The impact and effectiveness of a nurse led telehealth education program for Chronic Obstructive Pulmonary Disease patients

Dr. Rezwanul Rana[1,2], Prof. Jeff Gow[2,3,*], Prof. Clint Moloney [4,5,6]

1. Macquarie University Centre for the Health Economy, Macquarie Park, Australia
2. School of Business, University of Southern Queensland, Toowoomba, Australia
3. School of Accounting, Economics and Finance, University of KwaZulu-Natal, Durban, South Africa
4. College of Health and Biomedicine, Nursing and Midwifery, Victoria University, Melbourne, Australia
5. Institute for Health and Sport, Victoria University, Melbourne, Australia
6. Adjunct Affiliate for Queensland Centre for Evidence Based Nursing and Midwifery: A Joanna Briggs Institute Centre of Excellence, Mater Health, Brisbane, Australia

* Corresponding author:
Prof. Jeff Gow
School of Business
University of Southern Queensland
West Street, Toowoomba QLD, 4350
Australia
Telephone: +61 (0)7 4631 2617
Email: gowj@usq.edu.au

August 2022

Executive Summary

Aim: This study aimed to measure the clinical impact and economic effectiveness of a longitudinal nurse led self-management education and coaching program via telehealth for Chronic Obstructive Pulmonary Disease (COPD) patients. It tested two hypotheses: that the program would result in reduced healthcare utilisation and that there would be a net economic benefit to the health system of the program. Medication non-compliance has been recognised as a key contributor to additional healthcare usage by COPD patients.

Methods: Descriptive, cross sectional and longitudinal study. Patient data were obtained from self-reports. Cost data was sourced from government records and the literature. Health outcome was measured with COPD assessment test scores and were analysed using binomial regression analysis. Cost-effectiveness was assessed by dividing the mean difference in cost per person (before and after the intervention) with the net change in health outcome or mean difference in health-related quality of life. Sensitivity analysis was also undertaken.

Results: The education program was cost-effective. It improved health related quality of life, lowered healthcare consumption and resulted in cost savings of COPD related treatment after the education program was adopted. Holding other things constant, patients had 2.36 times and 1.49 times higher likelihood of ED presentation and hospital admission, respectively, before the education program compared to after the program.

Conclusions: This nurse-led telehealth education program for COPD improved patient health, thereby leading to a reduction in healthcare utilisation, improved patient health-related quality of life and provided an economic benefit to the health care system.

1. Introduction

COPD contributes to high levels of morbidity and mortality, nationally and internationally. Lung disease is ranked as the fourth leading cause of mortality globally and is the leading cause of health burden in Australia within an aging population [1,2,3]. COPD is defined as a progressive and irreversible airway obstruction stemming from a group of lung diseases. Specific lung disease can include emphysema, chronic bronchitis, and chronic bronchitis, or a combination of two or more forms of lung disease [2]. The World Health Organisation (WHO) estimated 251 million cases of COPD internationally in 2016 and estimated that COPD contributes to 5% of all global deaths [4]. In Australia, over 2.1 million people have COPD and the rate of hospitalisation for COPD among those aged 55 and over was 1,052 per 100,000 in 2015 [1,5]. Medication non-compliance is recognised as a key contributor to Emergency Department (ED) presentations of COPD patients [6].

The WHO has called for planned ongoing assessment, care and support coordinated by a proactive investment in real time solutions that address the increasing burden of COPD. WHO has endorsed targeted patient support strategies that coordinates care over time, and which address the physical and mental health needs of people with chronic illness [4]. Poorly managed COPD is one of the top two causes of avoidable hospital presentations and prevalence is increasing [1].

International evidence surrounding chronic disease presentations has revealed that moving from reactive management to proactive management with improved communication channels demonstrate that an increase in specialist nursing interventions can decrease ED presentations and bed use at hospitals [3]. A systematic review detailing empirical findings confirmed that case

management could be effective in reducing ED usage for adults with chronic illnesses like COPD [7].

The significance of this research topic relates to previous ED and admission avoidance research of COPD patients which strongly advocates for effective longitudinal patient support and mentorship interventions to reduce unnecessary exacerbations and ED and hospital presentations [8,9,10]. In 2019 Lung Foundation Australia (LFA) introduced a nurse led telehealth education program for clients with Chronic Obstructive Pulmonary Disease (COPD) to address these issues.

Study hypotheses:

1. Nurse led but self-managed education program for COPD patients will result in a reduction in healthcare utilisation, especially unnecessary ED presentations.

