COPD

The Economic Effect of Early Management in Patients with Early Chronic Obstructive Pulmonary Disease: Results from a Population-Based Nationwide Survey

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Abstract

Purpose The economic effect of regular follow-up and early management in patients with early chronic obstructive pulmonary disease (COPD) has not yet been clarified. Therefore, this study aimed to estimate the economic effect of regular follow-up and early management in these patients.

Methods Patients with early COPD were identified from the Korea National Health and Nutrition Examination Survey. We analyzed medical utilization and cost for 2 years without any missing data by using the Korean National Health Insurance data. Patients with routine healthcare maintenance were defined as, after diagnosis, those with regular visits to the hospital and receiving early management of COPD.

Results Among 1204 patients with early COPD, the patients who were classified as the group with routine healthcare maintenance (69/146; 47.3%) and the group with intermittent healthcare user (79/1058; 7.5%) visited to hospital for the next 2 years. The patients with routine healthcare maintenance had lower cost of inpatient service and frequencies of emergency room (ER) visit and intensive care unit (ICU) admission than intermittent healthcare users (cost of inpatient service, $4595 vs. $4953 per person; ER visit, 7.2 vs. 11.5; ICU admission, 4.3 vs. 7.7). Even in patients with COPD and $FEV_1 \geq 80$, early intervention through follow-up reduced the cost of inpatient service because these patients could have had less severe acute exacerbations than intermittent healthcare users.

Conclusion Patients with early COPD, even those with $FEV_1 \geq 80$, need regular follow-up for early management and disease control as well as for reducing the socioeconomic burden of the disease.

Keywords Chronic obstructive pulmonary disease · Korea · Early intervention · Economics

Abbreviations

COPD	Chronic obstructive pulmonary disease
FEV_1	Forced expiratory volume in 1 s
FVC	Forced vital capacity
KNHANES	The Korea National Health and Nutrition Examination Survey
KNHI	The Korean National Health Insurance
PFT	Pulmonary function test
ICD-10	The International Classification of Diseases-Tenth Revision
ER	Emergency room
ICU	Intensive care unit
USD	US dollars
KRW	Korean won

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Introduction

Chronic obstructive pulmonary disease (COPD) has a prevalence of 13.4% in people older than 40 years in Korea [1]. It is a serious public health problem in many countries, considering its high mortality and increasing economic burden. COPD is a progressive, but treatable lung disease [2]. Thus, early management of patients is important.

Patients with mild-to-moderate COPD can experience a more rapid decline in lung function than those with severe-to-very severe COPD [3–8]. In addition, patients

with mild-to-moderate COPD can experience acute exacerbation, which might result in death [4–13]. However, patients with so-called early COPD usually do not visit a hospital for diagnosis and follow-up of the disease. Because lung function is relatively good and symptoms are mild in patients with early COPD, there is little motivation for them to see a physician for regular follow-up [13]. For the same reason, doctors are also less concerned about patients with early COPD than with patients with progressed COPD. Therefore, the treatment of patients with early COPD is delayed until the disease progresses to symptomatic COPD [5, 13]. Treatment in patients with early COPD focuses on inhaler therapy, management of comorbidity, removal of risk factors, and education about smoking cessation and disease course. In patients without respiratory symptoms, the need for follow-up is unclear. Nevertheless, even these patients, it is important to provide management of comorbidity, removal of risk factors, and education about smoking cessation and disease course.

According to our literature review, the economic effect of regular follow-up and early disease management in patients with early COPD, especially in those with a forced expiratory volume in 1 s (FEV_1) ≥ 80%, is still unclear [2, 14–19].

Korea has two big databases containing national healthcare data, the Korea National Health and Nutrition Examination Survey (KNHANES) and the Korean National Health Insurance (KNHI) [1, 20]. These databases are well-organized databases controlled by a government organization within the Ministry of Health in South Korea. Although the investigation of total medical cost in patients with early COPD was extremely difficult in other countries, the combination of data from the KNHANES and KNHI helped trace every single detail of medical utilization and cost in patients with early COPD [13].

The aim of this study was to investigate the economic effect of the regular follow-up and early disease management in patients with early COPD by analyzing data from two combined databases, the KNHANES and the KNHI.

