

Cost-Effectiveness of Long-Term Oxygen Therapy for Chronic Obstructive Pulmonary Disease

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Long-term oxygen therapy (LTOT) prolongs life in patients with chronic obstructive pulmonary disease (COPD) and severe hypoxemia (ie, an arterial oxygen tension [PaO_2] of ≤ 55 mm Hg or 56 to 59 mm Hg associated with cor pulmonale or polycythemia).^{1,2} At the same time, nocturnal or ambulatory oxygen therapy is often prescribed in patients with COPD who are not severely hypoxemic (PaO_2 of >60 mm Hg) at rest but who desaturate during sleep or with ambulation, despite a lack of supportive evidence.^{3,4}

Approximately one-third of the direct medical costs are due to the cost of LTOT, and an estimated 80% of this cost is borne by the Centers for Medicare & Medicaid Services.⁵ Each year, approximately 1 million patients receive LTOT through the Centers for Medicare & Medicaid Services, at a cost exceeding \$2 billion per year.⁶ This cost is increasing at an annual rate of 12% to 13%. Because LTOT is a costly therapy, Medicare reimbursement for its prescription is tightly regulated. The Medicare budget has been shifted to pay for the prescription Part D drug benefit, while payments for LTOT were reduced by 30% in the Balanced Budget Act of 1997 and by approximately 10% in the Medicare Prescription Drug, Improvement, and Modernization Act of 2003. Beginning in January 2006, section 5101(b) of the Deficit Reduction Act limited rental of oxygen equipment to 36 months of continuous use (ie, the first time this policy would affect the program is January 2009).⁷ After 36 months, title to the equipment goes to the beneficiary, and Medicare only pays for oxygen content and nonroutine maintenance. Medicare since then has readjusted cuts in its release of the Medicare Improvements for Patients and Providers Act in July 2008. Nevertheless, the revision of the budget still impacts home oxygen services. There has been an ongoing debate about the current Medicare policies for LTOT reimbursement.

The objectives of this study were to examine the cost-effectiveness of LTOT, to compare it with the cost-effectiveness of other commonly used therapies for COPD, to facilitate proper allocation of limited healthcare resources, and to refine the medical indications for LTOT that could lead to substantial cost savings without compromising patient survival or well-being.

Objectives: To assess the cost-effectiveness of long-term oxygen therapy to facilitate proper resource allocation.

Study Design: Markov process.

Methods: A Markov model was developed to estimate the incremental cost-effectiveness ratios (ICERs) for continuous and nocturnal oxygen therapies. The maximum time horizon was set to 5 years. Efficacy variables were obtained from pertinent clinical studies. Cost variables were based on the current Medicare reimbursement rate and on appropriate sources. Multiple 1-way and probabilistic sensitivity analyses were performed to examine the robustness of base-case results.

Results: The ICER for continuous oxygen therapy (\$16,124 per quality-adjusted life-year [QALY]) was within bounds considered to be cost-effective, while that of nocturnal oxygen therapy was not (\$306,356/QALY). The estimated ICER for continuous oxygen therapy was robust (95% confidence interval, \$13,153-\$24,658/QALY) and was more favorable than the ICERs for commonly used medical and surgical therapies for chronic obstructive pulmonary disease. The ICER for nocturnal oxygen therapy was sensitive to variation in the mortality rate; it could be as low as \$18,267/QALY gained. At the other end, nocturnal oxygen therapy could be less effective than no oxygen therapy, despite additional costs.

Conclusions: There is substantial room for improvement in the current Medicare policies regarding long-term oxygen therapy. Medicare coverage can be improved by prescribing long-term oxygen therapy to patients who will receive substantial benefit and by providing adequate support for services and maintenance.

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METHODS

Literature Search and Review Strategy

Bibliographic databases, includ-

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ing the Cochrane Central Register of Controlled Trials, MEDLINE, EMBASE, and CINAHL, were searched to find any systematic review or randomized controlled trial of patients with COPD that examined the effect of LTOT on mortality, hospitalizations, and progression of the disease.

