

A Respiratory Therapist Disease Management Program for Patients Hospitalized With COPD

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BACKGROUND: Patients with COPD often require repeated emergency department visits and hospitalizations for COPD exacerbations. Such readmissions increase health-care costs and expose COPD patients to the added risks of nosocomial infections and increased mortality. **METHODS:** To determine whether a respiratory therapist (RT) disease management program could reduce re-hospitalization and emergency department visits, a prospective, single-center, unblinded, randomized trial was performed. **RESULTS:** We enrolled 428 subjects (214 intervention, 214 control). The primary outcome (combined non-hospitalized emergency department visits and hospital readmissions for a COPD exacerbation during the 6-month follow-up) was similar for the study groups (91 vs 159, $P = .08$). When the 2 components of the primary end point were analyzed individually, the percentage of subjects with non-hospitalized emergency department visits for COPD exacerbations was similar between groups (15.0% vs 15.9%, $P = .79$). Readmission for a COPD exacerbation was significantly lower in the intervention group (20.1% vs 28.5%, $P = .042$). The median (interquartile range) duration of hospitalization for a COPD exacerbation was less for the intervention group (5 [3–11] d vs 8 [4–18.5] d, $P = .045$). In-patient hospital days (306 d vs 523 d, $P = .02$) and ICU days (17 d vs 53 d, $P = .02$) due to COPD exacerbations were significantly less for the intervention group. Mortality was similar for both groups (1.4% vs 0.9%, $P > .99$). **CONCLUSIONS:** Our RT disease management program was associated with less readmission, fewer ICU days, and shorter hospital stays due to COPD exacerbations. Further studies are needed to determine the optimal utilization of RT disease management teams for patients with COPD to optimize outcomes and prevent return hospital visits. (ClinicalTrials.gov registration NCT01543217.) *Key words:* chronic obstructive pulmonary disease; disease management; hospital readmission. [Respir Care 0;0(0):1–•. © 0 Daedalus Enterprises]

Introduction

Patients with COPD often require frequent hospital admissions and/or visits to the emergency department for exacerbations of their lung disease.^{1,2} Such readmissions increase health-care costs and expose COPD patients to

the added risks of readmission, including nosocomial infections and increased risk of mortality.³ It is common for many of these repeat visits to occur within 30–180 d fol-

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lowing hospital discharge for a COPD exacerbation.^{3,4} There is little clinical experience and data examining the impact of a respiratory therapist (RT) disease management transition team to facilitate the hospital discharge of patients with COPD to the out-patient setting. Disease management can be broadly defined as a comprehensive strategy for improving overall health status and reducing health-care costs in chronic conditions.⁵ These programs are often conducted by physician extenders and may include education about the underlying disease, optimization of evidence-based medications, support from case managers, and institution of self-management principles.⁶

Disease management programs for chronic medical conditions, such as congestive heart failure and diabetes mellitus, have been successfully implemented.^{7,8} More recently, disease management programs for COPD have also been studied.^{9,10} However, the previous studies did not assess a mixed population representative of the general case mix cared for in most United States hospitals, including both males and females, individuals with and without health insurance, and non-veterans. Therefore, we performed a study to determine whether an RT disease management program could reduce re-hospitalization and emergency department visits for subjects hospitalized with an exacerbation of COPD.¹¹

Methods

Study Design

The study was conducted at Barnes-Jewish Hospital, a 1,250-bed urban academic hospital. During a 42-month period (July 2012 to December 2015), hospitalized patients with a diagnosis of COPD were evaluated. The Washington University Human Research Protection Office approved the protocol (approval number 201201116). Eligible subjects were identified by a study investigator using daily logs for bronchodilator treatments from the Department of Respiratory Care Services. Study subjects were randomly assigned to treatment groups in a 1:1 ratio using blocked randomization ($n = 4/\text{block}$). Severity of illness was assessed by APACHE II (Acute Physiology and Chronic Health Evaluation II) scores.¹² In addition to outcomes and demographic data, we also collected data on potentially confounding respiratory conditions to include asthma and obstructive sleep apnea, health insurance status, primary care physician access, spirometry, medications, and comorbidities. Data were collected throughout the 6-month follow-up period following study enrollment.

Inclusion and Exclusion Criteria

To be eligible, subjects had to be >18 y and <65 y of age, have spirometry-confirmed evidence of COPD, and

QUICK LOOK

Current knowledge

The use of respiratory therapist disease management teams has been associated with mixed outcome results from clinical trials examining their implementation. There is no current consensus on whether respiratory therapist disease management teams should be routinely employed.

