Economic evaluation of treating chronic obstructive pulmonary disease with inhaled corticosteroids and long-acting $\beta_2$-agonists in a health maintenance organization

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Summary

Objectives: In light of recent results from observational studies showing prolonged survival in subjects taking long-acting $\beta_2$-agonists (LABA) and/or inhaled corticosteroids (ICS) for chronic obstructive pulmonary disease (COPD), we investigated their cost-effectiveness (CE).

Methods: Costs and survival data were collected for a sample of members enrolled in a large Health Maintenance Organization in the United States. An observational study design was used to evaluate cumulative costs and health benefits of LABA, ICS, ICS+LABA, or comparison drugs. Survival was estimated using a parametric regression model. Costs were adjusted for censoring and prognostic factors. CE was evaluated over a time horizon of 36 months and the remaining lifetime of subjects.

Results: Over 36 months, life expectancy and costs were: 2.4 years (95\% confidence interval (CI): 2.3; 2.5) and $28,030 (CI: $23,400; $33,570) for not receiving ICS or $28,030 (CI: $23,400; $33,570) for not receiving ICS or

Abbreviation: CEAC, Cost-effectiveness acceptability curve; CI, 95\% confidence interval; COPD, Chronic obstructive pulmonary disease; ED, Emergency department; FEV\textsubscript{1}, Forced expiratory volume 1 s; HMO, Health Maintenance Organization; HR, Hazard ratio; ICER, Incremental cost-effectiveness ratio; ICS, Inhaled corticosteroids; LABA, Long-acting $\beta_2$-agonists; SD, Standard deviation

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LABA; 2.6 years (CI: 2.6; 2.7) and $35,170 (CI: $29,970; $40,620) for ICS alone; 2.6 years (CI: 2.5; 2.7) and $27,380 (CI: $21,780; $32,510) for LABA alone; and, 2.7 years (CI: 2.6; 2.8) and $33,780 (CI: $28,700; $39,440) for subjects treated with ICS+LABA. The lifetime analysis showed similar trends.

Conclusions: There is an acute need to find effective, life-extending treatments for persons with COPD. ICS, LABA or their combination represent promising treatment options and are currently being tested in randomized trials. If the impact on survival seen in these trials compares to that seen in observational studies, LABA and the combination treatment are likely to be cost-effective in the United States.

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Introduction

Chronic obstructive pulmonary disease (COPD) is a leading cause of morbidity and mortality worldwide and results in a substantial economic and social burden to all countries. The global burden of COPD has been increasing and is expected to continue to escalate in the coming decades. COPD was the eleventh leading cause of disability and the fifth leading cause of death in 2000. It is projected that by 2020, COPD will become the fifth leading cause of disability and third leading cause of death. Managing the chronic symptoms and exacerbations is also associated with elevated utilization of health care services and costs, including work absenteeism and lost productivity.

Other than smoking cessation, to date, only oxygen therapy has been shown to prolong survival. Other medical treatments have been aimed primarily at relieving symptoms and managing exacerbations. Nevertheless, there have been improvements in the survival of persons with COPD over the last several decades, suggesting that survival benefits of treatment may exist. Given the enormous burden attributable to the disease, any new medical treatments that prolong survival would have a wide indication among patients with COPD.

New treatments that are currently being tested in randomized trials of subjects with COPD are long-acting β₂-agonists (LABA) such as salmeterol and inhaled corticosteroids (ICS) such as fluticasone propionate. Recent randomized studies showed that lung capacity increased significantly among subjects receiving salmeterol alone and even greater benefit was experienced when fluticasone was added. It remains to be proven whether the improvements observed in bronchodilation derived from LABA and ICS also lead to prolonged survival. However, evidence from a recent study of survival among persons with COPD from two health maintenance organizations (HMO) in the United States suggests that there may be a survival advantage. Relative to subjects not receiving other medication, that study showed statistically significant reduced risks of death: for the ICS group, the hazard ratio (HR) was 0.6 (95% confidence interval (CI): 0.5; 0.8), for the LABA group HR = 0.55 (CI: 0.3; 0.9), and for ICS and LABA in combination HR = 0.3 (CI: 0.2; 0.7).

Using survival and cost data from one of those HMOs, we investigated the expected costs of care, the gains in life expectancy and the potential cost-effectiveness (CE) of ICS and LABA alone or in combination for treating subjects with COPD.

