed to be used outside the home - Internal battery allows several hours of use between charges
Home transfill <i>Accessory</i>	<ul style="list-style-type: none"> - Device to fill compressed oxygen tanks from oxygen delivered by stationary oxygen concentrator - Attached to stationary oxygen concentrator - Designed to be used in the home
Compressed oxygen tank <i>Portable</i>	<ul style="list-style-type: none"> - Compressed gas cylinder - Designed to be used outside of the home - Usually filled by a patient or caregiver using a home transfill system or by a DME company who delivers it to the home - Duration depends on prescribed flow
Oxygen conserving device <i>Accessory</i>	<ul style="list-style-type: none"> - Accessory that sits atop compressed oxygen tanks - Controls the flow of oxygen such that it releases only when the patient inhales - Designed to extend the duration of compressed oxygen tanks used outside of the home - Not all patients can maintain appropriate oxygen saturation using an oxygen conserving device
Liquid oxygen system <i>Portable</i>	<ul style="list-style-type: none"> - Liquid oxygen in the tank vaporizes to provide a steady flow of oxygen - Lightweight tank has prolonged duration of delivery - Filled by patient or caregiver from a home reservoir installed by DME company - Capable of delivering oxygen flow (>6 L/min)

Fig. 2. There are different types of home oxygen equipment that patients can use: stationary equipment to be used at home, portable equipment to be used outside the home, and accessories for use with portable and stationary equipment. DME = durable medical equipment.

Portable oxygen concentrators can provide continuous flow oxygen (oxygen delivered at a constant flow, not triggered by an inspiratory effort), pulse-dose oxygen (oxygen delivered during inspiration only; the

quantity of oxygen delivered is influenced by the breathing frequency), or both. Options for oxygen delivery using portable oxygen concentrators can vary by manufacturer.²⁸

Table 1. An Outpatient Visit With Mr. Carter* After Starting Home Oxygen

Pulmonologist:	Hello Mr. Carter. Thank you for coming to see us today for your follow-up appointment. I understand you had trouble breathing and were hospitalized for your COPD for about 5 days, and now you have been home for about 10 days. How are you doing today?
Mr. Carter:	I am having difficulty catching my breath.
Pulmonologist:	(after reviewing vital signs) I am sorry to hear that. Let's see how we can help. You don't have a fever, but the nurse's note says your oxygen level is 84%, which is lower than what we have seen in past clinic visits. Are you coughing or bringing up phlegm?
Mr. Carter:	I was coughing up phlegm when I was admitted to the hospital, but all that got better after taking the prednisone and antibiotics. Not much cough or phlegm now, just trouble catching my breath when I don't wear my oxygen.
Pulmonologist:	I don't see that you brought an oxygen tank or a portable oxygen concentrator with you today. Were you asked to use oxygen after leaving the hospital?
Mr. Carter:	They asked me to wear oxygen 24/7 after going home and to check with you if I still needed it. It was a big machine that they set up near my bed, which I am supposed to use at 2. They also dropped off a bunch of tanks. Don't see how I can use the tanks when I get out of the house because they are too heavy to carry around and they don't last more than an hour or so. Not enough time for me to get from home to your office and back to home. I also didn't know how to change tanks when the first one I was given ran out about a week ago.
Pulmonologist:	I see in the hospital discharge summary that you were prescribed home oxygen at 2 L/min. I don't see how much oxygen was prescribed when walking or during sleep or the type of oxygen equipment you were provided. Do you know how low your oxygen level was when they decided to prescribe home oxygen before you left the hospital?
Mr. Carter:	Isn't the information in the computer? I don't remember if they told me about my oxygen level. I also don't remember if I should use more oxygen when I am walking than when I am sitting, but it sure helps me breathe better when I increased the oxygen level to 6. But then the tank got empty quick.

This is a typical conversation between a patient and his pulmonologist following hospitalization for a COPD exacerbation.

* Name changed to protect the patient's privacy.