What this paper contributes to our knowledge

Implementation of a respiratory therapist disease management team within a large teaching hospital was associated with fewer hospital admissions, fewer intensive care unit days, and shorter hospital stays due to COPD exacerbations. The use of respiratory therapist disease management teams should receive further evaluation to determine if these results can be expanded to other hospital settings.

be at high risk for repeat hospitalization or emergency department visits as predicted by a hospital admission or emergency department visit in the previous 12 months for a COPD exacerbation, chronic home use of oxygen, or treatment with a course of systemic corticosteroids in the preceding 12 months. Our study only enrolled subjects under the age of 65 y due to the presence of a hospital-sponsored clinic for Medicare-eligible patients focused on providing post-discharge care to these individuals. The goal of this clinic was to prevent COPD readmissions to reduce undercompensated hospital care due to readmission. Spirometry criteria for COPD within 12 months of study enrollment included either an $FEV_1/FVC < 0.7$ or an $FEV_1 < 80\%$ predicted (performed before bronchodilator administration). Exclusion criteria included not being expected to survive the hospitalization, the presence of metastatic cancer, bed-bound individuals, non-English speaking, and inability to provide informed consent.

Interventions

Subjects assigned to the control group had their in-patient COPD care and hospital discharge planning and orders done in a conventional manner as dictated by the treating physicians. Additionally, each control subject received a one-page handout containing a summary of the principles of COPD care as developed by the Department of Respiratory Care Services and the telephone number of the medical clinic or physician's office where they were scheduled to receive follow-up care. Subjects assigned to the intervention arm had their in-patient care coordinated

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by RTs who focused on the study protocol elements (see the supplementary materials at <http://www.rcjournal.com>). Out-patient treatment physicians were not made aware of subject treatment assignments.

Subjects in the intervention arm also received a 1-h education in-service conducted by an RT case manager in accordance with the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines.¹³ The subject education session included general information about COPD, direct observation of inhaler techniques, a review and adjustment of out-patient COPD medications, smoking cessation counseling, recommendations concerning influenza and pneumococcal vaccinations, encouragement of regular exercise, and instruction in hand hygiene.¹⁴ The RT case managers conducting the education in-services all took the COPD Educator Certification Preparation Course.¹⁵ Each subject assigned to the intervention group also received an individualized written action plan along with the telephone number of the RT case manager who was assigned to oversee these interventions (see the supplementary materials).

All subjects received scheduled telephone calls, as indicated in the supplementary materials. Briefly, the scheduled telephone calls for subjects in the intervention group were to determine whether non-Barnes-Jewish Hospital readmissions had occurred and to determine whether the subject had any specific questions, concerns, or needs related to their COPD medications and/or other treatments. For subjects in the control group, the telephone calls only addressed non-Barnes-Jewish Hospital readmissions.

Outcomes

The primary outcome was the combined number of non-hospitalized emergency department visits and hospital admissions for a COPD exacerbation during the 6-month follow-up period after study enrollment. Secondary outcomes included the components of the primary outcome, hospital readmissions, and non-hospitalized emergency department visits for causes other than COPD exacerbations, hospital and ICU lengths of stay for study subjects requiring readmission, and all-cause mortality.

Statistical Analysis and Sample Size Justification

We estimated that 33% of hospitalized subjects with COPD would require hospital readmission and/or an emergency department visit within 90–180 d of their discharge date based on historic trends at Barnes-Jewish Hospital for the 12-month period preceding this investigation (30-d readmissions for COPD by month between 24 and 37%) and the reported literature.^{3,9,10} The intervention was estimated to reduce this by 36%,⁹ which required a sample size of

428 subjects (214 subjects for each group, power = 0.8 and $\alpha = 0.05$) for a statistically valid analysis. Categorical variables were compared using chi-square or Fisher's exact test as appropriate. Continuous variables were compared using the Mann-Whitney U test. We confirmed the results of the univariate analysis using multivariate analyses (see the supplementary materials). A *P* value of .05 was considered statistically significant, and all analyses were 2-sided (SPSS 22.0, SPSS, Chicago, Illinois).

