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Cost Trend Analysis of Chronic Obstructive Pulmonary Disease among Vietnamese Patients: Findings from Two Provincial Facilities 2015–2017

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ABSTRACT

Introduction: Chronic Obstructive Pulmonary Disease (COPD) is a serious public health concern and a leading cause of disability.

Aim: To explore the direct medical costs associated with COPD and identify the key cost drivers of disease of management.

Materials and Methods: In this retrospective prevalence-based study, a hospital electronic database was used to examine the healthcare utilization and costs associated with COPD from the patient, payer and provider perspectives. The analysis horizon was the three-year period between 2015 and 2017.

Results: A total of 33,617 patients with a diagnosis of COPD were identified, of which 28,869 outpatients met the criteria for direct medical cost analysis. The sample was predominantly male (86.0–92.2%). The age of majority was between 60 and 69 years, and almost all patients had health insurance. The mean age was 69.7±10.9 and 69.2±10.8, at Dong Nai General Hospital (DNGH) and Pham Ngoc Thach Hospital (PNTH), respectively. The median number of days for Length Of Stay (LOS) varied from 6 to 10 days (range 1–77). The direct medical costs varied from $22.4 to $32.7 per outpatient visit and from $180.9 to $386.9 per inpatient visit. The key driver of cost was pharmaceuticals, which accounted for more than 50% of total costs.

Conclusion: This analysis, for the first time, states the specific costs for COPD, which will provide state public health practitioners with estimates of the economic burden of COPD and illustrate the potential medical cost savings for the nation by implementing programs designed to prevent the onset of COPD (e.g., tobacco prevention and cessation).

Keywords: COPD, Cost of illness, Direct cost, Respiratory diseases, Vietnam

INTRODUCTION

COPD is an umbrella term for a condition characterized by the gradual progression of irreversible airflow obstruction, increased inflammation of the airways, and lung parenchyma and is generally distinguishable from the inflammation caused by asthma [1]. Unfortunately, COPD is not curable; however, available medical and physical treatments can help relieve symptoms, improve exercise capacity and quality of life, and reduce the risk of death. The Global Initiative for Chronic Obstructive Lung Disease (GOLD) is attempting to improve the diagnosis, prevention and management of COPD across the globe. GOLD uses the Forced Expiratory Volume (FEV1) test component of the standard pulmonary function test to categorise the severity of COPD into stages [2]. COPD may lead to cardiovascular, pulmonary artery, skeletal and, ultimately, nutritional disorders [3]. As a result, the burden of COPD is significant, resulting in major economic consequences for patients, their families, and society.

Currently, COPD is a leading cause of morbidity and mortality worldwide and results in an economic and social burden that is both substantial and increasing. From 1990 to 2015, the prevalence of COPD increased by 44.2%, ultimately affecting 174.5 million individuals [4]. As of 2016, the Global Burden of Disease (GBD) Study estimated that about three million people worldwide had died of COPD [1]. More than 90% of COPD-related deaths occur in low and middle-income countries [5]. By 2030, COPD is projected to have the fifth largest disease burden and be the fourth largest cause of death, at 7.8% [6]. However, COPD's cause-of-death ranking varies by country income group: fifth in high-income countries, third in middle-income countries and fourth in low-income countries [6]. In the United States (US), COPD remains the fourth leading cause of death, and there are over 32 million people affected by COPD [7]. In 2014, there were 147,101 American deaths due to COPD (accounting for 5.6% of all deaths).

COPD is a serious public health problem that affects approximately 9.5% of the Vietnamese population, which was the highest COPD prevalence in the Asia-Pacific Region [8]. The high prevalence is due to the high rate of smokers, which currently stands at 47.6% [8]. In Hanoi, the capital of Vietnam, the prevalence of COPD among 23–72 years old is 7.1%. Among males, this prevalence is 10.9%, as compared to 3.9% in females. Approximately 10% of the Vietnamese population over 40-year-old has been diagnosed COPD, with more than a half of COPD patients being in Stage I [9].

Furthermore, evidence regarding the economic burden of COPD is important for the prioritization of prevention and treatment services at the national and sub-national levels, as well as facilitating a better resource allocation in the healthcare system [10-12]. In 2016, a cross-sectional survey in the United Kingdom reported that the annual societal costs per patient varied widely across countries, ranging from 1,721 US Dollars ($) in Russia to $30,826 in the US [13]. In Greece, it was estimated that the treatment cost per patient with COPD accounted for €2,810, making up 59.4% of total costs [14].

As a whole, the treatment costs of COPD in Asia tend to be lower. In 2015, a retrospective study carried out in South Korea found the

societal costs expenses related to COPD to be $309.8 per person [15]. Direct medical costs accounted for 58.6% of this figure [15].

Despite the high prevalence of COPD, limited evidence regarding its economic burden exists, especially that considering its entire spectrum and including both hospitalization and outpatient management. Particularly in developing countries, where the economic burden of COPD is higher, such information is important for public health policymakers to advocate for the implementation of prevention and treatment recommendations. This study aimed to characterize the healthcare costs associated with COPD at two provincial hospitals, DNGH and PNTH. The later value could be useful in that it could inform further studies on cost-effectiveness, analyses of budget impact and, ultimately, future public health policy decisions in Vietnam.

MATERIALS AND METHODS

Research Design and Setting: A retrospective, prevalence-based study was conducted using the electronic record database at two provincial hospitals, to estimate the direct medical costs of COPD cases, including the Outpatient Department (OPD) and Inpatient Department (IPD). This analysis approached this task from the patient, payer and provider perspectives and considered data from 2015 to 2017. The study was conducted at DNGH and PNTH, which are public hospitals in Bien Hoa city and Ho Chi Minh city, respectively.