2. Nurse led but self-managed education program for COPD patients will result in an economic benefit from a health system perspective.

2. Methods

2.1 Study setting and participants

The premise of the LFA service was to support people with COPD to increase their knowledge, confidence, and skills for effective self-management practices of the condition. The service was designed to complement standard medical management and community programs.

Patients self-referred into the service through LFA who advertised on their website and social media. Commencing in 2019, it had contact up to June 2021 with 1327 people living with COPD. and 827 enrolled. Complete data on 81 patients were available for analysis.

The program involved four sequenced telephonic conversations. The first three occurred over a period of six months and then 12 months later. A longitudinal nurse-administered questionnaire was delivered at each session, collecting data on achieving the care management targets outlined in 'The COPD-X Plan: Australian and New Zealand Guidelines for the management of COPD' [2]. Each participant is provided individually tailored information about their care gaps, optimal management, and written/video materials particularly about correct inhaler device technique.

2.2 Study design

After providing verbal consent, participants completed verbal questionnaires of the outcome measures at baseline (T1), after 3 months (T2), 6 months (T3) and 18 months (T4). The interaction at T4 was to follow up 12 months after the program finished. The mean treatment effect of the program was calculated by differences in measures between T1 and T4.

2.3 Health/COPD related outcome measures

The COPD Assessment Test (CAT) is a validated instrument to quantify symptom burden and exacerbation risk and was administered at each interaction [11]. A written copy of it was provided to participants prior to their first interaction. It measures the impact of COPD on a person's lived experience.

The CAT is a short, self-administered eight-question instrument which has very high correlation with the widely used St George Respiratory Questionnaire (SGRQ) [11,12]. The CAT quickly assesses the impact and severity of exacerbations of COPD on health status [13]. The CAT includes eight items (cough, phlegm, chest tightness, breathlessness, limited activities, confidence leaving home, sleeplessness, and energy) with item scores ranging from zero to five points. This results in a total CAT score ranging from 0 to 40 points [11]. COPD patients are highly symptomatic if CAT

total score is ≥10 [14] or ≥ 18 [15]. Higher CAT scores are associated with significantly shorter time to first exacerbation [16]. Patients with high CAT scores show twice the risk of having moderate to severe exacerbations.

There is some debate on the significance of the magnitude of CAT score changes. For example, Kon et al., and Smid et al., concluded that a reduction of CAT of two or more is clinically significant [17,18]. However, Tsiligianni et al., estimated a significant change to be 3.76, and Alma et al., showed a reduction of 2.54 or more is a clinically significant improvement [12,19].

Another key outcome measure is weekly total physical activity. Studies conclude that increasing amounts and intensity of physical activity has a close relationship between improved health and lower risk of hospital readmission and longer survival for COPD patients [20].

2.4 Healthcare utilisation and its cost

The intervention aimed to improve patients' ability to manage COPD better; hence, its expected they will have lower COPD related healthcare utilisations. Several types of healthcare utilisation of COPD patients were considered. Health resources use (GP consultations, ED visits, and hospital admissions) were measured in natural units and valued in monetary terms per unit of provision, all expressed in 2020 Australian dollars (AUD). First, the cost of implementing the program including salaries of registered nurse, program manager, coordinator, overhead costs, professional development and postage was estimated. Second, healthcare resource utilisation associated with COPD exacerbations were prospectively recorded by active follow-up of the patients' self-reported data, GP visits, outpatient and ED visits and inpatient and outpatient hospitalisations.

Rana et al., calculated the weighted average ED presentation cost for COPD patients in Queensland in 2016-17 as $795.65 [10]. According to AIHW the average adjusted growth in medical

expenditure in Australia is 2.7% [21]. Hence, the per-event cost of ED presentation for COPD patients in 2020-21 was $885.12 = $795.65 [(1.027)^4]. Rana et al., also indicate that the average cost of COPD related hospitalisation (average length of stay three days) was $8,122 in 2017-18 [10]. Assuming a 2.7% growth rate the cost per event of hospitalization in 2020-2021 is $8,797 = $8,122 [(1.027)^3].

According to AIHW, in 2011–12, in Australian hospitals, the average cost per admission for COPD with complications was $9,700, with the average cost per admission ranging from $5,900 to $15,700 [22]. The average cost per admission for COPD without complications was $5,500, and the typical cost per admission ranged from $3,300 to $10,500. Assuming an average growth rate of 2.7% per annum, the mean cost of admission for COPD with complications is $12,328 and without complication is $6,990 in 2020-21.