Results

A total of 2,689 patients were screened for participation based on the Department of Respiratory Care Services bronchodilator logs (Fig. 1). Four hundred twenty-eight subjects were enrolled (214 intervention, 214 control) with 423 (98.8%) subjects completing the 6-month study end point. Subjects in both groups had similar demographics, health insurance status, access to a primary care physician, use of home noninvasive ventilation and home oxygen therapy, smoking status, and severity of illness at baseline (Table 1). The number of subjects having an emergency department visit or a hospital admission in the previous 12 months was also similar between study groups. Table 2 shows that there were more subjects with a diagnosis of asthma, prescribed a leukotriene receptor antagonist, prescribed nasal corticosteroids, and with a diagnosis of obstructive sleep apnea at baseline in the intervention group.

The mean number of follow-up telephone calls performed per subject was similar for the intervention and control groups (4.9 ± 0.2 calls vs 4.9 ± 0.3 calls, *P* = .19). All subjects except for the 5 (1.2%) who died before study completion had a 6-month follow-up call. There were significantly more study subjects directly spoken to in the intervention group during these calls as opposed to family members or surrogates (3.2 ± 1.2 calls vs 2.9 ± 1.2 calls, *P* = .01). For subjects in the intervention group, the following RT disease management protocol items were confirmed during at least one telephone call: attendance at follow-up clinic appointment, 135 (63.1%); successfully obtaining COPD medication prescription assistance, 15 (7.0%); success in quitting smoking since hospital discharge, 92 (43.0%); referral for sleep study or to titrate noninvasive ventilation settings, 59 (27.8%); referral for pulmonary rehabilitation program or exercise program, 36 (16.8%).

The combined number of non-hospitalized emergency department visits and hospital readmissions for a COPD exacerbation was not statistically different for the intervention and control groups (91 vs 159, *P* = .08) (Fig. 2). The individual components of the primary end point were also analyzed separately. The percentage of subjects with non-hospitalized emergency department vis-

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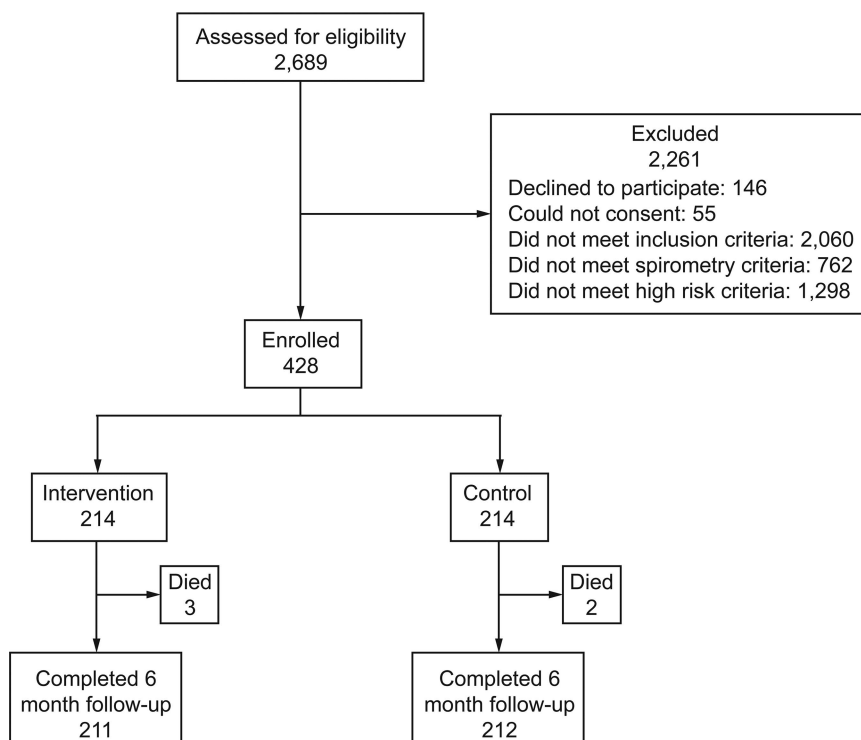


Fig. 1. Flow chart.

its for a COPD exacerbation, as well as for conditions other than COPD and for any condition, was similar between study groups (Table 3). The number of subjects with multiple non-hospitalized emergency department visits was significantly lower for the intervention group (0.9% vs 7.0%, $P = .001$). The percentage of subjects requiring at least one hospital readmission for a COPD exacerbation was significantly less in the intervention group (Table 4). The number of subjects with multiple hospital admissions was significantly lower in the intervention group (4.2% vs 10.3%, $P = .02$). The number of subjects requiring ICU admission was significantly lower in the intervention group for subjects with COPD exacerbations (1.4% vs 5.6%, $P = .03$) and for all combined conditions (5.1% vs 12.6%, $P = .01$).