Two studies^{1,2} were identified that included patients with severe resting hypoxemia (SRH), defined as a PaO₂ of 55 mm Hg or lower or in the range of 56 to 59 mm Hg associated with cor pulmonale or polycythemia. Four additional studies^{3,4,8,9} were identified in which study patients had less severe hypoxemia, defined as a PaO₂ in the range of 56 to 65 mm Hg or higher. Two studies^{3,4} identified patients with significant nocturnal desaturation (ND), defined as an arterial oxygen saturation (SaO₂) of less than 90% for at least 30% of total sleep time or an SaO₂ of less than 90% with a nadir value reaching 85% or lower, and examined the efficacy of nocturnal oxygen therapy (NOT). The remaining 2 studies^{8,9} examined the efficacy of continuous (>15-17 h/d) oxygen therapy (COT) in patients with mild to moderate hypoxemia and no ND. The latter 2 studies were not included in this study because most of the studied patients would not qualify for LTOT under the current Medicare criteria. The methodological quality of the included clinical studies¹⁻⁴ was scored as moderate (Jadad score, 3).

Analytic Overview

A cost-utility model (Markov process) was developed to estimate the clinical effects and costs of LTOT in patients with COPD. Two cohorts (the patients with SRH and those with ND) were created and analyzed in this study. The definitions of SRH and ND were derived from the included clinical studies¹⁻⁴ as already described. The ND cohort included patients with significant ND but without SRH. In each cohort, the LTOT strategy was compared with the absence of any oxygen strategy. Oxygen therapy was assumed to be continuous (>16 h/d) in the SRH cohort and nocturnal (9 h/d) in the ND cohort.

The model was constructed using 3 mutually exclusive disease states. The disease states include stage 1 disease (forced expiratory volume in the first second of expiration [FEV₁] of >50% of predicted), stage 2 disease (FEV₁ of 30%-50% of predicted), stage 3 disease (FEV₁ of <30% of predicted), and death.

In the SRH cohort, the hypothetical population was 63 years old, 78% male, and had an FEV₁ of 0.69 L based on the Nocturnal Oxygen Therapy Trial (NOTT)¹ and the Medical Research Council (MRC) study.² It was assumed that 50% of the initial cohort had stage 2 disease and that the remaining 50% had stage 3 disease. In the ND cohort, the hypothetical population was 63 years old and had an FEV₁ of 1.1 L based on data from previous studies.^{3,4} It was assumed that 15% of the initial cohort had stage 1 disease, 70% had stage 2 disease, and the remaining 15% had stage 3 disease.

Quarterly transitional probabilities of death were derived from the included clinical studies¹⁻⁴ by using an exponential approximation described by Beck et al.¹⁰ The mortality rates in the NOTT¹ and the MRC study² were aggregated to estimate quarterly transitional mortality rates in the SRH cohort. Because the available evidence fails to support that NOT prolongs life even in patients with SRH, the mortality rate of a hypothetical control (no oxygen therapy) group in the NOTT¹ was assumed to be the same as that of the NOT group. The 2-year mortality rates reported in the NOTT¹ were converted into 5-year mortality rates by using an exponential approximation and were combined with the 5-year mortality rates reported in the MRC study.² Then, the quarterly transitional mortality rates for the COT and no oxygen strategies in the SRH cohort were calculated based on the combined 5-year mortality rates and were estimated to be 6.0% and 3.1%, respectively. The 95% confidence interval (CI) of the quarterly mortality rate for the COT strategy was calculated based on the 5-year mortality difference between the COT and no oxygen strategies and was estimated to be 2.4% to 4.2%. This range was used for a 1-way sensitivity analysis. The quarterly mortality rates in the ND cohort were derived from pooled data from the 2 NOT studies^{3,4} by using the same method already described. The quarterly transitional mortality rates for the NOT and no oxygen strategies were estimated to be 3.27% and 3.38%, respectively. The 95% CI of the quarterly mortality rate for the NOT strategy was calculated based on the 3-year mortality difference between the NOT and no oxygen strategies and was estimated to be 1.29% to 9.65%.