2.5 Data analysis

Data were analysed using STATA version 16. The distribution of variables was tested with Shapiro-Wilk tests of Normality [23]. For normally distributed variables (e.g., CAT score, weekly physical activities), differences in mean values between two groups (measured before and after) were estimated using paired t-test [24,25]. For skewed data, Wilcoxon's rank-sum test was used to analyse differences in medians and distributions. The mixed models' procedure was used to estimate the between-group differences in health status by analysis of the repeated measurements. Negative binomial regression then estimated and compared the incident rate ratios for over-dispersed count variables such as ED presentations and hospital admissions. For this univariate regression estimate, a time dummy [before the program (T1) = 0 and after the program (T4) = 1] was the only explanatory variable. A p-value < 0.05 was considered statistically significant.

2.6 Economic evaluation

The economic analysis focused on understanding the cost per additional improvement in participants' health-related quality of life (HRQoL). Disease-specific HRQoL is measured/calculated by examining changes in the CAT score of COPD patients. Findings from a narrative review demonstrates the impact of uncontrolled COPD symptoms on the burden of disease, and that improved acknowledgement and understanding of poorly managed COPD are central to tackling this burden [26]. Using changes in CAT scores and changes in healthcare utilisation enables estimates of the overall cost savings or increases.

A health care provider perspective was taken, so indirect costs such as travel cost or losses in productivity were ignored. The time perspective was one year; therefore, no discounting was undertaken on costs and consequences.

To compare the program's impact on costs, baseline costs (cost of healthcare services used 12 months before the program) and post interventions (costs of healthcare services used 12 months after the program) were compared. First, the mean difference in CAT score (HRQoL) of patients at the two time periods was calculated. Then, the total additional or incremental program delivery cost per patient was calculated. Lastly, the program's additional cost (per patient) was divided by the mean change in CAT score to calculate the cost per CAT score change. Thus, cost-effectiveness was assessed by dividing the mean difference in cost per person (before and after the intervention) with the net change in health outcome or mean difference in HRQoL. The minimum clinically important improvement for the CAT score was taken to be -2.0 [17].

The cost per healthcare service provided was multiplied by the number of services provided to calculate the total cost for all patients before and after the program. Next, the total cost of three key health care services (discussion with a health professional, ED presentations, hospital

admission) was divided by the number of patients. This generated the mean cost per patient before and after the program. For simplification, its assumed that the cost per event remained fixed. Then, the differences in cost (before and after) for each service provided was calculated and summed to generate the total additional cost or cost savings from the program. Lastly, the overall net benefit of the education program was measured by multiplying the change in CAT score with assumed willingness to pay (WTP) for each unit of improvement and then deducting the additional healthcare costs from the value (Health Outcome x WTP – additional healthcare cost).

The validity of the findings was subjected to sensitivity analysis with a Monte Carlo simulation of 1000 iterations conducted. These generated cost-effectiveness planes that express uncertainty around the ICERs related to HRQoL. The simulated differences in health outcomes (CAT scores) were plotted against the differences against costs before and after the education program.

Ethical approval for the research came from University of Southern Queensland (H21REA124).

3. RESULTS

3.1 Descriptive analysis and patient characteristics

Demographic characteristics, health status, lifestyle variables and healthcare services usage are presented in Table 1. The table shows the two timelines for the 81 participants on which complete data was held. Some variables are time-invariant (e.g., gender), and others vary between times, which enables tests to be conducted to check whether mean differences between T1 and T4 are statistically significant.

The majority of participants were male (67.90%), and the mean age at T1 was 72.2 years. 72.4% of the participants were ex-smokers, and 12.35% continued smoking, which decreased slightly in

T4 (Table 1). They had 43.80 pack-years of smoking. More than half of the participants suffered from moderate COPD (56.79 vs 54.32), followed by severe COPD (27.16 vs 28.27). The weekly physical activity (minutes) showed much improvement pre- and post-intervention (123.21 vs 144.56); however, the mean difference was not statistically significant. Notably, a considerable number of participants did not use inhaler 1 (45%) and inhaler 2 (32%) correctly at T1. However, this improved significantly after the program. Moreover, participants who always adhered to medication jumped by almost 10% (82.81% vs 92.19%). Participants also reported a lower number of flare-ups at T4 than T1. After the program, patients showed significantly lower utilisation of primary care services (mean value: 6.88 vs 4.98) and ED presentations (mean value: 1.19 vs 0.51). These mean differences were statistically significant. The total number of hospitalisation admission events also reduced marginally from T1 (0.64) to T4 (0.43). Most importantly, the primary health outcome measurement, total CAT score, declined significantly before (mean value: 20.62) and after (mean value: 16.91).