In a study of 507 subjects with COPD prescribed LTOT, subjects reported > 25 different combinations of home oxygen equipment. The 3 most common combinations were a stationary concentrator and compressed oxygen tanks with an oxygen-conserving device (24%), a stationary concentrator and compressed oxygen tanks without an oxygen-conserving device (17%), and a stationary concentrator and a portable concentrator (11%).²⁹ These findings suggest that a substantial proportion of people are using compressed oxygen tanks rather than portable oxygen concentrators as their source of oxygen when outside the home. The inconvenience of compressed oxygen tanks (heavy to lift and to transport, especially for elderly patients or those with limited respiratory reserve; need for multiple tanks if the period of time outside the home is greater than a few hours) explains in part why patients only use 45–70% of the oxygen prescribed.^{30–33} Other factors that contribute to variable levels of adherence to oxygen therapy include inadequate understanding of the risks and benefits of oxygen therapy, limited self-efficacy in the use of home oxygen equipment, and stigma associated with using supplemental oxygen in public. These findings suggest the need for patient support, including education, and for equipment that is light-weight, unobtrusive, and easy to use.

Table 1 describes a typical conversation between a patient and his physician following a hospital admission for a COPD exacerbation. The pulmonologist, a physician who is seeing Mr Carter at a Veterans Administration Medical

Center (VAMC), requested a 6-min walk test by a respiratory therapist in the pulmonary function laboratory adjacent to the out-patient clinic. The test confirmed that the severe resting room air hypoxemia was corrected with oxygen delivered continuously at 2 L/min, but that Mr Carter needed 3 L/min to maintain a S_{pO_2} of 90% when walking. Mr Carter was prescribed home oxygen continuously at 2 L/min at rest, 3 L/min with activity, and (empirically) 3 L/min during sleep. Mr Carter does not qualify for a portable oxygen concentrator because at the VAMC this type of device is reserved for veterans who travel out-of-town, and Mr Carter could not afford to purchase a light-weight portable oxygen concentrator, which can cost between \$1,500 and \$3,000. Mr Carter was therefore prescribed a stationary oxygen concentrator when at home and oxygen cylinders (E-cylinders) for use when he leaves home, to be set at 2 L/min continuous flow at rest and 3 L/min continuous flow with exertion. He received education about the benefits and risks of home oxygen therapy and the appropriate use of his oxygen equipment, including how to safely change the regulator when his oxygen cylinder runs out and to avoid being close to an open flame or someone smoking a cigarette. Mr Carter agreed to join the VAMC's telemedicine program, which offers a pulse oximeter at no cost to check the adequacy of oxygen supplementation and to guide subsequent decisions to change the oxygen prescription. The clinic staff provided Mr Carter with a filled E-cylinder for his return trip to home. He was informed that this E-cylinder would last about 4 h at 2 L/min

(and 3 h at 3 L/min, which was sufficient for his 2-h trip to home) and was asked to return to the clinic in 4 weeks to re-assess his home oxygen needs. He was instructed to wear his oxygen 24 h/d for now, but that follow-up visits would be needed to learn whether his oxygen equipment helped him with activities of daily living and to evaluate his need for short-term oxygen therapy versus LTOT. As Mr Carter left clinic, his pulmonologist worried that the oxygen cylinders were likely too inconvenient for Mr Carter to use as prescribed when he leaves home.

The situation with Mr Carter is not uncommon. When a patient is discharged to home following a hospitalization for a COPD exacerbation, they are sometimes prescribed short-term oxygen therapy, especially if oxygen therapy allows the patient to be safely discharged from the hospital sooner. However, the details regarding the evaluation or prescription in the hospital are often poorly documented, missing altogether, or simply unavailable to the patient, their caregivers, and their out-patient clinician.³⁴ Also, patients initiated on home oxygen in the hospital often receive inadequate education about their options for home oxygen equipment and how to use the equipment, or they do not have appropriate, affordable access to the equipment that is right for them.²⁵ In the case of Mr Carter, a light-weight portable concentrator for ambulation may have been the best device.^{35,36} Patients, their caregivers, and their out-patient clinicians are therefore frustrated with the care that is currently accessible.