The model assumed that FEV₁ declined over time. The mean rates of FEV₁ decline in the SRH cohort were based on data from the NOTT¹ and the MRC study.² The mean rate of FEV₁ decline without oxygen therapy was estimated to be 28 mL per patient per year for the first 18 months and 40 mL per patient per year thereafter. The rate of decline with LTOT for COT and NOT was estimated to be 6.5 mL for the first 18 months and 0 mL thereafter. Using this assumption, the estimated probabilities for a person with stage 2 disease progressing into stage 3 disease during a 3-month period for the first 18 months and thereafter were 1.5% and 2.1%, respectively, without oxygen therapy and 0.3% and 0%, respectively, with LTOT. The mean rates of FEV₁ decline in the ND cohort were estimated as follows. The available evidence fails to support that NOT significantly reduces the rate of decline in FEV₁ among patients with ND but without SRH. The mean rate of FEV₁ decline in the ND cohort was estimated to be 30 mL per patient per year in the NOT and the control (no oxygen therapy) strategies based on data from Chaouat et al.⁴ Using this assumption, the probability of progression from stage 1 disease to stage 2 disease during a 3-month period was esti-

Table 1. One-Way Sensitivity Analysis in the Severe Resting Hypoxemia Cohort

Variable	Base-Case Estimate	Range Used in Sensitivity Analysis	Range of ICER, \$/QALY	
			Three-Year Horizon	Five-Year Horizon
Quarterly rate of death with COT	0.0311	0.0238-0.0417	19,313-36,700	13,153-24,658
Utility of stage 2 COPD	0.803	0.790-0.816	23,540-24,080	15,942-16,310
Utility of stage 3 COPD	0.731	0.699-0.762	23,509-24,123	15,924-16,335
Monthly electricity cost, \$	30	15-75	22,244-28,498	15,065-19,301
Discount rate	0.03	0-0.07	23,451-24,281	15,729-16,659

COPD indicates chronic obstructive pulmonary disease; COT, continuous oxygen therapy; ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life-year.

mated to be 0.47% and was 1.6% from stage 2 disease to stage 3 disease in the ND cohort.

The cycle length for the model was set to 3 months, and the maximum time horizon was set to 5 years. This time frame allowed maximal flexibility for patients to move across disease severity categories. The model was limited to 5 years because there were insufficient data on the efficacy of LTOT beyond this time horizon. A discount rate of 3% was applied to costs and health benefits based on international recommendations.¹¹ The effect of changes in the discount rate (0%-7%) was examined in a 1-way sensitivity analysis. A half-cycle correction was applied in each period to allow for the fact that transitions between health states could take place at any time during the modeled 3-month intervals.¹¹

The model generated the mean cost and effectiveness. Strategies were compared using incremental cost-effectiveness ratios (ICERs). Incremental cost-effectiveness is a measure of the additional cost of one strategy versus another compared with the additional effectiveness it delivers. In this calculation, the mean cost and effectiveness are calculated for each strategy. The ICER is calculated by dividing the incremental (additional) mean cost of a more costly strategy by the incremental mean effectiveness of that treatment strategy. TreeAge Pro (TreeAge Software, Inc, Williamstown, MA) was used to perform decision analyses.

Efficacy Data

The health outcome used in this study was health-related quality of life (HRQL). It was assumed that a patient's health status declined with decrements in FEV₁. The mean HRQLs for stable patients with stage 1, 2, and 3 disease were estimated to be 0.832 (95% CI, 0.821-0.843), 0.803 (95% CI, 0.790-0.816), and 0.731 (95% CI, 0.699-0.762) quality-adjusted life-years (QALYs), respectively, based on a study by Rutten-van Mólken et al.¹² The effect of exacerbations or COPD-related hospitalizations on HRQL was not incorporated into the model, as no randomized controlled stud-

ies showed a significant reduction in COPD exacerbation or hospitalization rates with LTOT in patients with SRH or ND,^{1-4,8,9} and the main objective of this study was to estimate the ICERs for LTOT relative to no oxygen therapy.