Study Sample Identification: The hospital electronic database, which contains information on primary diagnosis, gender, age, health insurance status and healthcare event costs, was used to identify all applicable patients diagnosed using the International Statistical Classification of Diseases and Related Health Problems, Tenth Edition Revision (ICD-10). This study extracted data on all patients with a primary or secondary ICD-10 diagnosis of J44 during the period from January 2015 to December 2017 (three years). Patients were ineligible for this study if they had been diagnosed with asthma, bronchitis or lung disease caused by external agents; had been discharged from or transferred to the hospital; lacked the medical records information needed for the research or did not agree to disclose personal information.

Defining the Cost of Care: The total direct medical costs were calculated through the summation of medications and consulting doctor/ hospitalization and labouratory tests and functional/ imagination tests and other medical service costs. The other medical services included blood products, surgery and medical supply. The cost was calculated through the summation of the products produced by multiplying the quantities of each resource by its acquisition unit cost.

$$TC_n = \sum_{j=1}^{J} QS_{nj} \times US_j + \sum_{k=1}^{K} QD_{nk} \times UD_k + \sum_{l=1}^{L} QM_{nl} \times UM_l$$

As for the costing analysis methodology, the standard costs for units of medical care (e.g., office visits and direct hospital service components) were identified using Trung QV et al., [16]. The cost data were collected using local currency units (Vietnam Dong, VND). All local currency amounts were converted into 2017 US $ ($1.00 = VND 22,411) [17].

STATISTICAL ANALYSIS

All analyses were conducted using R Version 3.4.3 and Microsoft Excel Version. With the double-bootstrap method, the study data were summarized using descriptive statistics (mean, standard deviation, minimum, median, maximum, frequency and percentage). The difference between two independent groups showing a non-normal distribution, which was investigated using a Z-test. The level of statistical significance was set at 0.05. Moreover, in order to identify the subgroups of patients for which the burden of COPD was disproportionately high, total direct medical costs were compared across the <50, 50-59, 60-69, 70-79, 80-89 and ≥90 age groups and across gender.

Sensitivity Analysis: A one-way sensitivity analysis was carried out to determine the variance of total direct medical costs. Variables were selected either because they had the potential to substantially impact overall costs or because there was a high degree of uncertainty in the parameter. Specifically, this study adjusted each of the components of the cost attributable to COPD by ±10%, ±20%, ±30%, ±40% and ±50%, respectively.

Ethics statement: This study was approved by the research and ethics hospital committee of DNGH and PNTH. Data handling did not involve revealing the identity of any patients or control subjects, so ethical approval was not required. Some patients had extremely high resource consumption levels, leading to a skewed distribution.

RESULTS

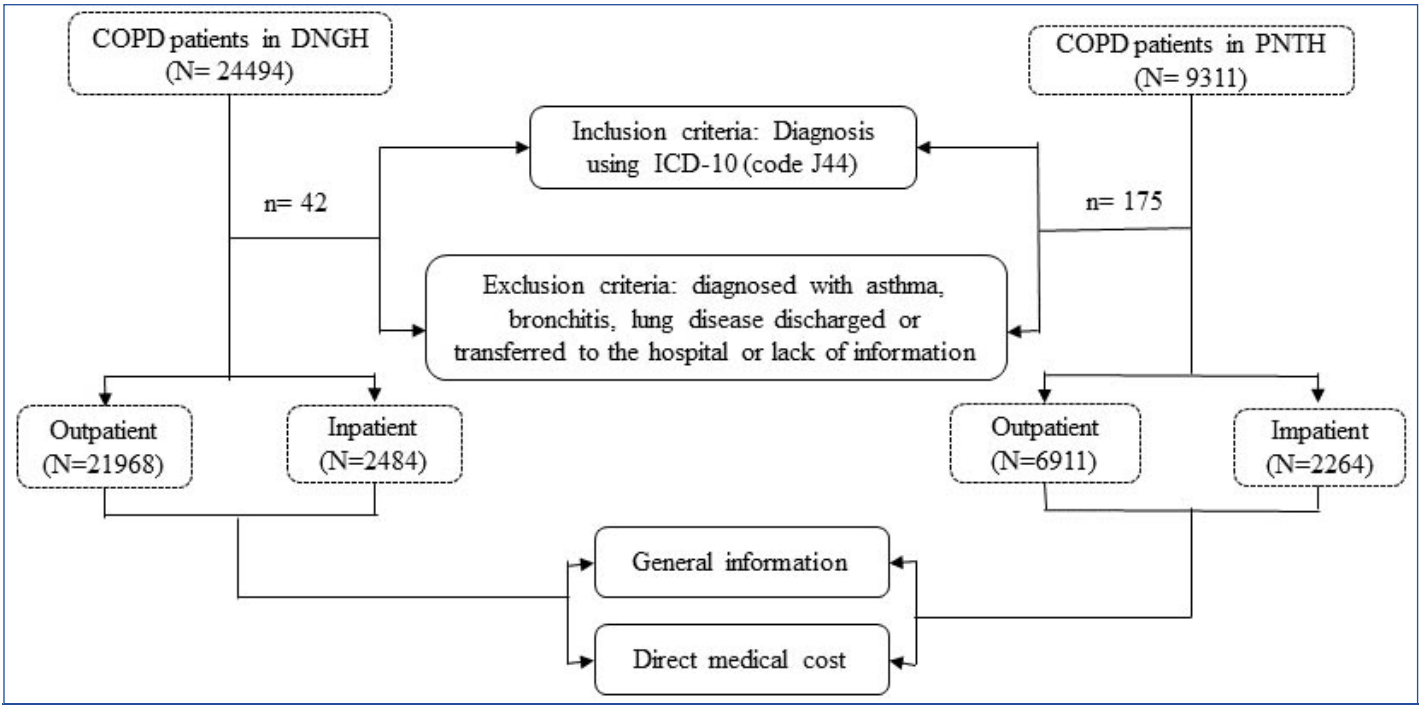
Socio-Demographic Characteristics of COPD Patients: During the study period, 33,617 eligible participants, of which 28,869 were outpatients, were admitted to the hospitals [Table/Fig-1]. The age, gender, health insurance status and length of stay of the study population are shown in [Table/Fig-2]. The sample was predominantly male (86.0–92.2%), reflecting the fact that the COPD prevalence is higher among males than among females. The majority were aged between 60 and 69 years, and almost all patients had health insurance. The median LOS varied from 6 to 10 days (range 1–77). When we compared the LOS incurred by patients who visited DNGH and PNTH, patients who visited PNTH stayed longer {median (Q1-Q3) was 10 (6–14) in PNTH and 7 (4–10) in DNGH}.

