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# Informing Shared Decisions about Advance Directives for Patients with Severe Chronic Obstructive Pulmonary Disease: A Modeling Approach

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A B S T R A C T

**Objective:** To estimate the survival and quality-adjusted life-years (QALYs) of Full Code versus Do Not Intubate (DNI) advance directives in patients with severe chronic obstructive pulmonary disease and to evaluate how patient preferences and place of residence influence these outcomes. **Methods:** A Markov decision model using published data for COPD exacerbation outcomes. The advance directives that were modeled were as follows: DNI, allowing only noninvasive mechanical ventilation, or Full Code, allowing all forms of mechanical ventilation including invasive mechanical ventilation with endotracheal tube (ETT) insertion. **Results:** In community-dwellers, Full Code resulted in a greater likelihood of survival and higher QALYs (4-year survival: 23% Full Code, 18% DNI; QALYs: 1.34 Full Code, 1.24 DNI). When considering patient preferences regarding complications, however, if patients were willing to give up >3 months of life expectancy to avoid ETT complications, or >1 month of life expectancy to avoid long-term institutionalization, DNI resulted in higher QALYs. For patients in long-term institutions, DNI resulted in a greater likelihood of survival and higher QALYs (4-year survival: 2% DNI, 1% Full Code; QALYs: 0.29 DNI, 0.24 Full Code). In sensitivity analyses, the model was sensitive to the probabilities of ETT complication and noninvasive mechanical ventilation failure and to patient preferences about ETT complications and long-term institutionalization. **Conclusion:** Our model demonstrates that patient preferences regarding ETT complications and long-term institutionalization, as well as baseline place of residence, affect the advance directive recommendation when considered in terms of both survival and QALYs. Decision modeling can demonstrate the potential trade-off between survival and quality of life, using patient preferences and disease-specific data, to inform the shared advance directive decision.

***Keywords:*** advance directives, COPD, decision modeling, end-of-life decision making, shared decision making.



## Introduction

When patients are critically ill, and no longer able to make decisions, advance directives help maintain patient autonomy by allowing them to specify the type of care desired [1]. Advance directives are particularly important for patients with chronic diseases who may have a more predictable course of illness and hospitalization. Only 25% of patients, however, have advance directives when end-of-life decisions need to be made [2]. Shared decision making between clinicians and patients could facilitate the writing of advance directives that coordinate patient preferences with specific trajectories of the patient's illness and treatment options. Yet most clinicians do not discuss advance directives with their patients [2] for reasons including lack of disease-specific prognostic information and difficulty incorporating quality-of-life considerations with individual patient preferences. Decision modeling provides an analytic framework in which the assumptions and methods used to arrive at the decision are made explicit and is useful for analyzing complex decisions regarding treatment options for which outcome data may not be available. Importantly, patient-specific data can be incorporated into the decision model to personalize the decision.

By using chronic obstructive pulmonary disease (COPD) as our model of a chronic illness, we sought to determine whether we could identify patient preferences regarding quality of life that might make a Do Not Intubate (DNI) advance directive result in more favorable outcomes, versus a Full Code directive, when considered in terms of quality of life rather than survival alone. We hypothesized that a Full Code directive would increase survival, but depending on patient preferences, there would be a trade-off between quality of life and survival because of the potential complications of invasive mechanical ventilation, such as nosocomial infections, and the likelihood of skilled nursing home placement and/or long-term ventilator dependence. We also hypothesized that Full Code patients residing in long-term institutions would have decreased survival compared with DNI patients because of the higher likelihood of mortality associated with intubation.

We used a Markov decision analytical model, an extension of our previously reported simple decision tree [3], to compare outcomes of DNI and Full Code advance directive decisions, specifically for patients with severe COPD. COPD is the fourth most com-

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mon cause of death in the United States, and particularly among those with severe COPD, many patients die of acute on chronic respiratory failure [4,5]. We used survival and quality-adjusted life-years (QALYs) as our outcome measures. We explored the effect of a range of plausible patient preferences and long-term institutionalization on these outcomes. Our model demonstrates potential trade-offs between quality of life and survival with alternate advance directives and may be used to better align end-of-life care with patient values.

## Methods

### The hypothetical patient population

We simulated 10,000 patients with severe COPD, as defined by American Thoracic Society criteria [6], who were at risk for hospitalization and/or long-term institutionalization due to COPD respiratory exacerbation. Although there are other causes of respiratory exacerbation in patients with COPD, we focused on patients who were admitted with a typical COPD exacerbation, which is the most common cause of respiratory failure and has the most available data. The age chosen was 65 years, based on the mean age of the cohort included in prominent COPD survival studies [6,7]. A cohort of patients residing in the community (community-dwellers) and a cohort residing in long-term extended care facilities (long-term ECFs) were analyzed separately.