Cost Data

The cost-effective analysis was conducted from a third-party payer's perspective; hence, only direct costs were included in this analysis. The monthly cost of LTOT was estimated to be \$198.40 based on the 2007 Medicare reimbursement rate for oxygen therapy and stationary oxygen equipment with or without a portable system.¹³ The costs of running an oxygen concentrator were estimated to be \$30 a month for COT¹⁴ and \$11 a month for NOT, assuming that the mean use of a concentrator for NOT was 9 h/d.^{3,4} To conduct sensitivity analyses, these running costs were varied from 50% to 250% of the base values according to a study by Reisfield and Wilson.¹⁵ All costs are reported in 2007 US dollars.

Sensitivity Analyses

Sensitivity analyses were conducted to test the robustness of baseline results to random variation in the values of key parameters in the model. Two types of sensitivity analyses were used, namely, traditional 1-way analysis and probabilistic analysis. The following variables were used in the sensitivity analyses: quarterly rates of death with COT and NOT, utilities of all stages of COPD, monthly electricity cost, and discount rate. The exact sensitivity ranges used for these analyses are given in **Table 1** and **Table 2**. For efficacy variables, these limits were derived from the 95% CIs of each efficacy variable from the pooled clinical data. For cost variables, the limits were derived from the highest and lowest costs. The probabilistic analysis (second-order Monte Carlo simulation) was performed to assess the variation of multiple parameters at the same time by varying all variables simultaneously. Each variable was derived from its probability distribution, yielding a hypothetical distribution of QALYs. Efficacy parameters were assigned beta distributions, and cost parameters were

■ **Table 2.** One-Way Sensitivity Analysis in the Nocturnal Desaturation Cohort

Variable	Base-Case Estimate	Range Used in Sensitivity Analysis	Range of ICER, \$/QALY	
			Three-Year Horizon	Five-Year Horizon
Quarterly rate of death with NOT	0.0327	0.0129-0.0965	28,005-Dominated ^a	18,267-Dominated ^a
Utility of stage 1 COPD	0.832	0.821-0.843	476,966-478,895	305,750-306,964
Utility of stage 2 COPD	0.803	0.790-0.816	473,016-482,945	303,406-309,365
Utility of stage 3 COPD	0.731	0.699-0.762	473,795-482,273	303,149-309,738
Monthly electricity cost, \$	30	15-75	465,106-516,398	298,136-331,015
Discount rate	0.03	0-0.07	470,372-487,985	298,139-317,486

COPD indicates chronic obstructive pulmonary disease; ICER, incremental cost-effectiveness ratio; NOT, nocturnal oxygen therapy; QALY, quality-adjusted life-year.

^aNocturnal oxygen therapy was more costly and less effective than no oxygen therapy.

assigned triangular distributions. The probabilistic analysis was based on 5000 simulations. The result of the probabilistic analysis was illustrated as a scatterplot of incremental effectiveness in QALYs versus incremental costs, with a 95% CI elliptical.

RESULTS

Baseline Findings

Table 3 and Table 4 give the baseline results of the incremental cost-effectiveness analyses. During the 3-year (\$23,807/QALY) and 5-year (\$16,124/QALY) horizons, the ICER for COT in the SRH cohort fell below \$25,000/QALY, a cutoff generally considered very cost-efficient.¹⁶ In contrast, the ICER for NOT in the ND cohort was far more than \$100,000/QALY, a commonly cited cutoff for cost-effectiveness¹⁷ (ie, \$477,929/QALY during a 3-year horizon and \$306,356/QALY during a 5-year horizon).