Table 1: Characteristics of participants and healthcare utilisation (T1 vs T4) (N=81)

Measured Parameters	T1	T4	Chi2 (df)	P-value
Gender (%)				
Male	67.90			
Female	32.10			
Age (mean years)	72.2 (1.03)	73.60 (2.00)		
Pack-years of smoking	43.80 (4.09)			
Work exposures (%)				
Yes	50.63			
No	49.37			
Smoking status (%)				
Current smoker	12.35	9.27		
Never smoked	14.81	14.81		
Ex-smoker	72.4	75.92		
Stage of COPD (%)				
Unsure/Mild	16.05	17.41		
Moderate	56.79	54.32		
Severe	27.16	28.27		
Total physical activity (minutes per week)	123.21 (116)	144.56 (122)	-1.13 (158)	0.26
diagnosis (%)				
COPD	72.84	70		
Asthma COPD Overlap	27.16	30		
Inhaler 1 technique correct (%)				
Yes	55.69	100	43.00	0.00
Inhaler 2 technique correct				
Yes	67.74	93.85	14.11	0.00
Adherence to medications (%)			-1.48 (160)	0.14
Always	82.81	92.19		
Most of the time	7.81	1.56		
Some of the time	3.13	0		
A little of the time	1.56	3.13		
Not at all	4.69	3.13		
Flare-ups in the last 12 months (mean)	2.32 (0.24)	1.92 (0.26)	1.09 (158)	0.28
Discuss COPD with professional last 12 months	6.88 (0.34)	4.98 (0.41)	31.32 (153)	0.00
ED presentations in the last 12 months (mean)	1.19 (1.76)	0.51 (1.22)	2.83 (158)	0.00
Hospitalisation in the last 12 months (mean)	0.64 (0.99)	0.43 (1.18)	1.22 (158)	0.22
CAT total score (HRQoL) Mean)	20.62 (7.27)	16.91 (8.12)	3.71 (162)	0.00

3.2 Clinical effectiveness of the program

Table 2 demonstrates a comparison of the changes in total CAT score and the total number of healthcare services used at T1, T2, T3 and T4. It is evident that at each timeline CAT scores and the number of healthcare services consumed both reduced. The change in health outcome and healthcare use between T1 and T4 is measured. Figure 1 depicts the average reduction in CAT total scores and an increase in weekly physical activities for patients. This is an indication of the positive health impacts of the education program. The average reduction in CAT total score from T1 to T4 was 3.71 (95% CI: 1.33-6.08, P-value<0.05).

The relationship between the education program and healthcare utilisation were examined using univariate negative binomial regression. Twelve months after completing the program (T4), patients reported significantly lower ED presentations (IRR: 2.36; 95% CI:1.32-4.23), hospital admissions (IRR: 1.49; 95% CI: 0.80-2.76) and discussions with health professionals (IRR: 1.38; 95% CI: 1.14-1.67). Holding other things constant, patients at T1 had 2.36 times (P-value<0.05) higher likelihood of ED presentation and 1.49 times higher likelihood of hospital admission compared to T4.