Diagnosis Direct Medical Costs: This evaluation of the healthcare costs incurred by COPD patients suggested that the direct costs per case were $23.2 (range $23.1–$23.3) and $386.9 (range $363.1–$414.7) in DNGH and PNTH, respectively [Table/Fig-3]. This difference was primarily caused by the higher costs of patient care in PNTH and the larger percentage of individuals seeking inpatient care as compared to outpatient care. In terms of these medical institutions, the cost due to medications was the largest contributor to direct medical costs in both DNGH and PNTH.

[Table/Fig-4] demonstrates that males had high costs for treatment. Furthermore, expenditures for people over 80-year-old were higher than those for younger patients [Table/Fig-5].

Healthcare Resource Utilisation and Costs: Pharmaceutical treatment during the maintenance phase mainly included Long-Acting Beta-2 Agonist (LABA) plus Inhaled Corticosteroid (ICS) (15.0%), Short-Acting Muscarinic Antagonists (SAMA) plus Short-Acting Beta-2 Agonists (SABA) (14.3%), SABA monotherapy (9.2%), systemic corticosteroids (0.6%), montelukast (0.2%) and antibiotics (29.2%), while the respective figure for the management of exacerbations, which were mainly treated with SABA + SAMA (11.0%), systemic corticosteroids (10.0%), SABA monotherapy (8.3%), ICS (5.7%), LABA + ICS (1.0%), long-acting muscarinic antagonists (tiotropium) (0.7%), theophyline (0.2%), montelukast (0.1%) and antibiotics (54.5%). Among antibiotics, levofloxacin was the key driver of medications costs for the IPD, accounting for 14.7% of such costs. As shown in [Table/Fig-6], the most common prescription medications claims for those in the IPD were antibiotics, whereas corticosteroid plus bronchodilators accounted for highest proportion among those in the OPD.

Labouratory tests included Complete Blood Count (CBC), biochemical tests, C-Reactive Protein (CRP) level, Erythrocyte Sedimentation Rate (ESR) and urine analysis. Functional and



[Table/Fig-1]: Diagram representing the patients enrolled in this study.

Characteristics	OPD					IPD				
	DNGH				PNTH	DNGH				PNTH
	2015 (N=5914)	2016 (N=8053)	2017 (N=7991)	2015-2017 (N=21958)	2016 (N=6911)	2015 (N=752)	2016 (N=968)	2017 (N=764)	2015-2017 (N=2484)	2016 (N=2264)
Age (years)										
Mean±SD	71.6±10.8	69.6±10.8	68.4±10.8	69.7±10.9	69.2±1.08	72.3±11.8	71.5±11.7	69.0±11.0	70.9±11.6	70.0±11.7
Median (Q1-Q3)	70 (63-81)	68 (62-79)	67 (61-76)	68 (62-69)	69 (62-76)	72 (64-82)	70 (63-81)	68 (61-78)	69 (62-81)	71 (63-80)
Range (Min-Max)	33-98	29-98	26-97	26-98	24-100	37-100	34-98	28-98	28-100	19-101
<50	84 (1.4)	159 (2.0)	169 (2.1)	412 (1.9)	194 (2.8)	19 (2.5)	21 (2.2)	8 (1.0)	48 (1.9)	70 (3.1)
50-59	640 (10.8)	1166 (14.5)	1359 (17.0)	3165 (14.4)	1087 (15.7)	73 (9.7)	120 (12.4)	121 (15.8)	314 (12.6)	324 (14.3)
60-69	2085 (35.3)	3163 (39.3)	3238 (40.5)	8486 (38.6)	2346 (33.9)	246 (32.7)	336 (34.7)	316 (41.4)	898 (36.2)	640 (28.3)
70-79	1395 (23.6)	1666 (20.7)	1638 (20.5)	4699 (21.4)	2030 (29.5)	180 (23.9)	212 (21.9)	152 (19.9)	544 (21.9)	651 (28.8)
80-89	1520 (25.7)	1681 (20.9)	1403 (17.6)	4604 (21.0)	1088 (15.7)	198 (26.3)	236 (24.4)	152 (19.9)	586 (23.6)	518 (22.9)
≥90	190 (3.2)	218 (2.6)	184 (2.3)	592 (2.7)	166 (2.4)	36 (4.9)	43 (4.4)	15 (2.0)	94 (3.8)	61 (2.6)
Gender										
Male	5418 (91.6)	7397 (91.9)	7369 (92.2)	20184 (91.9)	5972 (86.4)	682 (90.7)	862 (89.0)	692 (90.6)	2236 (90.0)	1946 (86.0)
Female	496 (8.4)	656 (8.1)	622 (7.8)	1774 (8.1)	939 (13.6)	70 (9.3)	106 (11.0)	72 (9.4)	248 (10.0)	318 (14.0)
Health insurance status (%)										
0(a)	-	-	-	-	139 (2.1)	49 (6.5)	41 (4.2)	39 (5.1)	129 (5.2)	444 (19.6)
60	-	-	-	-	-	38 (5.1)	42 (4.3)	28 (3.7)	108 (4.3)	222 (9.9)
80	2980 (50.4)	4205 (52.2)	4256 (53.3)	11441 (52.1)	4039 (58.4)	346 (46.0)	469 (48.5)	369 (48.3)	1184 (47.7)	841 (37.1)
95	695 (11.8)	858 (10.7)	803 (10.0)	2356 (10.7)	534 (7.7)	44 (5.9)	50 (5.2)	40 (5.2)	134 (5.4)	99 (4.4)
100(b)	2239 (37.8)	2990 (37.1)	2932 (36.7)	8161 (37.2)	2199 (31.8)	275 (36.5)	366 (37.8)	288 (37.7)	929 (37.4)	658 (29.0)
Length of stay (Days)										
Mean±SD	-					7.6±4.7	7.8±5.3	8.2±5.9	7.9±5.4	11.1±7.6
Median (Q1-Q3)	-					6 (4-9)	7 (4-10)	6 (4-11)	7 (4-10)	10 (6-14)
Range (Min-Max)	-					1-36	1-41	1-43	1-43	1-77