Materials and Methods

Study Design

This was a retrospective observational study, and the data were acquired by reviewing the KNHANES and KNHI databases from 2007 to 2012. We enrolled patients with early COPD, which was determined by pulmonary function test (PFT) data in the KNHANES database from 2007 to 2009. To evaluate the economic effect of regular follow-up and early management in patients with early COPD, we investigated whether these patients regularly visited the hospital of their own accord during the first 2 years after diagnosis. We classified patients into two groups (routine healthcare maintenance vs. intermittent healthcare users), and we analyzed the frequency and costs of medical intervention of these patients for the next 2 years, based on data from the KNHI database (Fig. 1). This study was approved by the Institutional Review Board of Konkuk University Hospital in the Republic of Korea (No. KUH1010624). The requirement for informed consent was waived by the ethical review board.

Two Big Database for National Healthcare Data in Korea

The KNHANES was a cross-sectional national survey conducted by a government organization within the Ministry of Health [1, 20–22]. Spirometry was performed by trained technicians using dry rolling-seal spirometers (Model 2130; SensorMedics, Yorba Linda, CA, USA), thus controlling for the quality of PFT as recommended by the American Thoracic Society/European Respiratory Society criteria for the standardization of PFT [23].

Fig. 1 Flowchart illustration patient enrollment. Abbreviations: PFT, pulmonary function test; KNHANES, the Korea National Health and Nutrition Examination Survey; KNHI, the Korean National Health Insurance. *Hospital visit was defined as a patient's visit to a hospital for regular follow-up or because of acute exacerbation
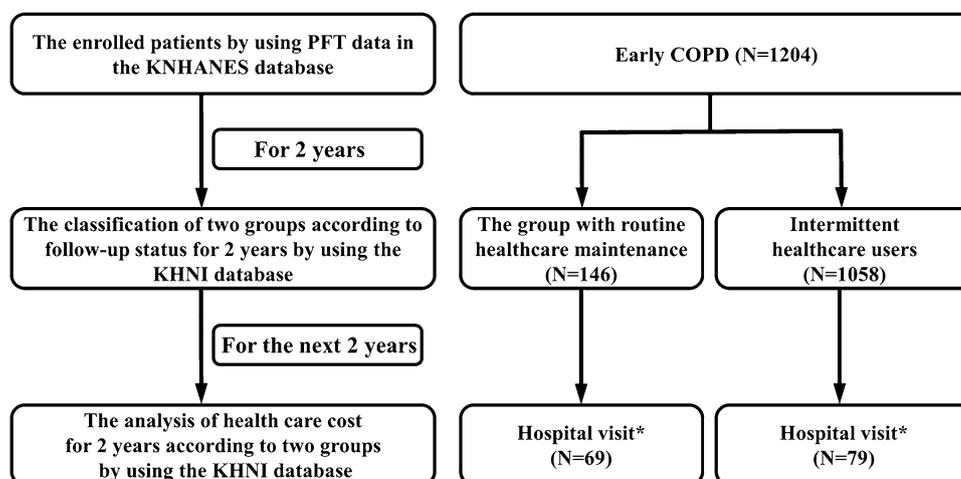
The KNHI is a universal public medical insurance system covering the entire Korean population in South Korea, and the government can support and supervise all medication and medical services conducted by all medical institutions. The KNHI database is linked to the Korea Health Insurance Review and Assessment Service that has details of all medications, medical services, and diagnoses for claims. Therefore, we could trace all medical utilization and cost without any missing data [19, 24–26].

Definitions

Patients with early COPD were defined as those with (1) age ≥ 40 years, (2) FEV_1/forced vital capacity (FVC) < 0.7, and (3) $FEV_1 \geq 50$. Patients with routine healthcare maintenance were defined as those who had regular hospital visits and underwent early management of COPD, such as inhaler therapy, management of comorbidity, removal of risk factors, and education about smoking cessation and disease course. Intermittent healthcare users were defined as patients who did not visit the hospital regularly but only visited when they suffered from acute exacerbation or other COPD-related problems. The analysis was confined to COPD-related medical utilization and cost. Medical utilization and cost were excluded from the analysis if they were not considered COPD-related, even when patients with COPD used the medical service. For utilization and cost of medication, only those using COPD-related medications, such as inhalers, systemic beta agonists, and oral corticosteroids, were analyzed. For outpatient and inpatient services, analysis was confined to the visit and admission when the principal or secondary diagnosis was COPD (J43.x-J44.x, except J430) or a COPD-related disease (pneumonia: J12.x-J17.x; pulmonary thromboembolism: I26, I26.0, and I26.9; dyspnea: R06.0; or acute respiratory distress syndrome: J80) by searching for the International Classification of Diseases-Tenth Revision (ICD-10) codes. In addition, for emergency room (ER) visits and intensive care unit (ICU) admission, analysis was confined to the visit and admission when the principal or secondary diagnosis was COPD or a COPD-related disease by searching for the ICD-10 codes and when patients were treated with systemic corticosteroid. All costs are presented in US dollars (USD), with an exchange rate of 1 USD to 1063 Korean won (KRW) (exchange rate as at December 31, 2012).