The median (interquartile range) duration of hospitalization for a COPD exacerbation was less for subjects in the intervention group (5 [3–11] d vs 8 [4–18.5] d, $P = .045$). Total in-patient hospital days and ICU days due to COPD exacerbations were significantly less for the intervention group (Table 5). Total in-patient ICU days due to conditions other than COPD exacerbations and for all conditions combined were also significantly less for the intervention group. Mortality during the 6-month follow-up period was similar for the intervention and control groups (1.4% vs 0.9%, $P > .99$).

Multiple logistic regression analysis confirmed that hospital readmission for a COPD exacerbation was signifi-

cantly less for subjects in the intervention arm after adjusting for potential confounders to include asthma, obstructive sleep apnea, use of leukotriene receptor antagonists, use of nasal corticosteroids, and daily alcohol ingestion (adjusted odds ratio 0.541, 95% CI 0.425–0.689, $P = .001$) (Hosmer-Lemeshow goodness of fit 0.727). A generalized linear model confirmed that there were fewer hospital readmissions for COPD exacerbations in the intervention arm (beta coefficient -0.714 , 95% CI -1.056 to -0.372 , $P < .001$) after adjusting for potential confounders.

Discussion

We found that an RT disease management team significantly reduced the number of hospital readmissions for COPD exacerbations but not emergency department visits in the 6-month period following study enrollment. Additionally, the median stay for a COPD exacerbation, as well as the total number of in-patient hospital days and ICU days for COPD exacerbations, was significantly lower for patients assigned to the intervention.

Our study adds to the available experience regarding formal disease management approaches to prevent disease exacerbations and re-hospitalization for COPD. A similar Department of Veterans Affairs intervention found that emergency department visits were reduced by 41% in the disease management group with substan-

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Table 1. Baseline Characteristics

Characteristics	Intervention Arm (n = 214)	Control Arm (n = 214)	P
Age, median (IQR) y	56 (50–60.25)	56.5 (51–61)	.26
Race, n (%)			>.99
Caucasian	95 (44.4)	94 (43.9)	
African American	117 (54.7)	118 (55.1)	
Other	2 (0.9)	2 (0.9)	
Male sex, n (%)	93 (43.5)	106 (49.5)	.21
Insurance status, n (%)			
Private	38 (17.8)	32 (15.0)	.43
Medicare/Private	10 (4.7)	14 (6.5)	.40
Medicare	24 (11.2)	30 (14.0)	.38
Medicare/Medicaid	45 (21.0)	27 (12.6)	.02
Medicaid	70 (32.7)	82 (38.3)	.23
None	27 (12.6)	29 (13.6)	.77
Primary care physician status, n (%)			.54
Private	92 (43.0)	99 (46.3)	
Resident clinic	99 (46.3)	88 (41.1)	
None	23 (10.7)	27 (12.6)	
Home noninvasive ventilation, n (%)	56 (26.2)	53 (24.8)	.74
Home oxygen therapy, n (%)	88 (41.1)	102 (47.7)	.17
Prescribed corticosteroids in past year, n (%)	189 (88.3)	178 (83.2)	.13
Emergency department visits in past year, n (%)*	100 (46.7)	91 (42.5)	.38
Hospitalized in past year, n (%)	131 (61.2)	119 (55.6)	.24
Smoking status, n (%)			
Current	107 (50.0)	89 (41.6)	.08
Quit	85 (39.7)	89 (41.6)	.69
Never	22 (10.3)	36 (16.8)	.048
Smoking, median (IQR) pack-years	35 (17–46)	37 (21–46.25)	.41
APACHE II score, median (IQR)	10 (8–12)	10 (8–12)	.89
FEV ₁ , median (IQR) % predicted	52 (37–63.5)	52 (36–65)	.80
FEV ₁ /FVC, median (IQR) %	64 (50.5–74)	63 (49–70.5)	.23

* Emergency department visits not associated with a hospitalization.