Sensitivity Analyses

Table 1 and Table 2 give the results of multiple 1-way sensitivity analyses for the ICERs for COT and NOT. Figure 1 and Figure 2 show the results of the probabilistic analyses. In the SRH cohort, the multiple 1-way sensitivity analyses showed

that all ICERs for COT were less than \$25,000/QALY, and the probabilistic analysis (Figure 1) showed that the 95% CI elliptical of COT was below the \$50,000/QALY line, both supporting the robustness of the base-case analysis.

In the ND cohort, the ICER for NOT varied widely when the quarterly rate of death with NOT was varied (Table 2). The NOT strategy could be very cost-effective, with an ICER as low as \$18,267/QALY. At the other end, NOT could be less effective than no oxygen therapy, despite additional costs. The ICER for NOT also varied widely in the probabilistic sensitivity analysis. The estimated ICER was more than \$100,000/QALY in a large portion of the 95% CI elliptical (Figure 2).

Model Validation

A simple validation process was performed by comparing the pooled mortality rates from the clinical studies¹⁻⁴ with those in the Markov models. The 5-year mortality rates from the pooled data were identical to those in the SRH cohort and were 47% for COT and 71% for the control. The 3-year mortality rates in the Markov model were estimated to be 32% for COT and 52% for the control.

The same was true for the ND cohort. The 3-year mortality rates were 47% for COT and 71% for the control. The 3-year

■ **Table 3.** Base-Case Analysis in the Severe Resting Hypoxemia Cohort^a

Strategy	Incremental Cost, \$	QALYs	Incremental QALYs	ICER, \$/QALY
Three-year horizon				
Control	—	1.56	—	—
COT	6567	1.84	0.28	23,807
Five-year horizon				
Control	—	2.07	—	—
COT	9517	2.66	0.59	16,124

COT indicates continuous oxygen therapy; ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life-year.

^aAll values are rounded.

■ **Table 4.** Base-Case Analysis in the Nocturnal Desaturation Cohort^a

Strategy	Incremental Cost, \$	QALYs	Incremental QALYs	ICER, \$/QALY
Three-year horizon				
Control	—	1.87	—	—
NOT	5975	1.88	0.0125	477,929
Five-year horizon				
Control	—	2.68	—	—
NOT	8615	2.70	0.0281	306,356

ICER indicates incremental cost-effectiveness ratio; NOT, nocturnal oxygen therapy; QALY, quality-adjusted life-year.
^aAll values are rounded.

mortality rates in the Markov model were estimated to be 23.3% for NOT and 24.1% for the control. These values were also identical to the aggregated data from the clinical studies.¹⁻⁴ The 5-year mortality rates in the Markov model were estimated to be 48.5% for NOT and 49.8% for the control.