Statistical Analysis

Differences between groups were assessed using the Chi-square test for categorical variables and Student's *t* test for continuous variables. All tests were two-sided, and *P* values < 0.05 were considered statistically significant. Data are expressed as mean ± standard deviation. All statistical analyses were performed using SAS version 9.2 (SAS Institute, Inc., Cary, NC, USA).

Results

Baseline Characteristics

A total of 1204 patients in the KNHANES database from 2007 to 2009 met the criteria of early COPD. Of these 1204 patients, 146 (12.1%) were followed up for 2 years after the time of enrollment. These patients were classified as the group with regular healthcare maintenance. The other patients did not visit a hospital for 2 years after the initial diagnosis for various reasons. These patients were classified as intermittent healthcare users (Fig. 1). The baseline clinical features of the groups are shown in Table 1. Patients with regular healthcare maintenance were older and more likely to be male than were intermittent healthcare users. Most patients with regular healthcare maintenance had a higher smoking level and lower lung function than intermittent healthcare users. Two–thirds of the patients with regular healthcare maintenance had a predicted $FEV_1 < 80$.

Clinical Characteristics of Patients According to the Follow-Up Status for 2 Years After COPD Diagnosis

For the following 2 years, after classifying patients into two groups (routine healthcare maintenance vs. intermittent healthcare user), 69 of 146 patients (47.3%) with routine healthcare maintenance and 79 of 1058 with intermittent healthcare users (7.5%) visited a hospital for follow-up or treatment of acute exacerbation (Fig. 1). We analyzed the healthcare-cost data of these patients. Clinical characteristics of the patients are shown in Table 2. Patients with routine healthcare maintenance tended to have a higher proportion of hospital visits than intermittent healthcare users (47.3% vs. 7.5%). Patients with routine healthcare maintenance had higher smoking level and proportion of bronchiectasis than did intermittent healthcare users. In addition, patients with routine healthcare maintenance had lower lung function than intermittent healthcare users. In other words, patients with routine healthcare maintenance could have had more severe COPD states and respiratory symptoms than intermittent healthcare users.

As shown in Table 1, the mean FEV_1 was 2.0 ± 0.6 L and the predicted value was 72 ± 14% in patients with routine healthcare maintenance. The corresponding values were 2.3 ± 0.6 L and 78 ± 14%, respectively, in intermittent healthcare users. As shown in Table 2, the mean FEV_1 was 1.9 ± 0.5 L and the predicted value was 70.1 ± 14.5% in patients with routine healthcare maintenance. The

Table 1 Clinical characteristics of patients with early COPD based on whether they regularly visited the hospital of their own accord for 2 years after enrollment

Variable	The group with routine healthcare maintenance ($N=146$)	Intermittent healthcare users ($N=1058$)	P value
Age (years)*	68 ± 10	61 ± 14	<0.001
Male	112 (76.7)	704 (66.5)	0.014
Current smoker	47 (32.2)	359 (33.9)	0.633
Pack-years*	34 ± 18	31 ± 20	0.398
Income ($)*	$1,448 \pm 1,604$	$2,175 \pm 5,788$	0.001
Educational level			
Elementary to middle	110 (75.3)	638 (60.3)	<0.001
High to University	36 (24.7)	420 (39.7)	
Body mass index (kg/m^2)*	23 ± 3	23 ± 3	0.050
Pulmonary function test*			
FEV$_1$, L	2.0 ± 0.6	2.3 ± 0.6	<0.001
FEV$_1$, % predicted	72 ± 14	78 ± 14	<0.001
FVC, L	3.4 ± 0.9	3.6 ± 0.9	0.026
FVC, % predicted	87 ± 14	91 ± 14	0.004
FEV$_1$/FVC, %	0.60 ± 0.081	0.64 ± 0.056	<0.001
FEV$_1 \geq 80$	39 (26.7)	446 (42.2)	<0.001
Comorbidity			
Ischemic heart disease	8 (5.5)	38 (3.6)	0.265
Hypertension	45 (30.8)	315 (30.0)	0.795
Osteoporosis	9 (6.2)	78 (7.4)	0.597
Depressive disorder	1 7(11.6)	144 (13.6)	0.513
Diabetes mellitus	17 (11.6)	130 (12.3)	0.824
Arthritis	33 (22.6)	225 (21.3)	0.712
Lung cancer	1 (0.7)	2 (0.2)	0.260
Bronchiectasis	8 (5.5)	19 (1.8)	0.005
Asthma	89 (61)	208 (19.7)	<0.001