[Table/Fig-2]: Sampled patients' demographic characteristics in both DNGH and PNTH from 2015 to 2017 {n (%)}.
Abbreviations: DNGH: Dong Nai General Hospital; PNTH: Pham Ngoc Thach Hospital; SD: standard deviation; Q1: the first quartile; Q3: the third quartile
Notes:(a): Out-of-pocket; (b): No payment

imaging tests included spirometry, electrocardiography, chest radiography (X-ray) and Computed Tomography (CT). The frequency and percentage of patients in DNGH undergoing each test, as well as the total costs per test, are presented in [Table/Fig-7].

Sensitivity Analysis: A one-way sensitivity analysis [Table/Fig-8] showed that among those in the IPD, the results were not sensitive to changes in estimated direct medical costs for levofloxacin, SABA+SAMA, and hospitalisation. However, for those in the OPD, treatment cost estimates were sensitive to changes in LABA+ICS cost.

DISCUSSION

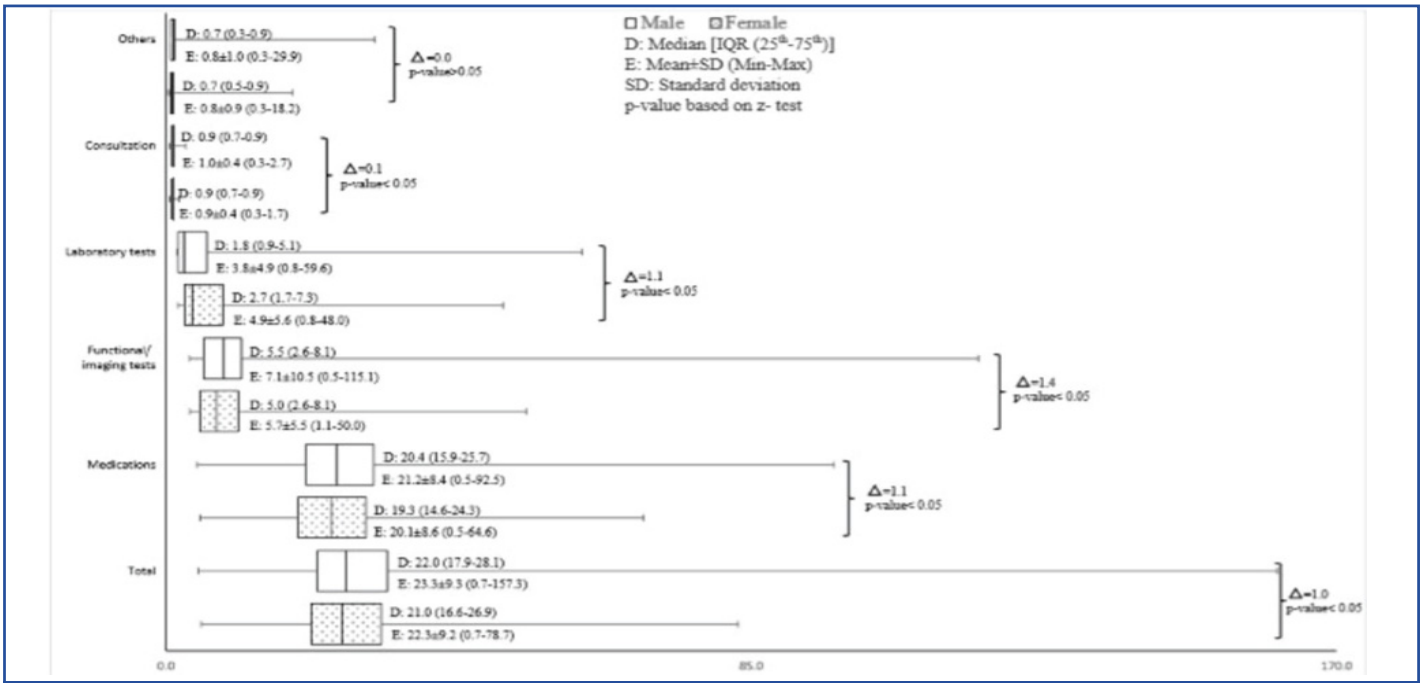
To our knowledge, this is the first COPD study that evaluated the direct medical costs of COPD on a provincial level. As health-care costs continue to increase, understanding cost trends in healthcare and identifying the factors that contribute to increased treatment