IQR = interquartile range

APACHE = Acute Physiology and Chronic Health Evaluation

tial cost savings.^{9,16} However, when the Department of Veterans Affairs studied a simplified education and self-efficacy reporting intervention, they found that re-hospitalization and emergency department visits were not reduced, suggesting that higher intensity disease management programs are most likely to be successful.¹⁷ Other studies confirmed the utility of disease management programs to reduce repeat hospitalizations for patients with COPD exacerbations.^{18,19} However, not all reported COPD disease management programs have been successful.²⁰ A large Department of Veterans Affairs study unexpectedly found contradictory results and was stopped early due to excess deaths in the disease management group.¹⁰

Our study builds upon these earlier investigations, especially those performed in the United States, by assessing the impact of an RT disease management program in a heterogeneous population from an urban med-

ical center. Most of the subjects enrolled in our study were African-American and lacked access to a primary care provider other than a teaching hospital resident clinic. Our program differed from many of the previous interventions by attempting to be comprehensive in terms of optimizing and coordinating patient activities following hospital admission. This included providing assistance in scheduling and travel to post-discharge follow-up visits, and arranging medication access assistance. However, our intervention had no significant effect on all-cause hospital readmissions or emergency department visits. The lack of impact on all-cause hospital readmissions is probably due to the diverse spectrum of readmission diagnoses differing from the index COPD diagnosis for which this intervention was specifically designed.²¹ The lack of impact on COPD emergency department visits may be due to the emergency department functioning as an out-patient or rescue clinic

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Table 2. Baseline Comorbidities and Prescribed Medications

Comorbidities/Medications	Intervention Arm (n = 214)	Control Arm (n = 214)	P
Asthma	57 (26.6)	37 (17.3)	.02
Obstructive sleep apnea	58 (27.1)	32 (15.0)	.002
Other pulmonary conditions	24 (11.2)	13 (6.1)	.058
Blind	5 (2.3)	3 (1.4)	.48
Hearing-impaired	6 (2.8)	6 (2.8)	>.99
Active illicit drug use	26 (12.1)	31 (14.5)	.48
Daily alcohol use	12 (5.6)	26 (12.1)	.02
Established psychiatric disorder	55 (25.7)	49 (22.9)	.50
Arthritis/rheumatologic condition	28 (13.1)	16 (7.5)	.056
CHF or coronary artery disease	115 (53.7)	107 (50.0)	.44
Diabetes	48 (22.4)	47 (22.0)	.91
Gastrointestinal disorder	35 (16.4)	29 (13.6)	.42
Genitourinary disorder	8 (3.7)	8 (3.7)	>.99
Hypertension	127 (59.3)	125 (58.4)	.84
Obesity*	30 (14.0)	20 (9.3)	.13
Chronic renal disease	27 (12.6)	16 (7.5)	.08
Neuromuscular condition	23 (10.7)	16 (7.5)	.24
Short-acting β agonist	202 (94.4)	191 (89.3)	.052
Long-acting β agonist	138 (64.5)	129 (60.3)	.37
Short-acting anticholinergic	43 (20.1)	33 (15.4)	.21
Long-acting anticholinergic	96 (44.9)	94 (43.9)	.85
Inhaled corticosteroid	142 (66.4)	134 (62.6)	.42
Antihistamine	17 (7.9)	11 (5.1)	.24
Leukotriene receptor antagonist	36 (16.8)	13 (6.1)	<.001
Oral corticosteroids	21 (9.8)	13 (6.1)	.15
Nasal corticosteroids	28 (13.1)	10 (4.7)	.002

All values are expressed as n (%).

* Obesity was defined as a body mass index \geq 25.

CHF = congestive heart failure

for patients with exacerbations of their disease.^{22,23} The reduction in ICU and hospital days for COPD readmissions in the intervention arm may be due to subjects coming into the hospital earlier or possibly receiving more aggressive self-care at home before readmission. Future studies are needed to fully address this issue.

Two systematic reviews of integrated disease management for patients with COPD have recently been published. Kruis et al²⁴ found that these programs improved the quality of life of subjects with COPD, improved exercise performance, and reduced hospital admissions as well as the number of hospital days per person. Similarly, Zwerink et al²⁵ reported that self-management interventions in subjects with COPD were associated with improved health-related quality of life, a reduction in respiratory-related hospital admissions, and improvement in dyspnea. However, no statistically significant differences were found in other outcome parameters, including all-cause hospitalization and mortality. These 2 systematic analyses highlight the heterogeneity among interventions, study populations, follow-up time, and outcome measures, making it difficult to establish clear recommendations regarding the

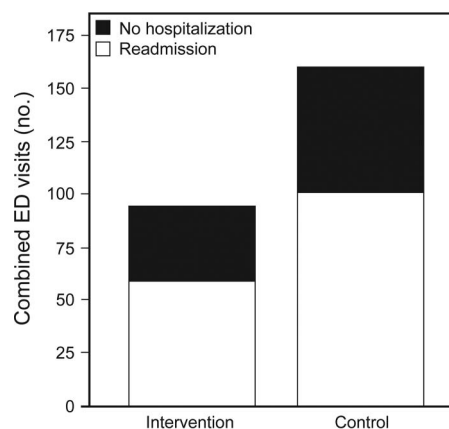


Fig. 2. Box plot demonstrating the combined number of emergency department visits without hospitalization and with hospital readmission for an exacerbation of COPD in the intervention and control groups. $P = .08$.