Methods

Using survival analysis techniques, we conducted a CE analysis of competing strategies for treating COPD over both the 36 months of the original study (i.e. “within-study” analysis) and the remaining lifetime of subjects (i.e. “lifetime” analysis that was extrapolated over the lifetime of the cohort). The perspective was that of a third party payer, such as a managed care organization or HMO. In addition to ICS, LABA and the combination ICS+LABA, we estimated costs and effects for a group of other medications including short-acting β₂-agonists, xanthine, anticholinergic or combined bronchodilators.

Data sources and survival study design

Subject level data on survival, costs and prognostic factors were derived from administrative records from the Lovelace Patient Database. The database contains records of hospital episodes, physician visits and dispensed medications for a 200,000-member HMO in New Mexico, the Lovelace Health Plan. Survival was determined using records of death certificates obtained from New Mexico vital records bureau for the years 1995–2000. These were linked deterministically to patient records based on name and social security number. Estimates of survival were obtained from a published
observational cohort study of treatment effectiveness. In that study, subjects were assigned to either an “exposed” group defined as having at least 90 days exposure to ICS, LABA or both, or to a “comparison” group defined as having no exposure to ICS or LABA, but at least 90 days exposure to other COPD drugs. Other inclusion criteria included: (1) enrollment in the HMO between 1 January 1995 and 31 December 2000 (the study period); (2) at least two outpatient encounters or at least one hospital admission coded as chronic bronchitis, emphysema, or COPD during the study period; (3) no evidence of cystic fibrosis, bronchiectasis, or lung cancer; (4) age 40 years or older; and, (5) at least 12 months of HMO enrollment prior to their study enrolment. The follow-up period began on the first day following the 90th day of drug exposure and continued until death, disenrolment or 31 December 2000, whichever came first. For each initial exposure group, subjects were assumed to be regular users of the medications.

To compare the likelihood of survival between treatment groups over 36 months, the investigators used a Cox proportional hazards model that included prognostic factors including demographic variables, comorbid medical conditions (Charlson score) and severity of COPD.

Costs were estimated as follows. Subject-level health care charges from the Lovelace Patient Database captured the following categories of health care utilization: outpatient prescription medications, ambulatory care and hospitalizations. Ambulatory care included all encounters such as physician visits, radiology, laboratory testing, rehabilitation, and other outpatient procedures and services.

Economic study design and analytical techniques

To derive incremental CE ratios, we estimated the life expectancies (life-years) for each treatment group. Although the semi-parametric Cox proportional hazards model can be used to calculate hazard ratios to determine relative measures of treatment effect, it does not yield a direct specification of the baseline hazard function. Determining the baseline hazard function is necessary to be able to estimate life expectancy. To do so, we used a parametric proportional hazards regression model based on a Gompertz distribution. The Gompertz model is specified to increase exponentially with time and is, therefore, more likely to reflect the survival patterns and poor long-term prognostic of individuals with COPD. Over the 36 months in the “within-study” analysis, parameter estimates and hazard ratios between non-parametric and parametric techniques remained similar. The covariates included in the regression model were the same as those used for adjustment in the survival study. To evaluate mean survival, we calculated the area under each fitted treatment-specific survival curve by previously setting covariates at their mean values. Mean survival was estimated both for the within-study analysis over 36 months and using the extrapolated survival curves over the remaining lifetime of subjects.

Because some subjects were censored, data on costs were incomplete. We accounted for the bias introduced by ignoring costs among censored subjects by partitioning the original time interval of the cost dataset into smaller subintervals and then applying weights to reflect the censoring patterns over time. This also results in improved statistical efficiency. Prior to applying weights to the cost data to address censoring, regression techniques can be used to adjust costs for potential confounders, which may include known prognostic factors.

We therefore created a costing dataset with monthly time increments. The costs were assigned to the month in which they were accrued. When health resources used for treating a particular event were spread over more than a month, the costs were apportioned to each month according to the respective number of days of utilization. To adjust for prognostic factors, we estimated a random-effects model using generalized least squares estimator that included the same covariates as in the analysis of survival. (Details of the random effects model parameters and coefficients are available from the authors upon request.) We then used the estimation results to generate fitted values of monthly costs. For the censoring adjustments in the within-study analysis, we relied on the inverse probability weighted method. The covariate-adjusted monthly costs were multiplied by the inverse of their monthly probability of being observed (or uncensored). For each treatment, the monthly probabilities of remaining uncensored were estimated by the Kaplan–Meier survivor function for time-to-censoring. Once costs had been weighted, we summed and averaged over the total number of subjects to derive the average cumulative cost per treatment option. A similar approach to weight costs using the probability of survival at each time point was used for the lifetime analysis. Costs were cumulated over the remaining lifetime of subjects which had been
previously estimated using the parametric survival analysis.