Perspective				Medications		Consulting doctor/ Hospitalization		Labouratory tests		Functional/ Imaging tests		Others		Direct medical cost		Burden cost
														Total cost	Median	
DNGH	2015	OPD N= 5914	Patient	n= 5895	2.1 (2.0, 2.2)-60.0	n= 5914	0.1 (0.1, 0.1)-2.9	n= 584	0.4 (0.3, 0.4)-11.4	n= 476	0.8 (0.6, 1.0)-22.9	n= 3105	0.1 (0.1, 0.1)-2.8	2.4 (2.3, 2.4)	1.6	13,925.9
			Payer		18.3 (18.1, 18.5)-62.9		0.6 (0.6, 0.6)-2.1		3.7 (3.4, 4.1)-12.7		5.8 (4.8, 6.9)-19.9		0.7 (0.7, 0.7)-2.4	20.1 (19.8, 20.3)	19.0	118,664.4
			Provider		20.4 (20.2, 20.6)-62.8		0.7 (0.7, 0.7)-2.2		4.1 (3.7, 4.5)-12.6		6.5 (5.4, 7.7)-20.0		0.8 (0.8, 0.8)-2.4	22.4 (22.2, 22.7)	21.6	32,590.3
		IPD N= 752	Patient	n= 750	20.0 (17.4, 23.4)-73.3	n= 752	3.0 (2.7, 3.3)-11.0	n= 453	1.7 (1.4, 2.1)-6.2	n = 359	2.1 (1.7, 3.5)-7.7	n= 752	0.5 (0.3, 1.2)-1.8	25.5 (22.3, 29.2)	11.0	9,157.5
			Payer		129.0 (115.5, 145.6)-78.7		15.8 (14.9, 16.6)-9.7		9.0 (8.3, 9.8)-5.5		8.7 (7.2, 10.4)-5.3		1.4 (1.1, 2.3)-0.8	155.4 (140.1, 174.5)	95.2	116,843.0
			Provider		149.0 (136.2, 165.4)-77.9		18.7 (17.9, 19.6)-9.8		10.8 (9.9, 12.0)-5.6		10.8 (9.1, 12.6)-5.6		1.9 (1.4, 2.9)-1.1	180.9 (165.5, 198.6)	118.9	136,000.5
	2016	OPD N= 8053	Patient	n= 8018	2.3 (2.2, 2.3)-57.5	n= 8053	0.1 (0.1, 0.1)-2.5	n= 638	0.5 (0.4, 0.5)-12.5	n= 622	1.0 (0.8, 1.1)-25.0	n= 4407	0.1 (0.1, 0.1)-2.5	2.6 (2.5, 2.6)	2.2	20,538.0
			Payer		19.4 (19.2, 19.5)-63.0		0.7 (0.7, 0.7)-2.3		3.6 (3.3, 4.0)-11.7		6.6 (5.9, 7.4)-21.4		0.5 (0.5, 0.5)-1.6	21.0 (20.8, 21.2)	19.9	169,043.3
			Provider		21.6 (21.4, 21.8)-62.4		0.8 (0.8, 0.8)-2.3		4.1 (3.7, 4.5)-11.9		7.5 (6.8, 8.4)-21.7		0.6 (0.6, 0.6)-1.7	23.5 (23.3, 23.7)	21.8	189,581.3
		IPD N= 968	Patient	n= 964	22.9 (20.2, 26.6)-70.9	n= 968	4.2 (3.8, 4.5)-13.0	n = 614	2.0 (1.7, 2.3)-6.2	n= 396	2.0 (1.4, 3.7)-6.2	n= 968	1.2 (1.1, 1.4)-3.7	30.3 (27.0, 34.6)	14.7	29,341.8
			Payer		150.5 (137.7, 168.5)-71.9		28.0 (26.7, 29.5)-13.3		14.0 (12.7, 15.5)-6.7		8.9 (7.6, 10.7)-4.2		8.5 (7.9, 9.2)-3.9	198.9 (183.9, 217.1)	131.2	192,570.1
			Provider		173.4 (159.9, 191.7)-71.6		32.2 (30.9, 33.6)-13.3		16.0 (14.6, 17.6)-6.6		10.9 (9.4, 13.1)-4.5		9.7 (9.0, 10.7)-4.0	229.2 (213.5, 250.2)	156.1	221,911.9
	2017	OPD N= 7991	Patient	n= 7958	2.2 (2.2, 2.3)-59.5	n= 7991	0.1 (0.1, 0.1)-2.7	n= 503	0.4 (0.3, 0.4)-10.8	n= 485	0.9 (0.8, 1.0)-24.3	n= 4728	0.1 (0.1, 0.1)-2.7	2.5 (2.4, 2.5)	2.0	19,817.5
			Payer		18.8 (18.7, 19.0)-63.3		1.2 (1.2, 1.2)-4.0		3.1 (2.7, 3.4)-10.4		5.8 (5.3, 6.4)-19.5		0.8 (0.8, 0.8)-2.8	21.0 (20.8, 21.2)	19.7	167,663.2
			Provider		21.1 (20.9, 21.3)-63.0		1.3 (1.3, 1.3)-3.9		3.4 (3.0, 3.8)-10.2		6.8 (6.2, 7.4)-20.3		0.9 (0.9, 0.9)-2.6	23.5 (23.3, 23.7)	22.5	187,480.7
		IPD N= 764	Patient	n= 760	22.0 (18.3, 31.4)-59.3	n= 764	7.5 (6.6, 8.7)-20.2	n = 495	3.0 (2.5, 3.8)-8.1	n= 307	1.4 (1.1, 1.6)-3.8	n= 764	3.2 (2.8, 3.8)-8.6	35.1 (30.1, 44.2)	13.7	26,843.2
			Payer		129.5 (115.3, 146.0)-57.8		49.8 (46.6, 53.3)-22.2		15.2 (13.8, 17.0)-6.8		9.3 (7.9, 10.9)-4.2		20.2 (18.5, 22.2)-9.0	212.4 (194.0, 236.4)	138.4	162,286.1
			Provider		151.5 (137.6, 171.1)-58.0		57.4 (54.5, 60.4)-22.0		18.2 (16.5, 20.2)-7.0		10.6 (9.3, 12.3)-4.1		23.4 (21.8, 25.3)-8.9	247.6 (226.8, 273.5)	163.0	189,129.3
	2015-2017	OPD N= 21958	Patient	n= 21871	2.2 (2.2, 2.2)-59.5	n= 21958	0.1 (0.1, 0.1)-2.7	n= 1720	0.4 (0.4, 0.4)-10.8	n= 1576	0.9 (0.8, 1.0)-24.3	n= 12240	0.1 (0.1, 0.1)-2.7	2.5 (2.4, 2.5)	1.9	54,266.2
			Payer		18.9 (18.8, 19.0)-63.0		0.8 (0.8, 0.8)-2.7		3.5 (3.3, 3.7)-11.7		6.1 (5.7, 6.6)-20.3		0.7 (0.7, 0.7)-2.3	20.7 (20.6, 20.9)	19.6	455,370.9
			Provider		21.1 (21.0, 21.2)-62.4		1.0 (0.9, 1.0)-3.0		3.9 (3.7, 4.1)-11.5		7.0 (6.5, 7.5)-20.7		0.8 (0.8, 0.8)-2.4	23.2 (23.1, 23.3)	22.0	509,637.1
		IPD N= 2484	Patient	n= 2274	21.8 (19.9, 24.2)-67.5	n= 2484	4.8 (4.5, 5.2)-14.9	n= 1562	2.2 (2.0, 2.5)-6.8	n= 1062	1.9 (1.6, 2.7)-5.9	n= 2484	1.6 (1.4, 1.9)-4.9	30.3 (28.1, 33.0)	13.1	74,803.2
			Payer		137.5 (129.8, 146.6)-68.7		31.0 (29.8, 32.3)-15.5		12.9 (12.2, 13.7)-6.4		8.9 (8.1, 10.0)-4.4		9.9 (9.4, 10.6)-5.0	189.9 (181.0, 199.3)	122.9	469,711.7
			Provider		159.3 (150.3, 170.0)-68.5		35.8 (34.5, 37.3)-15.4		15.1 (14.3, 16.1)-6.5		10.8 (9.9, 11.8)-4.6		11.5 (10.9, 12.3)-5.0	220.2 (210.2, 231.4)	147.9	544,514.9
PNTH				Medications & Medical supplies		Consulting doctor/ Hospitalization		Labouratory tests & Functional/ Imaging tests				Others		Direct medical cost		Burden cost
	2016	OPD N= 6911	Patient	n= 6911	3.5 (3.5, 3.6)-48.0	n= 6911	0.2 (0.2, 0.2)-2.7	n= 1660	2.5 (2.3, 2.8)-34.2			n= 789	1.1 (1.0, 1.2)-15.1	4.5 (4.4, 4.6)	4.1	31,087.9
			Payer		24.1 (23.8, 24.4)-61.6		0.9 (0.9, 0.9)-2.3		12.0 (11.5, 12.5)-30.7				2.1 (1.9, 2.3)-5.4	28.2 (27.8, 28.6)	25.8	195,126.2
			Provider		27.7 (27.3, 28.0)-59.6		1.1 (1.1, 1.1)-2.4		14.5 (13.9, 15.2)-31.2				3.2 (3.0, 3.4)-6.8	32.7 (32.3, 33.1)	30.1	226,214.1
		IPD N= 2264	Patient	n= 2264	57.8 (51.5, 66.7)-53.9	n= 2264	24.4 (22.0, 27.0)-22.8	n= 2264	18.1 (16.5, 19.8)-16.9			n= 2264	6.9 (5.8, 9.4)-6.4	107.2 (97.4, 121.7)	34.9	242,644.8
			Payer		154.4 (140.0, 171.3)-55.2		58.2 (54.9, 61.5)-20.8		47.9 (45.7, 50.9)-17.1				19.3 (17.2, 22.2)-6.9	279.8 (261.5, 303.0)	143.4	633,407.0
			Provider		212.2 (195.4, 230.8)-54.8		82.6 (78.4, 87.5)-21.3		66.0 (63.1, 69.8)-17.1				26.2 (23.6, 29.6)-6.8	386.9 (363.1, 414.7)	226.9	876,051.8