COPD chronic obstructive pulmonary disease; *FEV₁* forced expiratory volume in 1 s; *FVC* forced vital capacity

*Data are presented as mean ± standard deviation. Other variables are presented as number (%)

corresponding values were 2 ± 0.6 L and $74.7 \pm 15.2\%$, respectively, in intermittent healthcare users. Although patients with routine healthcare maintenance had lower initial lung function and more respiratory symptoms than intermittent healthcare users, lung function decline in patients with routine healthcare maintenance was less than that in intermittent healthcare users.

Healthcare Cost for the Following 2 Years According to Follow-Up After Diagnosis per Person

Table 3 shows the average healthcare cost for the following 2 years according to follow-up after diagnosis per person. Among patients visiting a hospital, those with routine healthcare maintenance had higher costs of outpatient service than intermittent healthcare users, because patients with routine healthcare maintenance tended to have regular follow-ups and, therefore, more hospital visits; thus, they incurred higher healthcare costs for follow-up than

did intermittent healthcare users. In contrast, patients with routine healthcare maintenance had lower costs of inpatient services than did intermittent healthcare users; this may be because intermittent healthcare users had poorly controlled and more severe acute exacerbations than those with routine healthcare maintenance when they visited a hospital. In fact, intermittent healthcare users had more frequent ER visits and ICU admissions than those with routine healthcare maintenance (ER visits, 11.5 vs. 7.2; ICU admissions, 7.7 vs. 4.3; Fig. 2). Thus, regular follow-up in patients with early COPD is important for better disease control and reduction in healthcare costs.

Total Economic Burden for Two Years According to Follow-Up After Diagnosis

In our study, the total costs during 2 years was similar between patients with routine healthcare maintenance and intermittent healthcare users; however, intermittent

Table 2 Clinical characteristics of patients whose healthcare cost were analyzed for the following 2 years based on whether they underwent 2 years of follow-up after enrollment

Variables	The group with routine healthcare maintenance ($N=69$)	Intermittent healthcare users ($N=79$)	P value
Age (years)*	68.3 ± 8.6	69.2 ± 8.8	0.534
Male	56 (81.2)	57 (72.2)	0.198
Current smoker	24 (34.8)	22 (28.2)	0.391
Pack-years*	36.9 ± 19.8	32.1 ± 22.8	0.444
Body mass index (kg/m^2) *	22.8 ± 2.8	23 ± 2.3	0.573
EQ-5D*	0.85 ± 0.18	0.84 ± 0.17	0.997
Pulmonary function test*			
FEV_1, L	1.9 ± 0.5	2 ± 0.6	0.379
FEV_1, % predicted	70.1 ± 14.5	74.7 ± 15.2	0.060
FVC, L	3.4 ± 0.8	3.3 ± 0.9	0.602
FVC, % predicted	88.2 ± 14	88.2 ± 15.3	0.983
FEV_1/FVC, %	0.57 ± 0.08	0.60 ± 0.07	0.011
$FEV_1 \geq 80$	16 (23.2)	28 (35.4)	0.104
Comorbidity			
Ischemic heart disease	3 (4.4)	2 (2.5)	0.542
Hypertension	22 (31.9)	26 (32.9)	0.894
Osteoporosis	6 (8.7)	7 (8.9)	0.972
Depressive disorder	7 (10.1)	13 (16.5)	0.263
Diabetes mellitus	9 (13.0)	12 (15.2)	0.709
Arthritis	15 (21.7)	25 (31.7)	0.176
Bronchiectasis	4 (5.8)	2 (2.5)	0.315
Asthma	31 (44.9)	28 (35.4)	0.240