As the cost figures represented charges rather than the actual cost of resource consumption, we transformed all estimates using the 2001 Lovelace Health Systems cost-to-charge ratio of 0.732 published by the Centers for Medicare and Medicaid Services. Cost and outcomes were discounted at a rate of 5% per annum and all costs are reported in 2001 US dollars. For transparency, we also replicated the analysis without discounting costs and outcomes.

To assess the incremental CE of treatments we: (1) rank-ordered different therapies according to their respective life expectancy, (2) used usual criteria for making comparisons between multiple alternatives in CE analyses, and (3) calculated the incremental CE ratio (ICER) between pairs of treatment options by taking the difference in expected costs and dividing it by the difference in life expectancies.

Uncertainty analysis of cumulative costs and life expectancy

To evaluate the uncertainty and build 95% confidence intervals around the estimates of cumulative costs and life expectancy, we used a non-parametric bootstrapping technique based on 1000 resamples. Because this technique does not rely on the specification of a particular distribution for costs and life expectancy, it is considered appropriate when the distribution of the data is skewed and traditional hypothesis tests would not be reliable. It also preserves the covariance structure of the data between costs and effects. The 1000 bootstrap resamples of costs and life expectancies for the within-study and lifetime analyses were plotted on CE planes. These are useful devices to provide a graphical representation of uncertainty surrounding the point estimates for each treatment group. On the CE plane, the costs are shown on the ordinate (y-axis) and the effects on the abscissa (x-axis). The difference in costs and effects between the two treatments shows the joint distribution of these two parameters.

An alternative presentation is called a cost-effectiveness acceptability curve (CEAC). This curve shows the probability that a medication is cost-effective compared with the alternative for a range of maximum acceptable values for ICERs. They present an alternative to having confidence intervals for the incremental cost-effectiveness ratios. The CEAC is derived by repeatedly sampling from the joint distribution of incremental costs and incremental effects using a resampling technique called “bootstrapping”. These curves are created to yield the probability that a treatment is cost-effective over a range of dollar values that a decision-maker would be willing-to-pay for

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Characteristics of 1154 subjects overall and by study group enrolled in the Lovelace HMO and diagnosed with COPD between 1995 and 2000.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Overall (N = 1154)</td>
</tr>
<tr>
<td>Age (± SD)</td>
<td>65.9 (10.1)</td>
</tr>
<tr>
<td>Gender-% male</td>
<td>51</td>
</tr>
<tr>
<td>Proportion with Charlson score ≥ 1 (based on hospitalization)</td>
<td>0.1</td>
</tr>
<tr>
<td>Proportion with Charlson score ≥ 1 (based on outpatient encounters)</td>
<td>0.3</td>
</tr>
<tr>
<td>Percent with ≥ 20 COPD outpatient visits in year prior to study enrolment</td>
<td>17.9</td>
</tr>
<tr>
<td>Percent with ED encounter in year prior to study enrolment</td>
<td>3.8</td>
</tr>
<tr>
<td>Percent with hospital admission in year prior to study enrolment</td>
<td>5.1</td>
</tr>
<tr>
<td>Number of deaths (%)</td>
<td>208 (18)</td>
</tr>
</tbody>
</table>

Abbreviations: HMO: Health Maintenance Organization; COPD: Chronic obstructive pulmonary disease; ICS: Inhaled corticosteroids; LABA: Long-acting β2-agonists; SD: Standard deviation; ED: Emergency department.
individuals to gain one extra year of life. We generated CEAC for each treatment option to determine the most favorable alternatives over the range of willingness-to-pay (WTP) values.

All statistical analyses were conducted using SAS 8.0\textsuperscript{R} for Windows\textsuperscript{R}, STATA 7.0\textsuperscript{R} for Windows\textsuperscript{R} and the CEACs were generated using Excel\textsuperscript{R} for Windows\textsuperscript{R}.

**Results**

The cohort included 1154 subjects with a mean age of 66 years and approximately equal proportions of women and men (Table 1). The largest share of costs originated from hospitalizations (Table 2) which accounted for 50% of the total average monthly cost, followed by ambulatory care at 38% and costs of outpatient medications at 12%. Over 36 months, the three components as a share of total costs remain relatively stable (data not shown).