A group of front-line, hospital-based, and out-patient physicians, respiratory therapists, nurses, patients, their caregivers, DME providers, and representatives of the American Association for Respiratory Care (AARC) and the American Thoracic Society (ATS) have begun to examine gaps in home oxygen care following hospital discharge in patients with COPD. The group, known as the SHERLOCK Consortium, includes about 170 stakeholders, including 47 patients and their caregivers, 83 hospital-based and out-patient clinicians (40 physicians, 17 respiratory therapists, 11 nurses, 15 social workers and other clinicians), 4 hospital discharge planners, 4 DME providers, 16 researchers, and 17 other individuals with expertise in COPD or home oxygen policies. The SHERLOCK Consortium was established following the publication of the COPD National Action Plan in 2017,³⁷ the first-ever framework for action in the United States to reduce the public health impact of COPD in the United States.

In the sections that follow, we describe the interim findings of the SHERLOCK Consortium that highlight opportunities to develop an evidence base to support better care and health for patients with COPD who are prescribed home oxygen during hospital-to-home transitions. Some aspects of this report were presented during the sixth Thomas L Petty Memorial Lecture on “Everyone Needs

Oxygen” at the 2018 AARC International Respiratory Congress (December 4–7, 2018, Las Vegas).³⁸

Stakeholder Perspectives About Home Oxygen Therapy During Hospital to Home Transitions

We provide below a synthesis of perspectives of three stakeholder groups in the SHERLOCK Consortium: patients and their caregivers, DME providers, and front-line clinicians.

Patients and Caregivers

Mr Carter’s experience after being started on home oxygen therapy is not unique. In February 2017, people with COPD and their families attended a health education workshop about home oxygen in Florida, convened by the Villages Airheads (a patient support group), the COPD Foundation (a non-profit organization that supports education, research, and policies to support the needs of people with COPD),³⁹ clinicians, and researchers from the SHERLOCK Consortium.

Workshop participants expressed a high level of frustration about gaps in care and information about home oxygen therapy. Participants had numerous questions about practical aspects of living with home oxygen, including how long they would need to use oxygen, performance characteristics (eg, size, weight, noise level, battery life, adequacy of oxygen flow) of various types of stationary and portable oxygen concentrators, quality of services provided by different DME providers, out-of-pocket costs of various types of equipment and disposables (eg, nasal cannula, humidifiers), options during air travel, safety of using home oxygen during a shower, how to troubleshoot when their oxygen equipment malfunctions, and assessing the adequacy of their home oxygen prescription with changes in respiratory symptoms.

Clinicians felt that they were mostly unprepared to answer the questions with the level of detail that workshop participants wanted, so we asked participants to submit their questions in writing and, with the help of the AARC and the COPD Foundation, produced a Frequently Asked Questions and Answers document that was made available after the workshop (Table 2).⁴⁰ Participants identified an ongoing need for an independent and trustworthy source of updated information to supplement what they were able to learn from their physician offices, DME providers, and other content that may be available online—similar to what is available through Consumer Reports for other products and services.⁴¹ Participants also supported the development of a national oxygen equipment registry to facilitate public reporting about access, out-of-pocket costs, and perfor-

Table 2. Frequently Asked Questions And Answers About Home Oxygen Therapy

Category	Sample questions
Theme 1: General questions about COPD	<p>"What is respiratory therapy?"</p> <p>"How do I know the questions I should be asking if I'm new to this?"</p>
Theme 2: Ways to use oxygen	<p>"How much oxygen should I use per minute?"</p> <p>"Can I take a shower with oxygen on?"</p>
Theme 3: Symptoms to watch out for	<p>"How can I determine whether I have a COPD exacerbation, the flu, a cold or am I just plain sick?"</p> <p>"If my oxygen saturation goes below 88% for a short time, how much damage am I doing to my body?"</p>
Theme 4: Oxygen safety	<p>"What are the dangers of having oxygen tanks around?"</p> <p>"Can you light candles when you are wearing oxygen?"</p>
Theme 5: Traveling with oxygen	<p>"How can I travel with oxygen by air and sea?"</p> <p>"Can I rent a small machine to travel on a bus for a few days?"</p>
Theme 6: Companion treatments	<p>"Do all people use an inhaler and use oxygen, too?"</p> <p>"What are the latest surgical procedures available?"</p>
Theme 7: Equipment issues and maintenance	<p>"Are all the pieces of equipment the same? How can I know which one is best?"</p> <p>"How often should you change oxygen tubing?"</p>
Theme 8: Service issues and advocacy	<p>"How do you know what Medicare will cover, what you're allowed?"</p> <p>"Who do I call if I am not getting proper service?"</p>

mance characteristics of different oxygen equipment by region and by insurance provider.⁴²