### The decision model

We developed a Markov model to simulate long-term survival and the probability of multiple respiratory exacerbations. We used published data and expert opinion, when available, for the parameter estimates and plausible ranges (Table 1). The outcomes measured were survival and QALYs. The time frame for each Markov cycle was 1 month. All patients were followed until death. All future benefits and utilities were discounted at 3%, consistent with the recommendations of the Panel on Cost Effectiveness in Health and Medicine [43].

### Health states

Hypothetical patients could exist in one of five Markov states: *baseline in community* (baseline health state with COPD and no respiratory failure), *hospitalized* (with respiratory failure), *short-term ECF* (living in a short-term ECF for rehabilitation), *long-term ECF* (living in a long-term ECF/long-term institutionalization), or *dead*. After each Markov cycle, patients could transition to other health states or stay in the same health state, depending on treatments received and outcomes (e.g., a patient who received mechanical ventilation and had complications would have a higher probability of discharge to *long-term ECF*).

### Respiratory resuscitation options

Respiratory resuscitation options for COPD exacerbation included no mechanical ventilation, that is, supplemental oxygen and medications; noninvasive mechanical ventilation (NIMV), that is, pressurized air via a noninvasive mask = bilevel positive airway pressure ventilation or continuous positive airway pressure ventilation; and invasive mechanical ventilation, that is, endotracheal tube (ETT) insertion and attachment to a mechanical ventilator. All treatments were assumed to occur while the patient was hospitalized. The probability of receiving a treatment depended on the patient's advance directive choice and the severity of respiratory exacerbation. If any of these treatments failed, the probability of receiving subsequent treatments depended on the advance directive.

### Clinical outcomes

The health outcomes were divided into short-term and long-term outcomes. Short-term outcomes included the need for either NIMV or ETT, successful weaning from mechanical ventilation, failure to wean from mechanical ventilation, complications of mechanical ventilation, and death (Fig. 1). Complications of invasive mechanical ventilation were defined as organ damage [10–12], infection, or the inability to discontinue mechanical ventilation [11,15,44–46]. Complications of NIMV were defined as the inability to wean from mechanical ventilation, based on the available literature [8,10,11,18,19,21–24,47,48]. Long-term outcomes were discharge to the community versus short-term ECF versus long-term ECF, and death.

### Probability estimates

Estimates were obtained by systematically reviewing the literature (Table 1). The interdependence of respiratory exacerbation episodes, assuming that the probability of respiratory exacerbation was increased after a prior respiratory exacerbation, was considered [34]. When evidence was not available from the literature, we used "expert opinion," obtained from a consensus of pulmonologists and intensivists at our institution and a wide range of plausible values for sensitivity analysis. Decision rules were used to pool relevant data. When data were sufficiently homogeneous, results were pooled by using the random effects method of DerSimonian and Laird [49]. Homogeneity was defined as having a Q statistic of $>$0.10, an $I$ statistic of $<$25%, and a $P$ value of $<$0.05 with no significant outliers on the Forest plot. If data were not homogeneous, the median value was used and the point estimate and plausible ranges were specified according to the lowest and highest reported confidence intervals. Because the results may not be normally distributed, the median value was used, rather than the mean, to decrease the influence of outliers on the parameter estimate.

### Life expectancy

We estimated all-cause age-specific death rates from US life-table data [50]. The probability of death in the model was drawn from the death rate obtained from COPD survival data [7], with the minimum probability bound by the US life-table rates to ensure that COPD could never reduce mortality. Although the COPD survival data includes 52 months of follow-up, we chose to use data over 38 months because there was inadequate statistical precision after 38 months (large drops in incremental survival on the Kaplan–Meier curve).

### Utility estimates and patient preferences

A utility is a preference-weighted, generic quality-of-life measure on a scale of 0 to 1, with 0 representing death and 1 representing perfect health. Five utilities were considered in the model: being at baseline in the community (baseline disease utility), hospitalized with respiratory exacerbation, in a short-term ECF, in a long-term ECF, and having an ETT complication.

The utility of being at baseline health in the community (0.65) was estimated by using utilities reported for noninstitutionalized patients with severe chronic lung disease [36,42]. The utility of being hospitalized with a respiratory exacerbation (0.22) was based on the ratio of patients with similar acute respiratory compromise admitted with congestive heart failure (CHF) in the setting of a myocardial infarction to patients having no CHF [36–38]. The utility of being in a short-term ECF (0.60) was based on the utilities of patients with similar short-term ECF stays (patients in a rehabilitation facility for 8 weeks) [36,41]. Patients with CHF, like patients with COPD, are also chronically ill with periods of exacerbations during which they may experience extreme shortness of