Some differences between groups in some of the demographic variables and measures of disease severity were found (Table 1).

The adjusted survival curves estimated from the parametric Gompertz model are presented in Fig. 1. Those curves show the survival patterns observed for each treatment group in the within-study and lifetime analyses.

After rank-ordering the four treatment options by their estimates of life expectancies, the ICS alone and the “comparison” group of no ICS or LABA in the within-study analysis both show higher costs and lower effectiveness when compared to the next option of LABA alone (Table 3). Those options were considered “dominated” (i.e. lower effectiveness at greater cost) so we only estimated the ICER between the remaining two alternatives of LABA and the ICS+LABA combination. In the lifetime analysis, only ICS was dominated so that the ICER was also calculated for LABA and the “comparison” group of no ICS or LABA.

Table 3 also shows the cumulative costs and life expectancies for the within-study and lifetime analyses including the 95% confidence intervals derived from the analysis of uncertainty. The 1000 bootstrap replicates of cost and effect pairs are shown on the CE plane for the within-study analysis.

![Figure 1](image-url) Adjusted survival curves for each treatment group estimated from the Parametric Survival Model for 1154 subjects enrolled in the Lovelace HMO and diagnosed with COPD between 1995 and 2000: (a) within-study analysis and (b) lifetime analysis. Note: The vertical line at month 36 represents the start point of extrapolated survival estimates; adjusted survival curves were estimated with covariates set at their mean values. Abbreviations: COPD: Chronic obstructive pulmonary disease; ICS: Inhaled corticosteroids; LABA: Long-acting $\beta_2$-agonists.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Description of monthly costs (2001 $US) of treating 1154 subjects enrolled in the Lovelace HMO and diagnosed with COPD between 1995 and 2000.</th>
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</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Mean (proportion of total cost)</td>
</tr>
<tr>
<td>Outpatient medication</td>
<td>146 (0.12)</td>
</tr>
<tr>
<td>Hospitalization</td>
<td>639 (0.50)</td>
</tr>
<tr>
<td>Ambulatory care</td>
<td>487 (0.38)</td>
</tr>
<tr>
<td>Total cost</td>
<td>1,272</td>
</tr>
</tbody>
</table>

Abbreviations: HMO: Health Maintenance Organization; COPD: Chronic obstructive pulmonary disease; $\text{sd}$: Standard deviation.
(Fig. 2) and the lifetime analysis (Fig. 3). There was higher uncertainty surrounding the results of the lifetime analysis than the within-study analysis. This is represented by the wider confidence intervals around costs and effects (Table 3) and the broader dispersion of the bootstrap replicates (Fig. 3). Although the point estimates for the incremental CE ratios would indicate that LABA dominates both ICS and no ICS in the 36-month analysis and that ICS is still dominated in the lifetime analysis, the substantial uncertainty surrounding the estimates of costs and effects prevents us from making this conclusion. In those circumstances, the more useful approach to analyze uncertainty is through CEACs for each treatment.

The CEAC for results of the within-study and lifetime analyses are shown in Figs. 4 and 5, respectively, using WTP values ranging from $0 to $200,000 per year-of-life gained. The CEAC for the within-study analysis indicated that for lower values of WTP (i.e. less than $91,000 per year of life gained), the treatment with LABA was the most favorable option. For values higher than $91,000 the combination ICS+LABA then became the one with the highest probability of being cost-effective.

For the lifetime analysis, the comparison group of no ICS or LABA was the most favorable option for very low values of WTP (i.e. less than $6,100). Then, for values between $6,100 and $27,500, LABA had the highest likelihood of being cost-effective. Above a WTP of $27,500 the combination ICS+LABA provided the best value for money.