most effective COPD disease management programs. Moreover, these analyses, along with our data, highlight the difficulty in preventing all-cause re-hospitalization for patients with COPD because hospital readmission is often due to a medical condition other than the disease leading to the index hospitalization.²¹

A recent guideline published by the American College of Chest Physicians and the Canadian Thoracic Society has systematically evaluated the evidence from clinical trials in support of interventions aimed at preventing exacerbations of COPD.²⁶ This group recommended that simply providing education alone and case management alone should not be employed for the prevention of COPD exacerbations, because these did not appear to influence patient-specific outcomes, such as readmission and mortality. However, their review supported a recommendation for case management that included direct access to a health-care specialist at least monthly to prevent severe exacerbations of COPD as assessed by decreases in hospitalizations. Additionally, their analysis recommended education combined with a written action plan and case management to prevent exacerbations of COPD as assessed by decreased hospitalizations and emergency department visits. The authors of this guideline emphasized that specially trained staff are required to supervise education efforts and case management as well as to ensure that patient selection is individualized, to maximize the likelihood of a successful program.

Our study has several limitations. First, it was performed at a single health-care system, and the results may not be reproducible. Second, we examined subjects under the age of 65 y, limiting the scope of our findings. Third, it is likely that some of our subjects would be better classified as having asthma-COPD overlap syndrome based on their clinical characteristics.²⁷ Fourth, the RTs carrying out the

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Table 3. Outcomes: Emergency Department Visits

Outcomes	Interventional Arm (<i>n</i> = 214)	Control Arm (<i>n</i> = 214)	<i>P</i>
At least one COPD emergency department visit, <i>n</i> (%)	32 (15.0)	34 (15.9)	0.79
Total COPD emergency department visits, <i>n</i>	35	59	0.60
Per-subject COPD emergency department visits, median (IQR)	0 (0–0)	0 (0–0)	
At least one non-COPD emergency department visit, <i>n</i> (%)	41 (19.2)	46 (21.5)	0.55
Total non-COPD emergency department visits, <i>n</i>	56	62	0.54
Per-subject non-COPD emergency department visits, median (IQR)	0 (0–0)	0 (0–0)	
At least one combined emergency department visit, <i>n</i> (%)	64 (29.9)	67 (31.3)	0.75
Total combined emergency department visits, <i>n</i>	91	121	0.45
Per-subject combined emergency department visits, median (IQR)	0 (0–1)	0 (0–1)	

Shown are emergency department visits not associated with a hospital admission.

IQR = interquartile range

Table 4. Outcomes: Hospital Admissions

Outcomes	Interventional Arm (<i>n</i> = 214)	Control Arm (<i>n</i> = 214)	<i>P</i>
At least one COPD hospital admission, <i>n</i> (%)	43 (20.1)	61 (28.5)	.042
Total COPD hospital admissions, <i>n</i>	56	100	.03
Per-subject COPD admissions, median (IQR)	0 (0–0)	0 (0–1)	
At least one non-COPD hospital admission, <i>n</i> (%)	71 (33.2)	74 (34.6)	.76
Total non-COPD hospital admissions, <i>n</i>	124	119	.88
Per-subject non-COPD admissions, median (IQR)	0 (0–1)	0 (0–1)	
At least one combined hospital admission, <i>n</i> (%)	103 (48.1)	108 (50.5)	.63
Total combined hospital admissions, <i>n</i>	180	219	.31
Per-subject combined admissions, median (IQR)	0 (0–1)	0 (0–2)	

IQR = interquartile range

Table 5. Outcomes: In-Patient Days

Outcomes	Interventional Arm (<i>n</i> = 214)	Control Arm (<i>n</i> = 214)	<i>P</i>
COPD admission			
Total hospital days, <i>n</i>	306	523	.02
Hospital days/subject, median (IQR)	0 (0–0)	0 (0–1.25)	
Total ICU days, <i>n</i>	17	53	.02
ICU days/subject, median (IQR)	0 (0–0)	0 (0–0)	
Non-COPD admission			
Total hospital days	987	924	.80
Hospital days/subject, median (IQR)	0 (0–3)	0 (0–3.25)	
Total ICU days	58	133	.046
ICU days/subject, median (IQR)	0 (0–0)	0 (0–0)	
Total combined hospital days, <i>n</i>	1,293	1,447	.41
Total combined hospital days/subject, median (IQR)	0 (0–6)	0.5 (0–7)	
Total combined ICU days, <i>n</i>	75	186	.005
Total combined ICU days/subject, median (IQR)	0 (0–0)	0 (0–0)	

* Calculations are based on the entire study cohort. The hospital days and ICU days are related to the indication for hospital and ICU admission being either COPD, a non-COPD condition, or the combined indications.