EQ-5D the EuroQol five dimensions questionnaire; *FEV_1* forced expiratory volume in 1 s; *FVC* forced vital capacity

* Data are presented as mean ± standard deviation. Other variables are presented as number (%)

Table 3 Health care cost per person for the following 2 years based on whether they underwent 2 years of follow-up after enrollment

	The group with routine healthcare maintenance			Intermittent healthcare users			P value
	$FEV_1 \geq 80$ ($N=16$)	$50 \leq FEV_1 < 80$ ($N=53$)	Total ($N=69$)	$FEV_1 \geq 80$ ($N=28$)	$50 \leq FEV_1 < 80$ ($N=51$)	Total ($N=79$)	
Outpatient service							
Medical examination	36 ± 47	58 ± 65	54 ± 62	45 ± 36	37 ± 47	39 ± 44	0.213
Radiologic examination	14 ± 8	32 ± 58	27 ± 51	16 ± 14	12 ± 12	13 ± 12	0.109
Medication	561 ± 725	891 ± 1120	812 ± 1044	129 ± 256	253 ± 497	207 ± 426	< 0.001
Others	119 ± 134	156 ± 237	147 ± 216	58 ± 74	69 ± 88	65 ± 83	0.005
Total cost	700 ± 820	1095 ± 1362	1001 ± 1259	208 ± 295	353 ± 577	300 ± 495	< 0.001
Inpatient service							
Medical examination	370 ± 480	762 ± 1327	657 ± 1157	470 ± 670	837 ± 803	750 ± 774	0.775
Radiologic examination	74 ± 91	78 ± 114	77 ± 105	75 ± 84	184 ± 206	158 ± 189	0.108
Medication	944 ± 1170	1908 ± 2727	1651 ± 2408	896 ± 1375	1081 ± 1082	1037 ± 1124	0.370
Others	2084 ± 2610	2257 ± 2660	2211 ± 2553	2521 ± 3482	3161 ± 3331	3009 ± 3290	0.438
Total cost	3472 ± 4287	5004 ± 6612	4595 ± 5971	3961 ± 5545	5263 ± 4831	4953 ± 4897	0.845