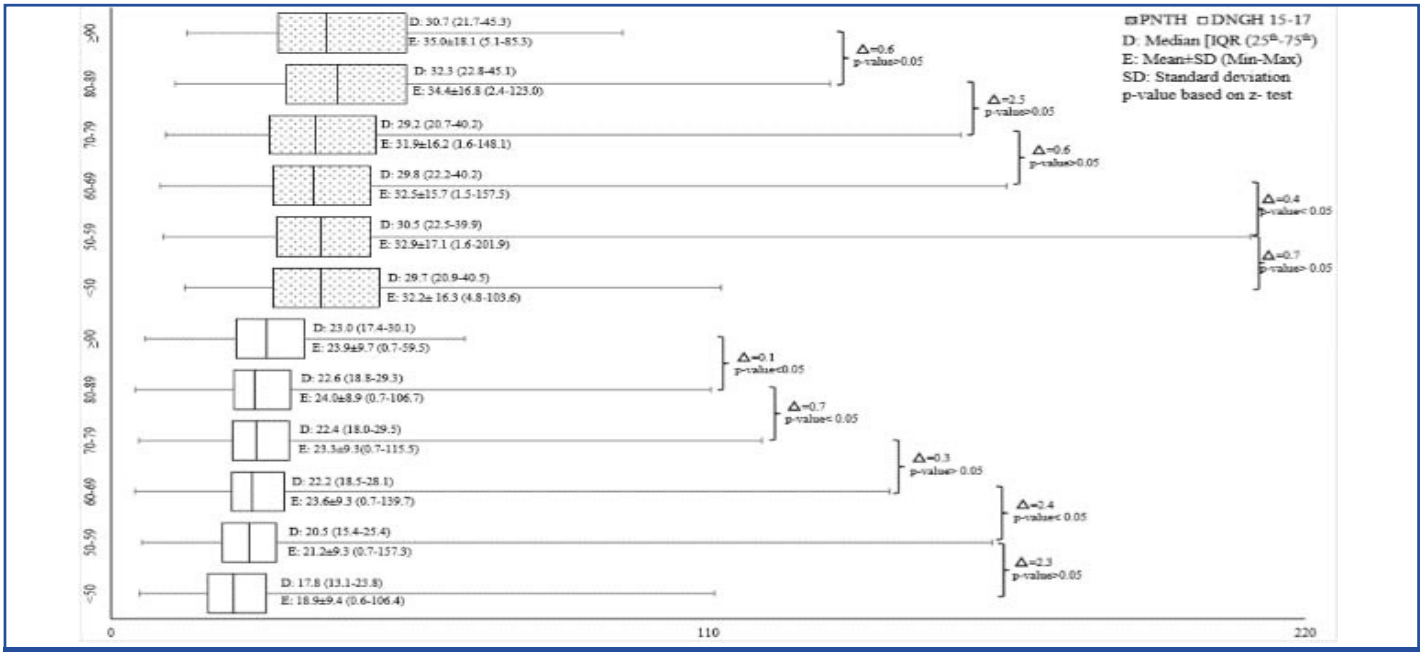
[Table/Fig-3]: Per case and total direct medical costs attributable to COPD in DNGH and PNTH (Arithmetic mean (Bootstrap 95% CI)-%), {Arithmetic mean (bootstrap 95% CI)-%, Median}.
Abbreviations: DNGH: Dong Nai General Hospital; PNTH: Pham Ngoc Thach Hospital