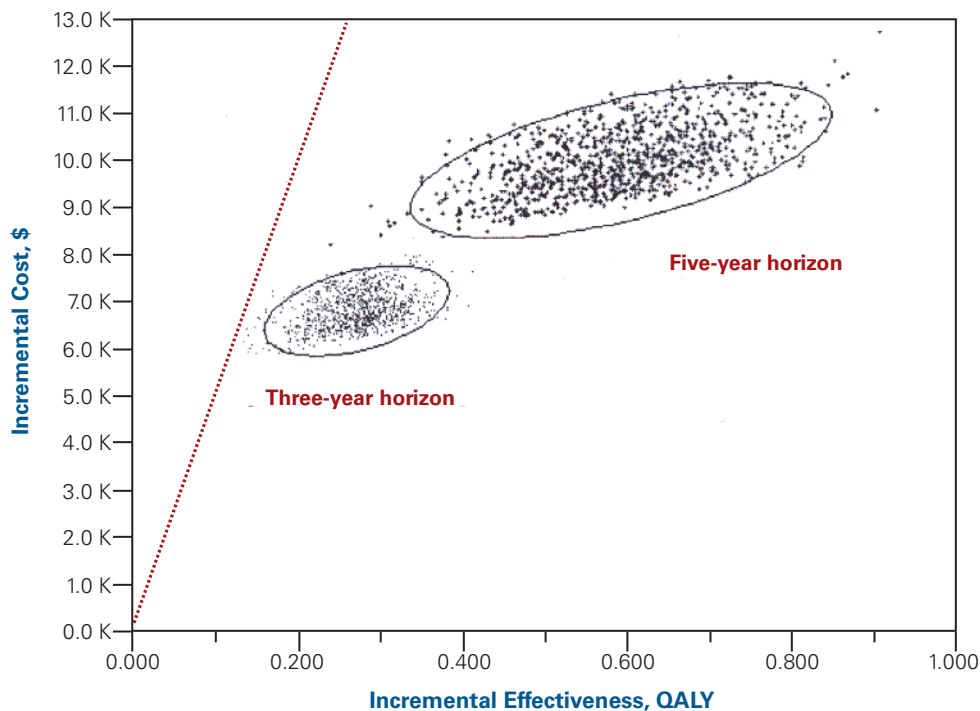
DISCUSSION

Long-term oxygen therapy is one of a few therapies that have been shown to improve long-term survival in patients having COPD with SRH. Although evidence of LTOT cost-

effectiveness has been published,^{18,19} no formal analyses have been conducted, to my knowledge. The present analysis showed that the cost-effectiveness of COT in patients with SRH was far more favorable than that of surgical therapies for COPD that were approved by Medicare and were comparable to or more favorable than commonly used medical therapies for COPD (Table 5). The robustness of the estimates of ICERs was confirmed by the sensitivity analyses for COT.

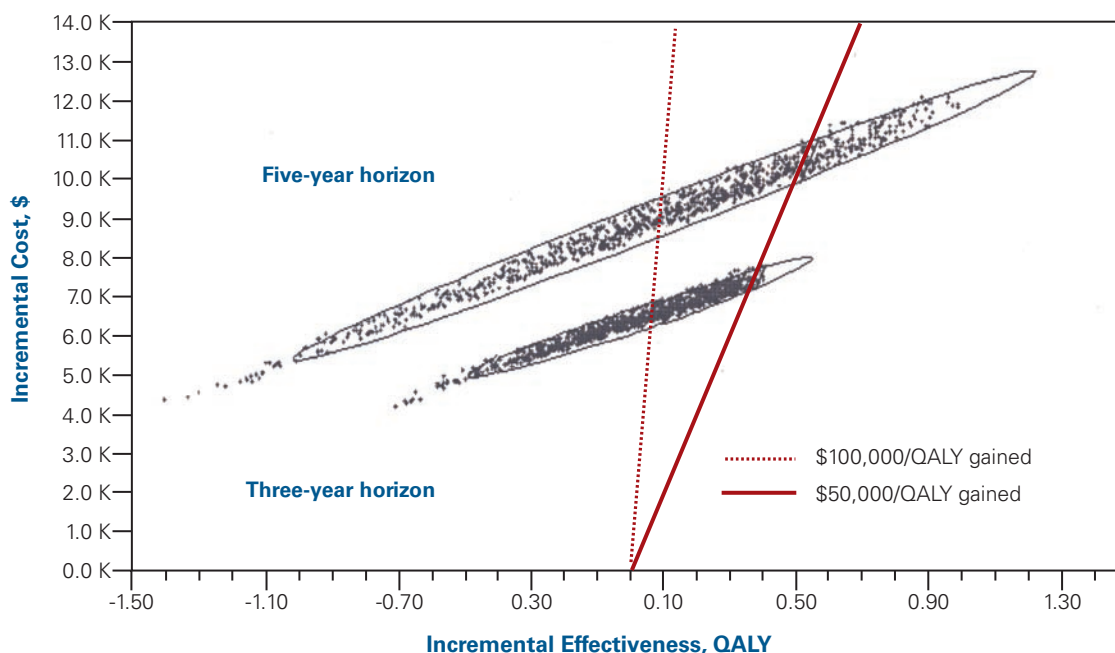
The Deficit Reduction Act provision that limits rental of all home oxygen equipment to 36 months and then transfers ownership to the beneficiary may significantly reduce services

■ **Figure 1.** Results for Incremental Cost-Effectiveness of Continuous Oxygen Therapy (COT) From 5000 Model Simulations Are Represented



The ellipse defines the 95% confidence interval for the true incremental cost-effectiveness of COT compared with no oxygen therapy. The dotted line indicates a cost-effectiveness ratio of \$50,000 per quality-adjusted life-year (QALY).