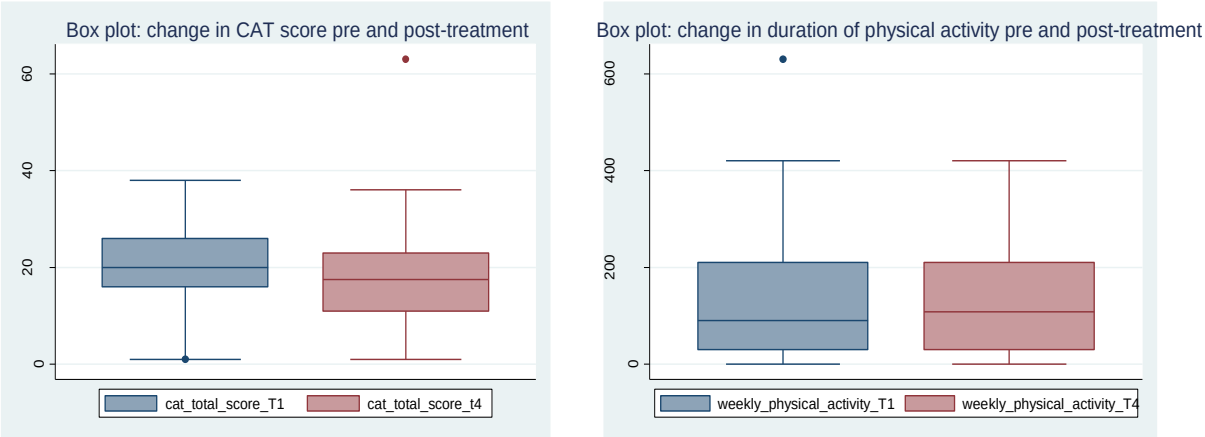

Figure 1: Box plot of average change (T1 vs T4) in CAT score and weekly physical activities

Table 2: CAT (HRQoL) and healthcare utilisation at baseline, 3, 6, 12 & 18 months (N=81)

Measured parameters (Total)	T1	T2	T3	T4	Treatment effect (health and healthcare use)		Univariate Negative Binomial Regression	
					Mean Change [T4-T1]	***95% CI***	***IRR (SE)***	***95% CI***
CAT total score or Disease-specific measure (HRQoL)	1670	1414	1224	1390	-3.71*	1.33-6.08		
Discuss COPD with professional last 12 months	558	610	620	369	-1.77*	0.47-3.06	1.38* (0.13)	1.14-1.67
ED presentation events in the last 12 months	97	103	107	40	-0.68*	0.61-0.109	2.36* (0.70)	1.32-4.23
Hospitalisation events in the last 12 months	52	62	64	34	-0.21	-0.13-0.54	1.49 (0.47)	0.80-2.76

Note: T1 is baseline before the start of the education program, T2 is 3 months into the education program, T3 is 6 months into the education program and T4 is 12 months after the end of the education program. CI is the confidence interval, IRR is the incident rate ratio and SE means standard error. For ED presentations: Likelihood-ratio test of alpha=0: chibar2(01) = 79.57, Prob>=chibar2 = 0.000. For hospitalisation: Likelihood-ratio test of alpha=0: chibar2(01) = 40.72, Prob>=chibar2 = 0.000. For discuss COPD with professional: Likelihood-ratio test of alpha=0: chibar2(01) = 42.18 Prob>=chibar2 = 0.000.

3.3 Gender-difference in program impacts

There are significant gender differences in HRQoL and healthcare utilisation at T1 and T4 (Appendix Table A1). The adjusted mean CAT score was considerably more for men (22) at T1 compared to women (17). At T4, the reduction in mean CAT score was 4.93 (P-value<0.05) for men and 0.97 (P-value>0.05) for women. Men had considerably higher mean numbers of COPD-related discussions with health professionals, ED presentations and hospital admissions, at both T1 and T4.

At T4, men's mean discussions with health professionals reduced from 7.07 to 5.31 and ED presentations decreased from 1.36 to 0.61 (both significant). However, women had a significantly

higher engagement in physical activities compared to men in both T1 and T4 with women reporting a 58-minute increase in weekly physical activities.

3.4 Economic evaluation

Summary of the cost data and healthcare consumed at T1 and T4 is presented in Table 3. Four cost components (healthcare services) have been used. First, the mean cost of each service was multiplied by the number of events. Next, the mean cost per patient for each service was calculated by dividing the total estimated cost by number of patients (n=81). Then, the costs per patient to estimate the mean total cost of healthcare utilisation of the patients at T1 and T4 were added. Importantly, the cost of the education program was zero at T1 compared to $48,092 in T4. However, due to the overall lower number of healthcare services consumed, the total estimated cost savings from the education program was $168,110, which is approximately $2,075 for each patient. Therefore, it is evident that the overall cost of COPD related treatments reduced for these 81 patients at T4 ($4,901) in comparison to T1 ($6,977).

Table 3: Cost data calculations

Mean annual cost per patient	T1 (COPD patients healthcare use 12 months before the intervention)			T4 (COPD patients healthcare utilisation 12 months after the intervention)			Cost difference ($)	Source of cost data
(N= 81)	Number of events or services	Cost ($) per event	Total cost per patient (n=81)	Number of events	Cost ($) per event	Total cost per patient (n=81)	T4-T1	
COPD management education course	0	593.73	0	81	593.73	48,092.13	48,092.13	Authors Calculation
Discuss COPD with professional last 12 months	558	39.10	21,817.80	369	39.10	14,427.90	-7,390.80	Medicare rebate for GP visit
ED presentations in last 12 months.	97	885.12	85,856.64	40	885.12	35,404.80	-50,451.64	Rana et al. 2020
Hospitalisation in last 12 months	52	8,797.80	457,485.60	34	8,797.80	299,125.20	-158,360.40	Rana et al. 2020
Total cost saving from the education program for 81 patients at T1 vs T4.			565,160.04			397,050.03	-168,110.01	
Cost of healthcare utilisation (per COPD patient)			6,977.28			4,901.85	-2,075.43	

Note: Mean cost per patient = [(Cost per event x total event)/ total number of patients]. Some values were indicated as more than 10 by the respondents. All these values were converted into 10 as the actual value was unknown.

