A Discrete Event Simulation Tool with Health Economics for Better Management of COPD

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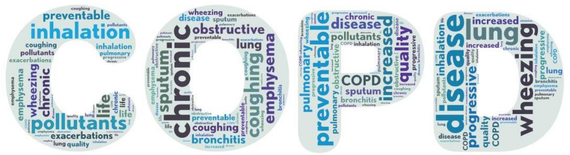

Abstract

The number of chronic obstructive pulmonary disease (COPD) patients is increasing and the readmission rate is remarkably high amongst these patients. Healthcare professionals and managers have financial and workforce-related pressures due to increasing demand with severe financial cuts, as well as staff shortages. Many studies have previously been conducted using Markov modelling and Monte-Carlo simulation for COPD, however, **a discrete event simulation (DES) model** or **an operational model** at this scale **has never been developed**. Therefore, a DES model incorporating health economics and readmission dynamics is developed **to improve the management of patients and efficiencies.**

We, firstly, **conceptualised the pathway for COPD patients** in collaboration with the COPD team of a hospital and community service in London. Then, the impact of post exacerbation pulmonary rehabilitation (PEPR) policy **is tested** for a demonstration of **the developed simulation tool**. We notice that the PEPR is cost-effective with improvements in QALY, reduction in emergency readmissions, occupied bed days and its associated costs. The tool can be used for assessing the impact of a wide range of scenarios on key performance metrics (such as activity, service hours, readmission rate, financial implications etc) by key decision makers.

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is chronic obstruction of lung airflow and the common terms ***'chronic bronchitis***' and ***'emphysema'*** are included within the COPD diagnosis[1]. It is **a progressive** but **preventable** lung disease and the world's third deadliest disease[2]. Smoking is the main cause of COPD and people over the age of 35 and heavy smokers are risk group for the disease. About 3.2 million people in the UK are estimated to be living with COPD, but sadly, **2.2 million are undiagnosed**[3].

COPD is one of the most costly chronic conditions[4] and around 1 million in-patient bed days are used by COPD patients[5]. **The readmission** is **very high** amongst COPD patients and the 30-day readmission policy penalties for the emergency admissions after 30 days of discharge following an admission.

While there are many modelling studies about cost-effectiveness of new drugs, therapies and treatments for COPD, **there are no known models** that capture individual patient pathway within COPD services. Therefore, this study aims to develop a discrete event simulation (DES) tool for the COPD pathway so as to enhance the efficiency and quality of patient care by assessing the impact of changes or new policies. **The core objectives** of this project are;

1. *constructing a COPD patient pathway*,
2. *engaging health economics and readmission dynamics* to the simulation tool,
3. *designing a user-friendly interface* to enable hospital managers and practitioners to use the model.

Methods and Materials

The COPD patient pathway is constituted and verified with **the COPD team** (specialist consultants, nurses, physiotherapists, and service manager) from **the Royal Free London**. The pathway **(see Figure 1)** shows the possible movement of patients, referral/discharge points and departments that are usually visited by COPD patients within a hospital setting as well as the course of the disease.

DES is chosen as the simulation tool because it **is more capable** and **convenient** to model the hospital environment where processes and events happen at discrete times. Input parameters;

1. COPD patient records are acquired from *the Hospital Episodes Statistics (HES),*
2. Pathway related parameters from *the COPD team,*
3. *The literature* was consulted for data, e.g. disease severity transition, cost of treatments and bed days etc.