■ **Figure 2.** Results for Incremental Cost-Effectiveness of Nocturnal Oxygen Therapy (NOT) From 5000 Model Simulations Are Represented



The ellipse defines the 95% confidence interval for the true incremental cost-effectiveness of NOT compared with no oxygen therapy. The dotted and solid lines, respectively, indicate cost-effectiveness ratios of \$100,000 and \$50,000 per quality-adjusted life-year (QALY) gained.

for fragile elderly patients and could raise numerous patient safety issues. A recent industry study by Morrison Informatics, Inc²⁷ showed that 72% of the cost in providing home oxygen therapy to Medicare patients represents services, delivery, and other operational costs and that only 28% of the cost represents equipment. A September 2006 report from the Department of Health and Human Services Office of the Inspector General²⁸ indicated that an estimated 22% of Medicare patients continue using home oxygen therapy beyond 36 continuous months. Continuous oxygen therapy for patients having COPD with SRH is very cost-effective compared with

other technologies and surgical procedures used to extend life or to improve the quality of life. Although Medicare has readjusted cuts in its release of the Medicare Improvements for Patients and Providers Act in July 2008, the changes in Medicare rules may still restrict home oxygen services. The effects of these changes on patient care and health outcomes should be carefully monitored.

The cost-effectiveness of NOT in patients with ND but without SRH was far less favorable than that of COT. The ICER for NOT was much greater than that of other widely used therapies for COPD except for alfa₁-antitrypsin therapy

■ **Table 5.** Cost-Effectiveness Estimates of Other Interventions for Chronic Obstructive Pulmonary Disease (COPD)

Intervention	\$/QALY	\$/QALY Adjusted to 2007 US Dollars ^a	Source
Lung volume reduction surgery vs medical therapy at 5 y	140,000	161,356	Ramsey et al, ²⁰ 2007
Lung volume reduction surgery vs medical therapy at 3 y	190,000	218,983	Ramsey et al, ²¹ 2003
Lung transplant vs standard care ^b	176,817	253,713	Ramsey et al, ²² 1995
Alfa ₁ -antitrypsin therapy vs standard care for life	696,933	815,943	Gildea et al, ²³ 2003
Tiotropium bromide for moderate-to-severe COPD	26,094	27,703	Oba, ²⁴ 2007
Inhaled corticosteroids for stage 2 or 3 COPD	17,000	21,157	Sin et al, ²⁵ 2004
Behavioral rehabilitation program	24,256	48,405	Toevs et al, ²⁶ 1984

QALY indicates quality-adjusted life-year.

^aUsing the Consumer Price Index inflation calculator provided by the US Department of Labor: http://www.bls.gov/data/inflation_calculator.htm.

^bFor patients with end-stage lung disease, 42% of whom had emphysema.

(Table 5). However, the cost-effectiveness of NOT varied greatly in the sensitivity analyses. The 1-way sensitivity analysis revealed that this was due to the wide range of mortality estimates for NOT relative to no oxygen therapy (Table 2). The precision of this estimate may be improved when additional data are available from clinical trials such as the National Institutes of Health–sponsored Long-term Oxygen Treatment Trial.²⁹ Nocturnal oxygen therapy is not as effective as COT to extend life in patients having COPD with SRH,¹ and its efficacy in patients without SRH has been questioned.^{4,8} Because many of the costs of LTOT are fixed, having a better understanding of the effects and indications of NOT, as well as improving patient adherence, would likely lead to improvements in cost-effectiveness. Eliminating inappropriate use of oxygen therapy may also be a source of potential cost saving.