**Discussion**

We found that treatment with LABA alone and in combination with ICS provided gains in life for persons with COPD that may be considered cost-effective at conventional levels. These findings

| Table 3 | Cumulative costs, life expectancy and incremental cost-effectiveness ratios for 1154 subjects enrolled in the Lovelace HMO and diagnosed with COPD between 1995 and 2000—within-study and lifetime analyses. |
|-----------------|--------------------|------------------|----------------|----------------|------------------|
|                | Costs (US $)      | Discounted costs (US$*) | Life expectancy | Discounted life expectancy* | Incremental cost (US$) per year of life gained† |
| **Within-study analysis (36 months)** | | | | | |
| Comparison (no ICS or LABA) | 29,250 (24,420, 35,050) | 28,030 (23,400, 33,570) | 2.52 (2.40, 2.67) | 2.41 (2.30, 2.55) | Dominated‡ |
| ICS | 36,840 (31,410, 42,500) | 35,170 (29,970, 40,620) | 2.72 (2.67, 2.80) | 2.60 (2.56, 2.68) | Dominated‡ |
| LABA | 28,690 (22,8730, 34,060) | 27,380 (21,780, 32,510) | 2.75 (2.64, 2.87) | 2.63 (2.53, 2.74) | — |
| ICS+LABA | 35,440 (30,090; 41,440) | 33,780 (28,700; 39,440) | 2.83 (2.76, 2.91) | 2.70 (2.64, 2.78) | 91,430 |
| **Lifetime analysis** | | | | | |
| Comparison (no ICS or LABA) | 55,170 (35,480, 85,060) | 48,950 (31,800, 72,500) | 4.34 (3.53, 5.94) | 3.88 (3.25, 5.02) | — |
| ICS | 84,290 (57,970, 129,500) | 71,860 (50,900, 103,180) | 5.88 (4.88, 8.33) | 5.06 (4.34, 6.6) | Dominated‡ |
| LABA | 68,230 (36,890, 116,310) | 57,500 (32,380, 91,720) | 6.17 (4.68, 9.38) | 5.27 (4.19, 7.21) | 6110 |
| ICS+LABA | 97,190 (58,320, 165,370) | 79,560 (50,020, 122,070) | 7.39 (5.59, 11.59) | 6.14 (4.89, 8.63) | 27,570 |

Abbreviations: HMO: Health Maintenance Organization; ICS: Inhaled corticosteroids; LABA: Long-acting β₂-agonists; COPD: Chronic obstructive pulmonary disease.

*Costs and outcomes discounted at 5% per annum after the first year; monetary values have been rounded to the nearest ten.
†Incremental cost-effectiveness ratio based on discounted values. Calculated relative to the next less costly non-dominated treatment strategy, eg in the within study analysis, for ICS alone relative to ICS+LABA calculated as: (33,780 / 27,380) / (2.70 / 2.63) = 91,430.
‡‘’Dominated’’ means that the treatment is both more costly and less effective than the LABA alternative.
warrant consideration given the lack of effective treatments for this condition. Two published analyses have previously examined the CE of salmeterol and fluticasone propionate.\(^{44,45}\) However, no study has described the CE of the four treatment options including ICS, LABA, ICS+LABA and other medications but no intake of ICS or LABA. Additionally, our study is the only one that investigated the CE of these treatments using a health outcome of survival and that calculated life expectancy.

Because there is clear evidence that ICS and LABA relieve the symptoms of COPD and improve quality-of-life,\(^{19,21,27,46–49}\) many investigators examine markers of lung capacity or the rate of exacerbations of COPD. Evidence of an increased benefit on lung function from combination therapy is starting to accumulate. In a 12-month randomized clinical trial, the combination of salmeterol and fluticasone resulted in significantly improved lung function (FEV\(_1\)) against placebo, salmeterol alone or fluticasone alone.\(^{28}\) That study was not powered to detect differences between treatments for other outcomes such as the total rate of exacerbations or survival.

A significant reduction in the rates of COPD exacerbations for ICS versus placebo was demonstrated in several randomized controlled trials presented in a systematic review.\(^{50}\) Although the investigators of the systematic review did not find a statistically significant effect of ICS on all-cause mortality, there was a trend suggestive of a survival benefit.

Considering the results from other observational studies suggesting survival benefits,\(^{24,25}\) randomized studies are being designed to investigate whether survival benefits are reproduced in an experimental setting. In the absence of randomized data, we relied on an observational dataset from a large HMO in the United States. The dataset had the advantage of being more representative of actual treatment patterns and, thus, carries a greater potential for generalizability of the results. However, the potential for greater generalizability must be weighed against a greater likelihood of confounding by known and unknown risk factors because subjects were not randomized to their treatment regimens. Of particular concern in a non-randomized study is confounding by indication, i.e. subjects are given a treatment specifically