costs will be important in planning for future healthcare costs and for prioritising and allocating medical resources.

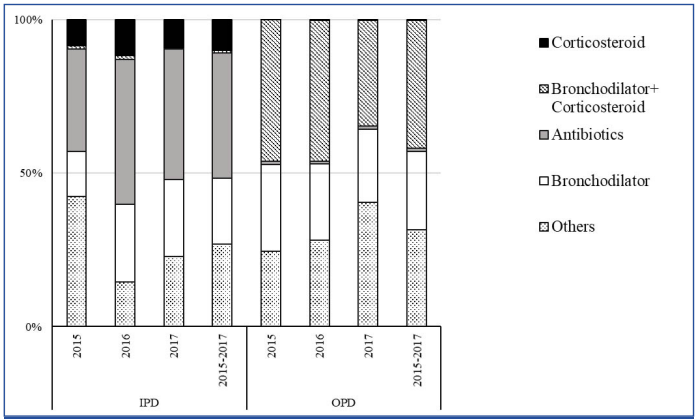
In this paper, an age of ≥90 years, male gender, and a long duration of hospitalisation were factors found to increase the costs for patients with COPD. The mean duration of hospitalisation was 7.6–11.1 days, similar to that reported in a study in the US, where the



[Table/Fig-4]: Box plots of total OPD hospital expenditures by gender in DNGH over the total three-year period for specific complications.



[Table/Fig-5]: Box plots for total IPD expenditures by hospital based on patient age in years.



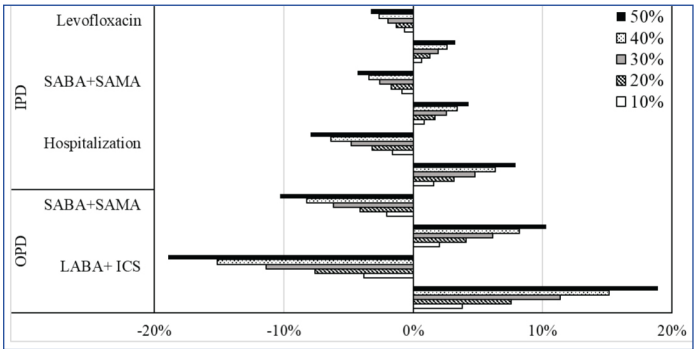
[Table/Fig-6]: Contributions of specific categories to total hospital medications in DNGH by class over the three-year period.

average LOS values for simple admissions and complex admissions were 4.5 days and 8.8 days, respectively [18]. In other studies, the average duration was found to be 2.7–11.4 days [14,19,20]. Longer hospital duration was also associated with increased daily costs due to severe treatment-resistant cases with many accompanying comorbidities, in addition to increased expenditures for hospital stays. The relationship between increased costs and a lengthy hospital stay has been demonstrated in many studies [21,22]. Hence, the improvement of quality of life in patients, their extended presence in the labour market, and a reduced number of hospitalisations would mitigate the economic burden of the disease.

Variations in terms of the country of study, year, currency, analysis perspective, disease severity and cost/resource item under evaluation were observed in the published economic burden studies, making it difficult to compare across health economies. Comparing these data with previously published evidence, the cost estimate for COPD ($278.4–$386.9) was lower than those indicated elsewhere. In Germany, the mean annual cost per patient was reported to be between about €4,441 for grade 1 COPD, about €5,321 for grade 2, about €7,801 for grade 3 and about €10,770 for grade 4 [19]. A study in Canada reported a mean cost of €1,681 per hospitalisation and €633 per outpatient visit during a 10-year follow-up period [23]. In 2016, a study in the United Kingdom conducted using international databases indicated that COPD exacerbation management costs ranged from $504 in South Korean to $9,981 in the United States in terms of the annual direct costs per patient