This study has several limitations. First, it was conducted from a third-party payer's perspective. Hence, indirect costs such as costs associated with absence from work and inability to perform usual activities were not included. However, indirect costs are probably irrelevant, as only a small proportion of patients with COPD have a paid job,³⁰ and patients receiving LTOT are likely to have disabilities.

Second, the cost-effectiveness estimates of LTOT in this study could be very conservative because of the assumption that LTOT would not reduce COPD-related hospitalizations. Several observational studies^{19,31-33} reported a significant reduction in hospitalizations with LTOT. Three studies^{19,31,32} compared the hospitalization rates before and after the initiation of LTOT, and the other study³³ compared rates with a historical control. When the estimates of reduction in hospitalizations from a study by Stewart et al¹⁹ were incorporated into the present model, COT was more effective and less costly than no oxygen therapy because of a substantial saving from fewer hospital days with COT (data not shown). However, this should be interpreted with caution, as the randomized controlled trials^{1,2} failed to show a statistically significant reduction in hospitalizations, and the reduction in hospitalizations in the observational studies could have been due to more intensive outpatient care or the regression to the mean phenomenon³⁴ rather than due to the direct effect of LTOT per se.

Third, the present model was limited to a 5-year horizon. The rationale for this limitation is as follows. The clinical efficacies of LTOT have not been studied beyond this time frame, to my knowledge. In addition, the future financial burden of this life-gaining therapy is also unknown. For example, patients receiving COT tend to have fewer hospitalizations

Take-Away Points

Continuous oxygen therapy for chronic obstructive pulmonary disease is highly cost-effective, while nocturnal oxygen therapy may not be cost-effective.

- There is substantial room to improve the cost-effective use of long-term oxygen therapy.
- Medicare coverage can be improved by prescribing long-term oxygen therapy to patients who will receive substantial benefit and by providing adequate support for services and maintenance.

and shorter hospital stays for the first 5 years, but all hospitalization costs of extra survivors must be added if a time horizon is extended beyond 5 years, so that what is gained could be easily lost. Additional data from clinical studies would be necessary to precisely estimate the cost-effectiveness of LTOT beyond this time frame.

Fourth, the estimate of change in HRQL was based on the predicted decline in FEV₁ derived from the clinical studies.^{1,4} The effect of LTOT on HRQL is highly controversial, and there are no definite data from which appropriate estimates can be drawn. Unfortunately, the MRC study² did not report data on HRQL. The NOTT³⁵ reported minor improvement in neuropsychological function. However, no study has clearly demonstrated a benefit in HRQL through LTOT.³⁶ It is possible that significant improvement in some neuropsychological function had little effect on HRQL. However, more clinical data would be necessary to incorporate the effect of LTOT on HRQL into its cost-effectiveness.

Fifth, some of the efficacy data from the clinical studies^{1,4} were derived more than 30 years ago among a modest sample of patients who likely differ from patients today. The efficacy data may need further validation with a future study. However, there is no reason to believe that the efficacy of LTOT would be much different in today's patients, as there has been no new treatment developed in the past 30 years that improves survival or slows the progression of the disease, and recently developed pharmacotherapies are unlikely to affect the efficacy of LTOT or to interact with it.

Despite these limitations, the present study revealed that the cost-effectiveness of COT in patients with SRH was within bounds considered to be cost-effective, while that of NOT was not. The ICER for COT was more favorable than the ICERs for widely used medical and surgical therapies for COPD. When the costs are significant and the treated population is large, cost-effectiveness may suffer. However, we need to ensure that the Deficit Reduction Act provision will not adversely affect patient health, interrupt continuity of care, or shift additional costs to patients. Although specific advantages of new effective therapies may justify their implementation at higher costs, proper allocation of limited medical resources should be pursued. The cost-effectiveness of LTOT

can be improved by prescribing LTOT to patients who will receive substantial benefit, by improving patient adherence, by re-evaluating the initial prescription in a timely fashion,³⁷ and by providing adequate support for services and maintenance. There is substantial room for improvement in the current Medicare policies regarding LTOT reimbursement.

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