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**Figure 2** Results of 1000 bootstrapped costs and effects for each COPD treatment—within-study analysis. Abbreviations: COPD: Chronic obstructive pulmonary disease; ICS: Inhaled corticosteroids; LABA: Long-acting \(\beta_2\)-agonists; Note: Larger white circles represent the point estimates for each treatment group and the thick black line is the cost-effectiveness efficiency frontier joining non-dominated treatment alternatives.
because the physician believes that it would have the greatest beneficial effect.\textsuperscript{51,52} Also, the measures of disease severity in this study were based on proxy information (i.e. health care utilization). While analytical techniques are available to control for potential confounders, it is not possible to be entirely confident that all relevant factors have been included. Future studies would benefit from inclusion of information on severity of illness from spirometric measurements. By selecting the same covariates used as predictors of survival to adjust costs, the potential for some residual confounding may introduce some bias in the estimates of costs. The need for including covariate adjustments to guard against confounding that would result in biased estimates of CE are also highlighted by the presence of imbalances in the distribution of subject characteristics between treatment options.

Additionally, in order to emulate a randomized trial, the original survival study started the follow-up after the ninetieth day of exposure to LABA, ICS, ICS+LABA, or comparison drugs. This meant that subjects receiving between 1 and 90 days of these treatments were excluded and that the date of entry into the cohort was different for different groups of subjects. This can create what has been called an “immortal time bias”\textsuperscript{53} in which, by using this definition of exposure, the outcome cannot occur during some period in which exposure occurred. This can potentially result in an overestimation of risk or benefit if subjects do not survive long enough to be prescribed the exposure of interest, and are categorized as unexposed. By artificially inflating the outcome rate among unexposed subjects, a treatment can appear more beneficial than it actually is. One solution is to design a study in which exposures are allowed to vary over time.\textsuperscript{53} However, study designs that incorporate time-dependent use medications are subject to protopathic bias, which can arise in situations where medications are used to treat acute symptoms of COPD.\textsuperscript{54} Some investigators argue that a time-dependent analysis should not be used to evaluate the effects of chronic pharmacologic therapies when they may also be used to treat acute exacerbations.\textsuperscript{55} These issues,
which are specific to observational cohort studies, will become clearer with the publication in 2006 of a randomized controlled trial of these treatments in COPD.56

Using a third party payer perspective meant that indirect costs were not included in our study. Our analysis was limited to health care charge data contained in the medical claims of an HMO. Future economic evaluations would benefit from adopting a societal perspective that includes these indirect costs, since COPD is a disease that has an important impact on work absenteeism and lost productivity. Another avenue of investigation is to develop a cost utility model by incorporating information on quality of life in the form of utilities among persons with various degrees of COPD. This type of information on the health status burden of COPD exacerbations has been presented elsewhere.57

The lifetime analysis was based on the assumption that the survival patterns over the remaining lifetime of subjects follows similar trends to those observed over the 36 months of data. This would need to be further validated in the context of a long-term follow-up study of survival in subjects with COPD.

Because of these limitations, the results from our analysis must be considered hypothesis-generating and should be confirmed in prospective clinical trials. However, our findings provide a useful point of reference for further discussions on potential treatments for this highly prevalent disease that result in substantial economic burden worldwide.

Our results are similar to a recent Canadian economic evaluation that compared persons with different stages of receiving ICS. Those investigators conducted parallel sets of analyses assuming that ICS improved quality of life only, and that there was also a mortality benefit. Over the lifetime of patients, ICS was cost-effective at conventional levels for stages 2 and 3 COPD: CDN $21,200 per quality adjusted life year without an assumed mortality gain and CDN $2,900 per quality adjusted life year when a mortality benefit was included.58

There is an acute need to find effective, life-extending treatments for persons with COPD. ICS,

Figure 4 Cost effectiveness acceptability curves showing strategies most likely to be cost-effective for 1154 subjects enrolled in the Lovelace HMO and diagnosed with COPD between 1995 and 2000—within-study analysis. Note: The willingness-to-pay is the maximum amount that a decision-maker would pay for a gain of one year in life expectancy. LABA is the most cost-effective option until willingness-to-pay reaches $91,429 per year of life gained and ICS+LABA thereafter. Abbreviations: HMO: Health Maintenance Organization; ICS: Inhaled corticosteroids; LABA: Long-acting $2-agonists.
LABA or their combination represent promising treatment options and are currently being tested in randomized trials. If the impact on survival seen in these trials compares to that seen in observational studies, LABA and the combination treatment are likely to be cost-effective in the United States.

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