Data are presented as mean ± standard deviation

Fig. 2 Utilization rate of ICU and ER by patients with early COPD (the group with routine healthcare maintenance vs. intermittent healthcare users). **a** ICU admission, **b** ER visit
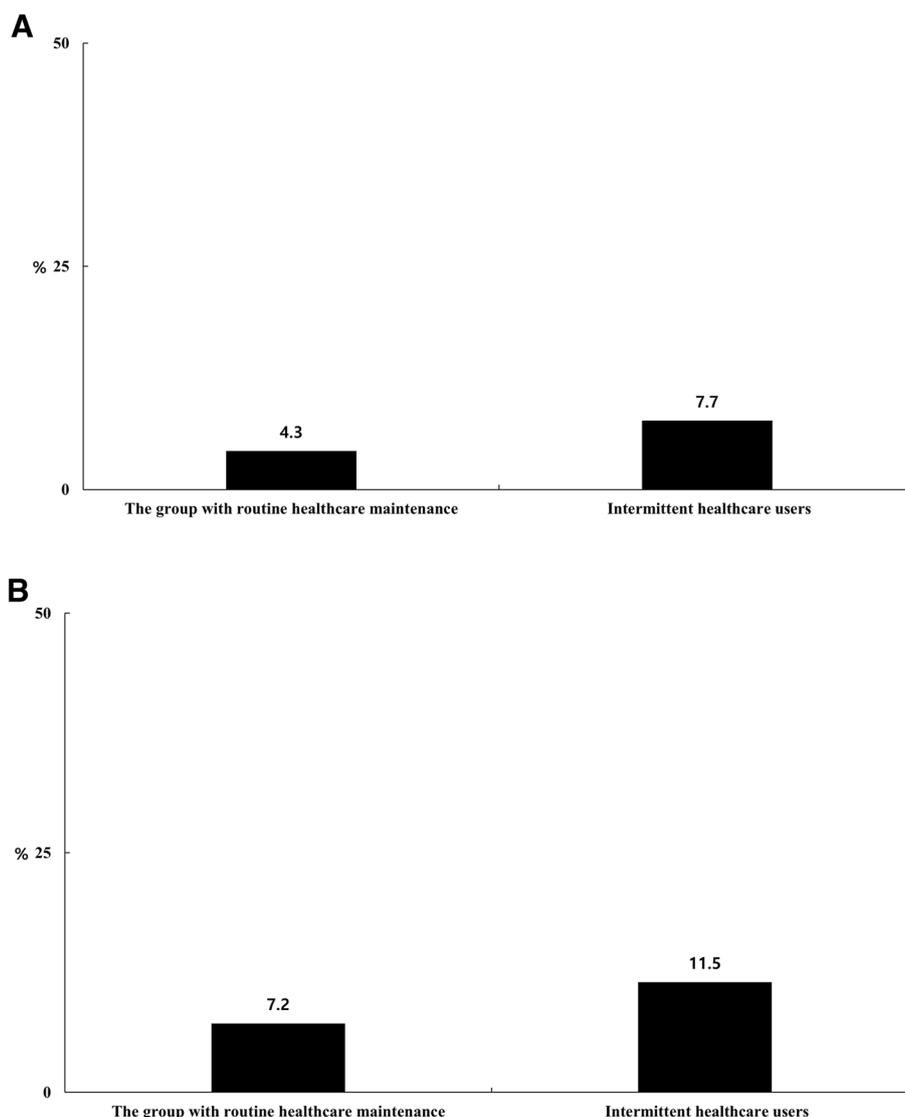
healthcare users had higher inpatient costs than did those with routine healthcare maintenance. In Korea, inpatient costs are similar to outpatient costs because of Korea's universal health insurance system [26]. However, inpatient costs, including ER and ICU costs, are higher than outpatient costs in other countries. Thus, in other countries, intermittent healthcare users might have higher total costs than those with routine healthcare maintenance, and this translates to a higher economic burden. In other words, patients with early COPD who have regular follow-up and early intervention therapies have a lower total economic burden (Table 4).

The Effect of Early Intervention in Patients with $FEV_1 \geq 80$

In patients with COPD and $FEV_1 \geq 80$, healthcare costs for the following 2 years were analyzed in 16 of 39 (41%) patients with routine healthcare maintenance and 28 of

446 (6.3%) intermittent healthcare users. The 16 patients with routine healthcare maintenance tended to be older and had lower quality of life than did the 28 intermittent healthcare users. The proportion of current smokers was higher among patients with routine healthcare maintenance than among intermittent healthcare users. Thus, most patients with routine healthcare maintenance could have respiratory symptoms. However, lung function in patients with routine healthcare maintenance was similar to that in intermittent healthcare users.

For outpatient services, patients with routine healthcare maintenance had higher total healthcare costs than did intermittent healthcare users because patients with routine healthcare maintenance tended to have regular follow-ups and more hospital visits. For inpatient services, patients with routine healthcare maintenance had lower healthcare costs than did intermittent healthcare users. Thus, patients with COPD and $FEV_1 \geq 80$ need regular follow-up

Table 4 Total economic burden for the following 2 years based on whether they underwent 2 years of follow-up after enrollment in our study

	The group with routine healthcare maintenance			Intermittent healthcare users		
	FEV$_1 \geq 80$ (N=16)	$50 \leq$ FEV$_1 < 80$ (N=53)	Total (N=69)	FEV$_1 \geq 80$ (N=28)	$50 \leq$ FEV$_1 < 80$ (N=51)	Total (N=79)
Outpatient service						
Medical examination	215	1844	2060	403	1025	1428
Radiologic examination	113	819	932	125	307	432
Medication	8979	45415	54394	3225	10869	14094
Others	1896	7779	9675	1448	2964	4412
Total cost	11203	55857	67060	5200	15165	20365
Inpatient service						
Medical examination	1479	8378	9857	2347	13395	15742
Radiologic examination	297	853	1151	375	2948	3323
Medication	3776	20982	24758	4479	17291	21770
Others	8338	24826	33164	12,605	50577	63181
Total cost	13890	55040	68930	19,806	84210	104017

Data are presented as mean ± standard deviation

and early management to reduce their economic burden (Table 5).