IQR = interquartile range

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intervention were experienced providers. We cannot be certain that these results would be replicated with a less experienced group of RTs. Fifth, we cannot exclude some form of bias in terms of the outcome assessment because this was not a blinded study. Finally, we did not review the medical records of subjects hospitalized outside of the Barnes-Jewish-Christian Healthcare system. Thus, we cannot be certain of the diagnosis for the hospital readmission in those circumstances.

The need for more comprehensive out-patient services to prevent exacerbations and hospital readmission for patients with COPD is supported by the failure observed when simple in-patient initiatives are attempted²⁸ as well as the successful findings from multifaceted programs in other chronic diseases.^{29,30} Our data suggest that a comprehensive RT disease management program can be associated with reduced hospital readmissions and fewer hospital days from COPD exacerbations. Future studies are needed to identify the most cost-effective approach for preventing hospital visits attributed to exacerbations of COPD. Moreover, the RT disease management program could potentially be improved by incorporating monitoring and treatment aspects for out-patient care directed not only at COPD but also at the major comorbidities that patients with COPD often have. Additionally, efforts at exporting this RT disease management program to non-academic medical centers will probably be most successful if adequate resources and training are directed toward its implementation. Pilot studies utilizing an RT disease management program are likely to be most effective in determining whether the local application of such a program will be successful and cost-effective.

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REFERENCES

- Hunter LC, Lee RJ, Butcher I, Weir CJ, Fischbacher CM, McAllister D, et al. Patient characteristics associated with risk of first hospital admission and readmission for acute exacerbation of chronic obstructive pulmonary disease (COPD) following primary care COPD diagnosis: a cohort study using linked electronic patient records. *BMJ Open* 2016;6(1):e009121.
- Alexopoulos EC, Malli F, Mitsiki E, Bania EG, Varounis C, Gourgoulis KI. Frequency and risk factors of COPD exacerbations and hospitalizations: a nationwide study in Greece. *Int J Chron Obstruct Pulmon Dis* 2015;10:2665-2674.
- Hartl S, Lopez-Campos JL, Pozo-Rodriguez F, Castro-Acosta A, Studnicka M, Kaiser B, Roberts CM. Risk of death and readmission of hospital-admitted COPD exacerbations: European COPD audit. *Eur Respir J* 2016;47(1):113-121.
- Ford ES. Hospital discharges, readmissions, and ED visits for COPD or bronchiectasis among US adults: findings from the nationwide inpatient sample 2001-2012 and nationwide emergency department sample 2006-2011. *Chest* 2015;147(4):989-998.
- Martínez-González NA, Berchtold P, Ullman K, Busato A, Egger M. Integrated care programmes for adults with chronic conditions: a meta-review. *Int J Qual Health Care* 2014;26(5):561-570.
- Shaw RJ, McDuffie JR, Hendrix CC, Edie A, Lindsey-Davis L, Nagi A, et al. Effects of nurse-managed protocols in the outpatient management of adults with chronic conditions: a systematic review and meta-analysis. *Ann Intern Med* 2014;161(2):113-121.
- Glasgow RE, Funnell MM, Bonomi AE, Davis C, Beckham V, Wagner EH. Self-management aspects of the improving chronic illness care breakthrough series: implementation with diabetes and heart failure teams. *Ann Behav Med* 2002;24(2):80-87.
- Ofman JJ, Badamgarav E, Henning JM, Knight K, Gano AD Jr, Levay RK, et al. Does disease management improve clinical and economic outcomes in patients with chronic diseases? A systematic review. *Am J Med* 2004;117(3):182-192.
- Rice KL, Dewan N, Bloomfield HE, Grill J, Schult TM, Nelson DB, et al. Disease management program for chronic obstructive pulmonary disease: a randomized controlled trial. *Am J Respir Crit Care Med* 2010;182(7):890-896.
- Fan VS, Gaziano JM, Lew R, Bourbeau J, Adams SG, Leatherman S, et al. A comprehensive care management program to prevent chronic obstructive pulmonary disease hospitalizations: a randomized, controlled trial. *Ann Intern Med* 2012;156(10):673-683.
- Kidder R. Use of a respiratory care practitioner disease management (RCP-DM) program for patients hospitalized with COPD: interim analysis. 60th Annual Conference of the American Association of Respiratory Care, December 9-12, 2014, Las Vegas, Nevada.
- Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. *Crit Care Med* 1985;13(10):818-829.
- Global Strategy for Diagnosis, Management, and Prevention of COPD, Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2011. Available from <http://www.goldcopd.org>. Accessed July 10, 2012.
- American College of Chest Physicians and the Chest Foundation. Living well with COPD: chronic bronchitis and emphysema. Available from <http://www.chestnet.org/Search#q/q=living%20well%20with%20copd>. Accessed June 16, 2012.
- COPD Educator Certification Preparation Course. https://www.aarc.org/education/copd_course/index.cfm. Accessed June 16, 2012.
- Dewan NA, Rice KL, Caldwell M, Hilleman DE. Economic evaluation of a disease management program for chronic obstructive pulmonary disease. *COPD* 2011;8(3):153-159.
- Siddique HH, Olson RH, Parenti CM, Rector TS, Caldwell M, Dewan NA, Rice KL. Randomized trial of pragmatic education for low-risk COPD patients: impact on hospitalizations and emergency department visits. *Int J Chron Obstruct Pulmon Dis* 2012;7:719-728.
- Casas A, Troosters T, Garcia-Aymerich J, Roca J, Hernández C, Alonso A, et al. Integrated care prevents hospitalisations for exacerbations in COPD patients. *Eur Respir J* 2006;28(1):123-130.
- Bourbeau J, Julien M, Maltais F, Rouleau M, Beupré A, Bégin R, et al. Reduction of hospital utilization in patients with chronic obstructive pulmonary disease: a disease-specific self-management intervention. *Arch Intern Med* 2003;163(5):585-591.
- Bucknall CE, Miller G, Lloyd SM, Cleland J, McCluskey S, Cotton M, et al. Glasgow supported self-management trial (GSuST) for patients with moderate to severe COPD: randomised controlled trial. *BMJ* 2012;344:e1060.
- Dharmarajan K, Hsieh AF, Lin Z, Bueno H, Ross JS, Horwitz LI, et al. Diagnosis and timing of 30-day readmissions after hospitaliza-