It costs $160.46 for the program to reduce each unit of CAT score, holding all other key variables constant (Table 4). The clinically significant reduction in CAT total score ranges 2-3.76 per patient, and that is a one-unit improvement in COPD patients HRQoL. Therefore, the estimated

cost of producing a clinically significant improvement (for a similar cohort of patients) in the HRQoL of COPD patients is $321 ($160.46 x 2) with this program. Increasing this by 50% to $481 per clinically recognised HRQoL, the program will be cost-effective (holding all other things constant) at willingness to pay values of $500 or above. Next, a reduction of 3.76 as one-unit movement in HRQoL is assumed. Then, the cost per unit improvement in HRQoL is $601.78. Therefore, the program is cost-effective. Given the lower level of healthcare consumption and eventual cost savings of COPD related treatment after the education program is adopted, it can be concluded that the program improves health outcomes while reducing costs. Hence, it dominates the alternative of no education program.

3.5 Sensitivity analysis

The results of the Monte Carlo simulation on cost per unit of CAT total score reduction difference is shown in the Appendix (Figure A1). The assumption was that all COPD treatment and management related costs remain constant in the 12 months before and after the program. This is a very conservative assumption as lower levels of healthcare use and costs after the program was estimated. Therefore, only the program delivery cost per patient as the incremental cost to develop this cost-effectiveness plane were considered. Furthermore, the reduction in CAT score is the only measure of improvement in HRQoL. The results from the sensitivity analysis generally conform to the expected cost-effectiveness results. 99.95% fell into the northeast quadrant, indicating increased HRQoL at an incremental cost.

Table 4: Incremental cost effectiveness results for HRQoL

	Incremental analysis differences in means ($) **(T1 vs T4)**	**Base-case (Range in sensitivity analysis)**	**Net Benefit (Health Outcome x WTP) – Additional healthcare cost**
Cost analysis			
Total healthcare cost per patients	593.73	599.47 (247.43; 916.05)	If WTP = $500 per unit of reduction in CAT score (3.71 x $500)- 593.73 = $1261.27
Effectiveness analysis			
Disease-specific measure (CAT total score)	-3.71	3.69 (0.29; 8.64)	If WTP = $1,000 per unit of reduction in CAT score (3.71 x $1000)- 593.73 = $3116.27
Incremental cos-effectiveness ratio			
Disease-specific measures (Cost per CAT total score reduced)	160.46	191.31 (52.96; 2094.53)	If WTP = $2,000 per unit of reduction in CAT score (3.71 x $1000)- 593.73 = $6826.27
Cost per two-unit reduction in CAT total score	320.92		
Cost per 3.76 units reduction in CAT total score	601.78		
Probability that the intervention is cost-effective at the threshold value	The intervention will be cost-effective at willingness to pay threshold of $5000 and above.		

Note: Healthcare Outcome = per unit reduction in CAT score. Noticeably, in this study QALY was not calculated. Reduction in CAT score is assumed to be the improvements in HRQoL. Minimal clinically important difference in CAT score is 2 [Kon (2017); Smid (2014)] and 3.76 [Tsiligianni et al. (2012)].

4. Discussion

These research outcomes have further confirmed the findings of Joo et al., by adding to the pool of evidence that longitudinal nurse case management programs can reduce hospital utilisation for individuals with COPD [7]. The significance of these economic and HRQoL findings validates previous ED and admission avoidance research of COPD patients by [8,9,10] which strongly advocated for effective longitudinal patient support and mentorship interventions to reduce unnecessary exacerbations and ED and hospital presentations. The research has therefore confirmed that nurse led programs can be relatively effective in reducing costs and ED visitation burden and leads to a question around long term benefit to this patient population. This study was only a small case study of potential improved management of a lifelong disease. Continuous nurse case management models as recommended by [7] and supported by the evidence of this research should be a key focus moving forward for more clinically effective and cost saving management of COPD in a primary health setting.