DME Providers

The role of respiratory therapists in home oxygen services has been diminished dramatically over the past 3 decades. Until the early 2000s, DME providers were competing to provide more services to support patients on home oxygen, including home visits, during which respiratory therapists would provide self-management education and training to patients and their caregivers.

This support to end-users (patients, their families, and other caregivers) was especially important to those who were newly prescribed home oxygen, a group who needed practical information about their equipment (such as Mr Carter, who did not know how to remove the regulator from a used oxygen cylinder) and options for other types of equipment (eg, portable concentrators, oxygen-conserving devices) that may be better tailored to their current needs.

Reimbursements for home oxygen services have been declining since the 1990s, but they were reduced even more sharply following the implementation of the competitive bidding process by the Centers for Medicare and Medicaid Services in 2009 (initially in selected metropolitan areas, but then nationwide in 2016).^{35,43} Under this competitive bidding process, DME providers have seen a dramatic reduction in reimbursement for home oxygen services (ie, 50% or more). Such reductions in reimbursements have eliminated the ability of nearly all DME providers to routinely include home visits by respiratory therapists when delivering home oxygen. In most cases, a technician without clinical training now delivers home oxygen equipment to patients. By law, these technicians are not permitted to address any clinical questions from patients or their caregivers, including requests to assess the adequacy of home oxygen equipment or the ability of a patient or their caregivers to use the equipment appropriately.

The majority of orders for home oxygen are written as the patient is being discharged to home following an acute

cardiopulmonary illness, rather than in the out-patient setting.^{22,44} DME companies are often selected by hospital case managers or discharge planners based on speed of response, which implies a focus on the transaction, not the transition of care. The goal is to make sure the DME provider's truck gets to the patient's home before the oxygen cylinders provided on discharge from the hospital run out. There is a residual belief by clinicians that the DME provider is still a safety net that can provide all the education that is often not feasible to provide in the hospital. This is no longer true. As a respiratory therapist who previously worked in the DME industry explained, "There is now a giant hole in the safety net."

Front-Line Hospital-Based and Out-Patient Clinicians

Hospital-based clinicians noted varying levels of awareness and ability to provide home oxygen education to patients. Hospital-based physicians report being unable to answer questions about equipment, service, payment, or duration of home oxygen therapy that is initiated in the hospital. Hospital-based nurses are often responsible for reviewing discharge instructions and education materials with patients. However, the discharge process is typically short (5–10 min) and covers the patient's entire care plan. Details about home oxygen therapy are generally limited to what is documented by physicians. Moreover, patients are often overwhelmed with the amount of information provided at hospital discharge and are rarely in a position to ask questions about their home oxygen equipment (which they will often see only once they get home). Hospital-based respiratory therapists are not often involved in patient education or discharge unless requested. Even then, respiratory therapists acknowledged that they were generally not familiar with oxygen equipment supplied by DME providers and delivered to patients' homes.⁴⁵ Most hospital-based clinicians we interviewed believed that their patients were getting sufficient education and support for home oxygen equipment from the DME providers, apparently unaware of how significantly these services have been reduced in recent years.

Out-patient clinicians recognized that their patients were in need of more education and support but noted that they were also poorly equipped to provide it. Out-patient nurses reported that a substantial proportion of patients do not attend their follow-up appointments and may not undergo a re-evaluation regarding their home oxygen requirements. Nurses are also often unfamiliar with oxygen equipment and services that a patient may receive from a DME provider, and therefore they refer patients to their DME provider for any equipment-specific questions. An out-patient advanced practice nurse also expressed her frustration with

the lack of information she could access from the patient's hospitalization:

I only have 20 min with returning patients. It's not a lot of time for the clinical evaluation and patient and caregiver education. I don't think they're doing a walk test in the hospital. I don't know what oxygen company they were set up with. The discharge notes and summary are insufficient, as there is nothing documented related to the home oxygen prescription. There's no communication with the out-patient provider.