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- tion for heart failure, acute myocardial infarction, or pneumonia. *JAMA* 2013;309(4):355-363.
22. Hasegawa K, Tsugawa Y, Tsai CL, Brown DF, Camargo CA Jr. Frequent utilization of the emergency department for acute exacerbation of chronic obstructive pulmonary disease. *Respir Res* 2014; 15:40.
 23. Joynt KE, Jha AK. Characteristics of hospitals receiving penalties under the Hospital Readmissions Reduction Program. *JAMA* 2013; 309(4):342-343.
 24. Kruis AL, Smidt N, Assendelft WJ, Gussekloo J, Boland MR, Rutten-van Mölken M, Chavannes NH. Integrated disease management interventions for patients with chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2013;(10):CD009437
 25. Zwerink M, Brusse-Keizer M, van der Valk PD, Zielhuis GA, Moninkhof EM, van der Palen J, et al. Self management for patients with chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2014;(3):CD002990.
 26. Criner GJ, Bourbeau J, Diekemper RL, Ouellette DR, Goodridge D, Hernandez P, et al. Prevention of acute exacerbations of COPD: American College of Chest Physicians and Canadian Thoracic Society Guideline. *Chest* 2015;147(4):894-942.
 27. Postma DS, Rabe KF. The asthma-COPD overlap syndrome. *N Engl J Med* 2015;373(13):1241-1249.
 28. Jennings JH, Thavarajah K, Mendez MP, Eichenhorn M, Kvale P, Yessayan L. Predischarge bundle for patients with acute exacerbations of COPD to reduce readmissions and ED visits: a randomized controlled trial. *Chest* 2015;147(5):1227-1234.
 29. Hansen LO, Young RS, Hinami K, Leung A, Williams MV. Interventions to reduce 30-day rehospitalization: a systematic review. *Ann Intern Med* 2011;155(8):520-528.
 30. Rich MW, Beckham V, Wittenberg C, Leven CL, Freedland KE, Carney RM. A multidisciplinary intervention to prevent the readmission of elderly patients with congestive heart failure. *N Engl J Med* 1995;333(18):1190-1195.