Discussion

This study focused on evaluating the economic effects of regular follow-up and early management in patients with early COPD. In this study, patients with routine healthcare maintenance had much lower costs for inpatient services than did intermittent healthcare users. This result suggests that regular follow-up and early management of COPD could decrease the rate and severity of acute exacerbations, thus resulting in lower costs of inpatient services. Therefore, lung function decline in patients with routine healthcare maintenance was less than that in intermittent healthcare users. Since healthcare costs for inpatients are much higher than for outpatients, regular follow-up and early management may eventually decrease total healthcare costs of patients with early COPD. These findings highlight the importance of regular follow-up and early management in patients with early COPD.

Previous studies have revealed that early management in patients with early COPD, such as inhaler treatment, respiratory treatment, and rehabilitation, improved the quality of life and decreased the rate of lung function decline [4–8, 12, 27–30].

This study has several strengths. Our study analyzed the economic effect of regular follow-up and early management in COPD patients with FEV$_1 \geq 80$. To date, most studies on early COPD have focused on COPD patients with FEV$_1 < 80$ [4–7, 27, 29]. The use of nationwide surveys to research this question is necessary, because most COPD patients with

FEV$_1 \geq 80$ do not visit the hospital due to relatively good lung function and mild respiratory symptoms, and, thus, they are not easily accessible. Furthermore, routine follow-up of these patients is extremely difficult [13]. Thus, the economic effect of regular follow-up and early management in COPD patients with FEV$_1 \geq 80$ has remained unclear. To overcome these limitations, our study used two big databases, containing national healthcare data without any missing data, and our results are meaningful. In our study, patients with routine healthcare maintenance had lower healthcare costs for inpatient services than intermittent healthcare users. The most common cause of admission of COPD patients is moderate-to-severe acute exacerbation. High healthcare costs, especially high examination costs during admission, could reflect the severity of the acute exacerbation. When looking at inpatient service costs, intermittent healthcare users have higher examination costs and others than patients with routine healthcare maintenance. Therefore, intermittent healthcare users may have more severe acute exacerbation states than those with routine healthcare maintenance. In fact, in our study, intermittent healthcare users had more frequent ER visits and ICU admissions than those with routine healthcare maintenance (ER visits, 11.5 vs. 7.2; ICU admissions, 7.7 vs. 4.3). In other words, early management in COPD patients with FEV$_1 \geq 80$ could reduce the severity of acute exacerbation and, thus, could reduce healthcare costs during this phase. In addition, patients with severe or frequent acute exacerbation also had faster lung function decline, lower quality of life, and higher mortality rates than did those without severe or frequent acute exacerbation [11, 31–38]. This result was similar to that of previous reports. Regan et al. reported that 22.7% of patients with FEV$_1 \geq 80$ had significant dyspnea and 4.9% experienced

Table 5 Effect of early intervention in patients with FEV$_1$ ≥ 80

Variables	The group with routine healthcare maintenance (N = 16)	Intermittent healthcare users (N = 28)	P value
Age (years)*	70.7 ± 7.5	69.3 ± 8.4	0.574
Male	16(100.0)	18(64.3)	0.007
Current smoker	3(18.8)	4(14.3)	0.697
Pack-years*	16.1 ± 15.5	12.4 ± 33.6	0.868
Body mass index (kg/m^2) *	22.5 ± 2.2	23.8 ± 2.3	0.076
EQ-5D*	0.84 ± 0.16	0.88 ± 0.15	0.410
Pulmonary function test*			
FEV$_1$, L	2.5 ± 0.3	2.4 ± 0.5	0.266
FEV$_1$, % predicted	91 ± 8.3	91.3 ± 10.3	0.928
FVC, L	4.1 ± 0.6	3.7 ± 0.9	0.132
FVC, % predicted	100.6 ± 9.9	100.4 ± 11.8	0.949
FEV$_1$/FVC, %	0.63 ± 0.05	0.65 ± 0.03	0.229
Comorbidity			
Ischemic heart disease	1 (6.3)	1 (3.6)	0.682
Hypertension	6 (37.5)	11 (39.3)	0.907
Osteoporosis	0	2 (7.1)	–
Depressive disorder	0	5 (17.9)	–
Diabetes mellitus	2 (12.5)	3 (10.7)	0.858
Arthritis	3 (18.8)	12 (42.9)	0.105
Lung cancer	0	0	–
Bronchiectasis	1(6.3)	0	–
Asthma	4 (25)	7 (25)	0.999
Outpatient service*			
Medical examination	36 ± 47	45 ± 36	0.684
Radiologic examination	14 ± 8	16 ± 14	0.800
Medication	561 ± 725	129 ± 256	0.034
Others	119 ± 134	58 ± 74	0.113
Total cost	700 ± 820	208 ± 295	0.033
Inpatient service*			
Medical examination	370 ± 480	470 ± 670	0.810
Radiologic examination	74 ± 91	75 ± 84	0.990
Medication	944 ± 1170	896 ± 1375	0.957
Others	2084 ± 2610	2521 ± 3482	0.842
Total cost	3472 ± 4287	3961 ± 5545	0.889