Appropriate Home Oxygen Therapy Depends on a Successful Chain of Care During Transition From Hospital to Home

Discussions with the SHERLOCK stakeholders suggest that a chain of care involving 9 steps across the hospital, home, and out-patient settings is necessary to ensure that patients are successfully initiated on home oxygen therapy during transitions from hospital to home (Fig. 3).²⁵ The first 4 steps occur in the hospital, the fifth step occurs at home, and the remaining steps occur in the out-patient setting. Effective hospital-to-home transitions keep patients in a home-to-out-patient loop, while ineffective transitions return patients to a hospital-to-home loop.

A number of stakeholders can be involved in the 9 steps of a hospital-to-home chain of care for home oxygen. In the hospital it could include attending physicians, nurses, respiratory therapists, clinician trainees, discharge planners, and representatives of DME providers. At home, a patient and caregiver might see only a DME technician who delivers the home oxygen equipment; respiratory therapists or other clinicians are rarely involved in the delivery and setup of home oxygen equipment. In the out-patient setting, a primary care provider, pulmonologist, nurses, and clinician trainees might be involved; respiratory therapists are mostly hospital-based due to changes in reimbursement. The number of handoffs between professionals and settings makes it even more critical that each of the 9 steps be supported to deliver optimized home oxygen care.

How to Strengthen the Chain of Home Oxygen Care During Transitions From Hospital to Home

Thomas L. Petty MD (1932–2009), known as the "father" of modern pulmonary medicine, recognized that it was not enough to demonstrate that LTOT can save lives.⁴⁶ He understood the need to develop and sustain an infrastructure to promote collaboration among stakeholders to translate the evidence into practice. He helped convene a series of 6 LTOT consensus conferences between

Fig. 3. Chain of home oxygen care during hospital to home transitions.

1986 and 2005.⁴⁷ Reports from the consensus conferences focused on various topics considered essential to provide appropriate access to life-saving home oxygen therapy, including the need for standards for home oxygen services, adequate reimbursement, medical necessity forms that included appropriate information, patient and clinician education, and identification of gaps in evidence that require further research. Unfortunately,

after Dr Petty's death, the LTOT consensus conferences also ceased to exist.

Perhaps more than ever, we need an infrastructure to promote and sustain collaborative efforts among stakeholders to address the gaps in the chain of home oxygen care. We offer the following 2 recommendations: First, resume the LTOT consensus conference series with a full complement of stakeholders; second, leverage the framework proposed by the U.S. COPD National Action Plan.

Resume the LTOT Consensus Conference Series With a Full Complement of Stakeholders

The chain of home oxygen care involves multiple stakeholders in health care and community settings. Stakeholders include people prescribed home oxygen and the people who care for them; home-based professionals, including DME providers and home health agencies; hospital-based and out-patient clinicians (eg, physicians, nurse practitioners, respiratory therapists, physical therapists); home oxygen product manufacturers; payers (public and private); and policy makers. Building on the work of Dr Petty, convening an annual LTOT consensus conference would provide a mechanism to support stakeholder-supported standards, educational programs, and research to inform policies.

Leverage the Framework Proposed by the U.S. COPD National Action Plan

The COPD Action Plan is intended to reduce the public health burden of COPD by: (1) empowering people with COPD, their families, and other caregivers; (2) promoting the prevention of COPD and management of COPD across the care continuum; (3) supporting the collection of COPD-related public health data that drive change and track progress; (4) increasing and sustaining research to improve the care and health of people with COPD; and (5) translating the policies, educations, and other programs into research and public health care actions.³⁷ This framework of goals could support a range of efforts to promote the appropriate use of LTOT in patients with COPD, including the development of a trustworthy resource about home oxygen equipment and services for patients and caregivers, the improvement of hospital-to-home transitions for patients prescribed home oxygen therapy, the design and implementation of a national oxygen registry to identify opportunities for quality improvement initiatives, and the conduct of stakeholder-supported hybrid effectiveness/implementation studies to fill care gaps.

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