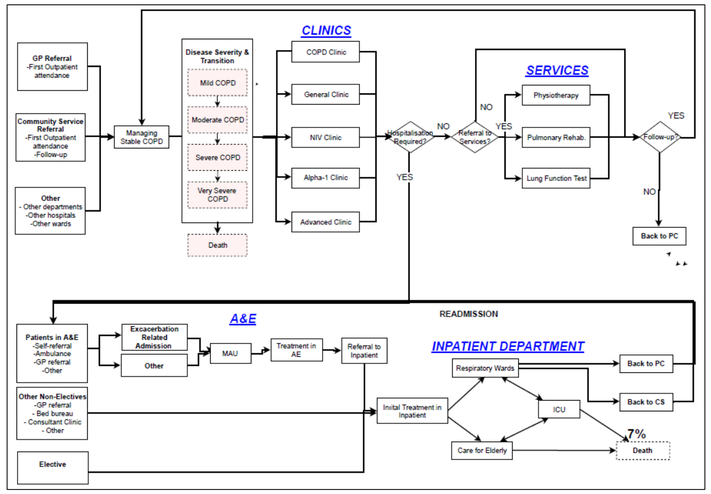

Figure 1 Conceptualised pathway for CODP patients

Table 2 The selected results of the simulation tool for each scenario (mean values – 95% CIs were omitted from the table)

	Baseline	Worst	Pessimistic	Realistic	Optimistic
Number of Inpatient Admission	1090	1090	1081	1040	998
Number of 30-day Readmission	169	169	158	143	122
Total Cut on Reimbursement (Penalty)	£124,341	£121,563	£113,035	£103,358	£87,810
Total Cost of Inpatient Bed days	£1,730,106	£1,696,231	£1,674,286	£1,620,007	£1,559,771
Total nurse service hours (TSNH)	39185	38842	38374	37185	35870
Total PR Cost to CCG	£204,016	£319,580	£322,668	£326,229	£330,037

Results

Amongst many scenarios and interventions (such as more referral to COPD services, vaccination, optimising medicine etc.), the scenario related to **post exacerbation pulmonary rehabilitation (PEPR) policy** is chosen for demonstration. PEPR suggests referring patients pulmonary rehabilitation within a short time after discharge (7-15 days) from hospital following an acute exacerbation of COPD. PEPR has **the highest potential of improving patient outcomes** and reduction in the risk of hospital readmission and length of stay[6-8]. The effect of PEPR varies in the studies, so four sets of scenarios (*worst, pessimistic, realistic and optimistic*) are established for the indicators of interest (such as reduction in readmission, decrease in LoS etc).

The model was run 50 times for a simulation period of 3.5 years (with a warm-up period of 0.5 year) to measure key performance indicators. The results **exclusively** show that;

1. **The use of PEPR decreases** inpatient admissions, occupied bed days, the penalty due to the 30-day readmission, service hours of nurses **(see Table 1)**.
2. Besides, the number of patients **completing the PR programme** is **increased** due to more referrals to PR.
3. In brief, the realistic and optimistic scenarios proved that the PEPR is **cost-effective** with cost reduction and gained QALY **(see Figure 2)**.
4. Lastly, **the incremental cost-effectiveness ratio (ICER)** of PEPR for each scenario is **found to be acceptable**.

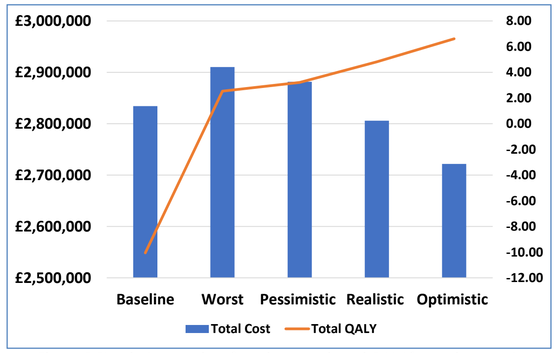

Figure 2 Simulation results of total cost and total QALY for each scenario

Discussion

Our model **is the first of its kind** that assesses **the quantifiable impact of re-designing** COPD services using DES as well as integrates **COPD readmissions** and **health economics**. According to our findings, **the use of PEPR** leads to **positive outcomes** in terms of reduction in the number of readmissions, total COPD treatment costs, staff workload and levels of activity. Even **the ICER value** of worst and pessimistic scenarios are **way lower than NICE's threshold** for ICER. Nevertheless, increased use of PR requires **financial investment and agile action**, in the form of staffs, room and planning activities.

The positive impact of the use of PEPR can be **generalised** to other providers in the UK. Variety of scenarios can be tested by healthcare professionals by adjusting input parameters using the simulation tool. **Community services (CS)** play a vital role in the management of COPD so the next stage of the study is to incorporate CS and test other scenarios around outpatient and CS.

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