4.1 Limitations

There are several limitations to this study both clinically and economically. Nurses could not observe patient inhaler techniques directly, rather they relied on how patients described the steps they take to use their inhaler over the telephone. Correct use of inhalers is an essential part of COPD management, and an important aim of the program was to reduce errors related to inhaler use techniques.

5. Conclusions

This paper aimed to examine if a nurse-led telehealth education program for COPD could improve patient health, lead to a reduction in healthcare utilisation, improve patient HRQoL and provide an economic benefit to the health care system.

Following data collection, both patient and cost, it is concluded that the nurse-led education program improves HRQoL of COPD patients and reduced overall healthcare costs in the follow-up year in this setting. Therefore, both study hypotheses hold.

Given it was unclear in an Australian context as to the nature of potential facilitators like a nurse led telehealth education program for COPD patients or inefficiencies influencing overall healthcare utilisation, especially ED presentations, this research study was well justified.

Funding

No funding was received for this evaluation.

Disclosure of Interest

The authors state they have no conflicts of interest to declare.

Data Availability

The data that support the findings are available from the corresponding author upon request.

References

1. Australian Institute for Health and Welfare (AIHW). 2019. Prevention of Chronic Obstructive Pulmonary Disease 2019. AIHW, Canberra.

2. Yang IA, George J, McDonald CF, et al. 2020. The COPD-X Plan: Australian and New Zealand Guidelines for the Management of Chronic Obstructive Pulmonary Disease. Thoracic Society of Australia and New Zealand. Sydney.

3. Lari S, Attaran, D, Tohidi M. 2014. Improving communication between the physician and the COPD patient: an evaluation of the utility of the COPD Assessment test in primary care. Patient Relat Outcome Meas. 5, 145-52. doi: 10.2147/PROM.S54484.

4. World Health Organization (WHO). 2018. Continuity and coordination of care: a practice brief to support implementation of the WHO Framework on integrated people-centred health services. WHO, Geneva.

5. Direct Health. 2020. Emphysema and COPD statistics 2020. Canberra.

6. Issac H, Taylor M, Moloney C, et al. 2021. Exploring Factors Contributing to Chronic Obstructive Pulmonary Disease (COPD) Guideline Non-Adherence and Potential Solutions in the Emergency Department: Interdisciplinary Staff Perspective. J Multidiscip Healthc. 14, 767-785. doi: 10.2147/JMDH.S276702.

7. Joo JY, Liu MF. 2017. Case management effectiveness in reducing hospital use: a systematic review. Int Nurs Rev. 64(2), 296-308. doi: 10.1111/inr.12335

8. Moloney C, Sneath E, Phillips T, et al. 2019. Recommendations and practices for holistic chronic obstructive pulmonary disease (COPD) assessment and optimal referral patterns in

emergency department presentations: a scoping review protocol. BMJ Open. 9(8), e030358. dx.doi.org/10.1136/bmjopen-2019-030358

9. Rana, R, Gow, J, Moloney, C, et al. 2020. A. Does distance to hospital affect emergency department presentations and hospital length of stay among COPD patients. Intern Med J. doi.org/10.1111/imj.15014

10. Rana, R., Gow, J., Moloney, C., et al. 2021. Estimating the frequency and cost of emergency department presentations and hospitalisation of chronic obstructive pulmonary disease patients: A retrospective analysis from regional Queensland. Emerg Med Australas. 33, 491-498. doi: 10.1111/1742-6723.13665

11. Jones PW, Harding G, Berry P, et al. 2009. Development and first validation of the COPD assessment test. Eur Respir J. 34, 648–54. doi:10.1183/09031936.00102509.

12. Tsiligianni, IG., van der Molen, T., Moraitaki, D. et al. 2012. Assessing health status in COPD. A head-to-head comparison between the COPD assessment test (CAT) and the clinical COPD questionnaire (CCQ). BMC Pulm Med. 12, 20. doi.org/10.1186/1471-2466-12-20.

13. Miravitlles, M, García-Sidro, P, Fernandez-Nistal, A, et al. 2013. Course of COPD assessment test (CAT) and clinical COPD questionnaire (CCQ) scores during recovery from exacerbations of chronic obstructive pulmonary disease. Health Qual Life Outcomes 11, 147. doi:10.1186/1477-7525-11-147

14. Jones PW, Tabberer M, Chen WH. 2011. Creating scenarios of the impact of COPD and their relationship to COPD assessment test (CAT) scores. BMC Pulm Med. 11, 42. doi: 10.1186/1471-2466-11-42.