EQ-5D the EuroQol five dimensions questionnaire; *FEV$_1$* forced expiratory volume in 1 s; *FVC* forced vital capacity

* Data are presented as mean ± standard deviation. Other variables are presented as number (%)

acute exacerbations over the previous year, especially if they were former or current smokers [39]. However, former or current smokers with FEV$_1$ ≥ 80 were not likely to visit a hospital because they could neglect mild symptoms, such as cough, sputum, and mild dyspnea [39, 40]. We have to manage patients with FEV$_1$ ≥ 80, especially former or current smokers, because significant radiologic changes and acute exacerbations are common in these patients despite their normal lung function [4–8, 12, 27–29, 39–41]. Smoking cessation reduces the severity of respiratory symptoms and slows the mean rate of lung function decline [8, 27, 42].

Thus, early management in COPD patients with FEV$_1$ ≥ 80, such as management of comorbidity, removal of risk factors, and education about smoking cessation and disease course, is as important as it is in other groups. Considering that COPD patients with FEV$_1$ ≥ 80 account for a significant proportion of the COPD population, these patients should undergo early management to decrease the total economic burden of COPD.

In addition, our study revealed that early COPD has a high economic burden. In 2009, the total average direct healthcare cost per COPD patient was $2,800 in Korea

[16]. This is slightly higher than that in Canada and the USA [16]. In our study, the total cost of only 148 patients reached almost $260,000 in 2 years despite Korea's unique health insurance system. Considering the proportion of patients with early COPD was substantial, the economic burden of early COPD might be enormous and increasing [1, 43].

In our study, only 12.1% of patients (146/1204) visited a hospital because of COPD in the 2 years following diagnosis. This result was similar to those of previous studies [4–8, 27–29]. Patients with early COPD tend not to visit hospitals. Because COPD is a progressive disease and patients with mild-to-moderate COPD can experience a more rapid decline in lung function than those with severe-to-very severe COPD, it is important that patients with early COPD are diagnosed and managed aggressively for COPD control [3–12].

This study has some limitations. First, this was a retrospective observational study and the data were acquired by reviewing the KNHANES and KNHI databases. Therefore, all data from each patient, such as laboratory data, serial PFT results, and mortality, were not included in our study. However, our data were absolutely meaningful data from the view of the analysis of economic burden in patients with early COPD because population-based data from a representative sample of the general population and the entire healthcare utilization data during follow-up, without any missing data, were included. Second, the total number of analyzed patients in our study was relatively small because patients with early COPD generally did not visit hospitals; thus, the total number of patients with follow-up was extremely low. Third, our study included some patients with asthma because the diagnosis was based on the results of PFTs without a bronchodilator test. Many epidemiologic studies used only pre-bronchodilator PFT data because post-bronchodilator PFTs are extremely difficult to perform in a nationwide epidemiologic study [44, 45].

In conclusion, the economic burden for patients with early COPD was relatively high. Patients with early COPD, even those with $FEV_1 \geq 80$, need regular follow-up for early management to control the disease status and reduce the socioeconomic burden of the disease.

Author Contributions LYS, MKH, YKH: Conception and design of the study; LYS, MKH, RCK, JKS, YKH: Data generation (When applicable); LYS, MKH, RCK, KYH, LSY, USJ, LCH, JKS, YKH: Analysis and Interpretation of the data; LYS, MKH, RCK, KYH, LSY, USJ, LCH, JKS, YKH: Preparation or critical revision of the manuscript.

Compliance with Ethical Standards

Conflict of interest The authors of this study declare that they have no competing interests in regard to this manuscript.

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