15. Smid DE, Franssen FM, Houben-Wilke S, et al. 2017. Responsiveness and MCID Estimates for CAT, CCQ, and HADS in Patients with COPD Undergoing Pulmonary Rehabilitation: A Prospective Analysis. J Am Med Dir Assoc. 18, 53–58. doi: 10.1016/j.jamda.2016.08.002

16. Lee, S.D., Huang, M.S., Kang, J., et al. 2014. The COPD assessment test (CAT) assists prediction of COPD exacerbations in high-risk patients. Respir Med. 108(4), 600-608. doi: 10.1016/j.rmed.2013.12.014

17. Kon SS., Canavan JL., Jones SE., et al. 2014. Minimum clinically important difference for the COPD Assessment Test: a prospective analysis. Lancet Respir Med. 2(3), 195-203. doi:10.1016/s2213-2600(14)70001-3

18. Smid DE, Franssen FM, Gonik M, et al. 2017. Redefining Cut-Points for High Symptom Burden of the Global Initiative for Chronic Obstructive Lung Disease Classification in 18,577 Patients with Chronic Obstructive Pulmonary Disease. J Am Med Dir Assoc. 18(12), 1097. doi: 10.1016/j.jamda.2017.09.003.

19. Alma, H., de Jong, C., Tsiligianni, I., et al. 2018. Clinically relevant differences in COPD health status: systematic review and triangulation. Eur Respir J. 52(3), 1800412. doi:10.1183/13993003.00412-2018

20. Gimeno-Santos E, Frei A, Steurer-Stey C, et al. 2014. Determinants and outcomes of physical activity in patients with COPD: a systematic review. Thorax. 69:731-739. doi: 10.1136/thoraxjnl-2013-204763

21. Australian Institute of Health and Welfare. (AIHW) 2020. Chronic obstructive pulmonary disease (COPD). Cat. no. ACM 35. AIHW, Canberra.

22. Australian Institute of Health and Welfare (AIHW). 2015. Hospital Performance: Costs of acute admitted patients in public hospitals in 2011–12. Cat. no. HPF 55. AIHW, Canberra.

23. Royston, JP. 1983. Some techniques for assessing multivariate normality based on the Shapiro-Wilk W. J R Stat Soc Ser C Appl Stat. 32(2), 121-133. doi.org/10.2307/2347291

24. Xu, M, Fralick, D, Zheng, JZ, et al. 2017. The Differences and Similarities Between Two-Sample T-Test and Paired T-Test. Shanghai Arch Psychiatry. 29(3), 184–188. https://doi.org/10.11919/j.issn.1002-0829.217070.

25. Kirkwood BR, Sterne JAC. 2003. *Essential Medical Statistics*, 2nd ed. Blackwell, Oxford. pp: 58-79.

26. Miravitlles, M., Ribera, A. 2017. Understanding the impact of symptoms on the burden of COPD. Respir Res. 18, 67. https://doi.org/10.1186/s12931-017-0548-3

Appendix

Table A1: Gender-differences in HRQoL and healthcare utilization for patents participated in nurse-led education program

Measured Parameters	T1	T4	T1	T4	t-stat (P-value)	t-stat (P-value)
	Male (n=55)	Male (n= 55)	Female (n= 26)	Female (n= 26)	Male	Female
CAT score (HRQoL) Mean)	22.05 (7.08)	17.12(8.28)	17.57 (6.38)	16.6 (7.91)	3.35 (0.00)	0.54 (0.58)
Discuss COPD with professional last 12 months	7.07 (3.12)	5.31 (3.5)	6.5 (3.03)	4.36 (3.46)	2.69 (0.00)	2.35 (0.02)
ED presentations in the last 12 months	1.36 (1.76)	0.61 (1.31)	0.85 (1.73)	0.28 (1.02)	2.52 (0.01)	1.41 (0.16)
Hospitalisation in the last 12 months	0.76 (1.03)	0.50 (1.25)	0.38 (0.85)	0.28 (1.02)	1.19 (0.23)	1.94 (0.05)
Total Weekly Physical activity (Mean minutes)	114.45 (116)	118.98 (97)	141.73 (114)	199.8 (153)	-0.22 (0.83)	-1.54 (0.14)

Note: Average age of male participants = 73.62 years, and female participants = 69.34 years.

Figure A1: Cost-effectiveness plane of the differences in costs against the differences in reduction in CAT total scores