			Labouratory tests							Functional/ imaging tests					
			Bio-chemi-cal tests(a)	CBC	CRP	Urine anal-ysis	ESR	Othe-rs(b)	Total	Chest radiogra-phy	Elec-tro-cardi-ogra-phy	Spirom-etry	Chest CT	Others(c)	Total
OPD	2015	n (%)	889 (40.4)	107 (4.9)	-	28 (1.3)	1 (<0.1)	1178 (53.4)	2203	268 (34.4)	142 (18.2)	157 (20.1)	9 (1.2)	204 (26.1)	780
		Cost (%)	770.6 (33.9)	191.0 (8.4)	-	43.7 (1.9)	1.3 (0.1)	1269.7 (55.7)	2276.3	446.4 (14.4)	170.4 (5.5)	560.4 (18.1)	454.9 (14.6)	1472.8 (47.4)	3104.9
	2016	n (%)	712 (36.3)	155 (7.9)	1 (0.1)	23 (1.2)	2 (0.1)	1071 (54.4)	1964	383 (36.7)	93 (8.9)	266 (25.5)	11 (1.1)	292 (27.8)	1045
		Cost (%)	660.0 (26.1)	276.6 (11.0)	0.9 (<0.1)	35.9 (1.4)	2.7 (0.1)	1549.1 (61.4)	2525.3	932.0 (19.9)	150.5 (3.2)	1381.2 (29.5)	554.6 (11.9)	1661.6 (35.5)	4680.0
	2017	n (%)	353 (30.5)	83 (7.2)	3 (0.3)	16 (1.4)	1 (0.1)	700 (60.5)	1156	235 (33.0)	62 (8.7)	142 (19.9)	5 (0.7)	269 (37.7)	713
		Cost (%)	343.5 (20.0)	159.9 (9.3)	4.3 (0.2)	26.2 (1.5)	1.5 (0.1)	1178.6 (68.9)	1714.0	690.7 (21.5)	118.9 (3.7)	865.8 (26.9)	189.1 (5.9)	1353.2 (42.0)	3217.7
	2015-2017	n (%)	1954 (36.7)	345 (6.5)	4 (0.1)	67 (1.3)	4 (0.1)	2949 (55.3)	5323	886 (34.9)	297 (11.7)	565 (22.3)	25 (1.0)	765 (30.1)	2538
		Cost (%)	1774.2 (27.2)	627.5 (9.6)	5.1 (0.1)	105.9 (1.6)	5.5 (0.1)	3997.5 (61.4)	6515.7	2069.1 (18.8)	439.8 (4.0)	2807.5 (25.5)	1198.7 (10.9)	4487.6 (40.8)	11002.6
IPD	2015	n (%)	618 (34.5)	375 (20.9)	60 (3.4)	35 (2.0)	23 (1.3)	679 (37.9)	1790	108 (18.8)	108 (18.8)	59 (10.3)	29 (5.1)	270 (47.0)	574
		Cost (%)	674.3 (13.8)	1085.6 (22.2)	92.4 (1.9)	56.2 (1.2)	30.8 (0.6)	2947.7 (60.3)	4887.0	193.5 (5.0)	154.3 (4.0)	210.6 (5.4)	1444.9 (37.3)	1867.5 (48.3)	3870.8
	2016	n (%)	712 (32.9)	485 (22.4)	37 (1.7)	11 (0.5)	14 (0.6)	908 (41.9)	2167	134 (20.6)	131 (20.2)	59 (9.1)	27 (4.2)	298 (45.9)	649
		Cost (%)	887.9 (9.1)	1378.4 (14.1)	44.2 (0.5)	18.7 (0.2)	18.7 (0.2)	7451.1 (75.9)	9799.0	347.5 (8.0)	240.6 (5.6)	304.6 (7.1)	839.0 (19.4)	2586.9 (59.9)	4318.6
	2017	n (%)	785 (36.8)	413 (19.4)	119 (5.6)	-	-	815 (38.2)	2132	104 (20.8)	105 (21.0)	32 (6.4)	13 (2.6)	246 (49.2)	500
		Cost (%)	1211.2 (13.5)	1316.6 (14.6)	280.0 (3.1)	-	-	6184.5 (68.8)	8992.2	334.2 (10.2)	274.8 (8.4)	176.0 (5.4)	397.3 (12.2)	2083.4 (63.8)	3265.6
	2015-2017 -2017	n (%)	2115 (34.7)	1273 (20.9)	216 (3.5)	46 (0.8)	37 (0.6)	2402 (39.5)	6089	346 (20.1)	344 (20.0)	150 (8.7)	69 (4.0)	814 (47.2)	1723
		Cost (%)	2773.4 (11.7)	3780.6 (16.0)	416.5 (1.8)	75.0 (0.3)	49.5 (0.2)	16583.2 (70.0)	23678.2	875.2 (7.6)	669.6 (5.8)	691.2 (6.0)	2681.2 (23.4)	6537.8 (57.2)	11455.0

[Table/Fig-7]: The numbers of COPD-related labouratory and functional/ imaging test and their expenditures in DNGH over the years
(a) Includes urea, creatinine, SGOT, SGPT, K, Na, Ca, and LDH test; (b) Includes blood glucose test, cholesterol and triglycerides test, prothrombin time blood test and so on
(c) Includes ultrasound scan, endoscopy and so on
Abbreviations: DNGH: Dong Nai General Hospital; CBC: Complete Blood Count; CRP: C-Reactive Protein; ESR: Erythrocyte Sedimentation Rate; SGOT: Serum Glutamic Oxaloacetic Transaminase; SGPT: Serum Glutamic Pyruvic Transaminase; LDH: Lactate Dehydrogenase; CT: Computed Tomography



[Table/Fig-8]: Tornado diagrams of the sensitivity analysis affecting IPD and OPD total burden in DNGH over the total three- years, by changing ±10%, ±20%, ±30%, ±40%, ±50% of expenditure of each category.

[13]; while in Greece, the annual direct healthcare costs were about $1,512 for exacerbation and about $835 for the maintenance phase managed in all healthcare settings [14]. Finally, the mean cost per exacerbation was estimated in about €5,563 in Denmark, with large differences observed between the costs of exacerbations requiring in-hospital treatment and those treated in an outpatient setting (€789) [24].

In developing countries, data on healthcare resource use attributable to COPD are sparse, making any direct comparison with the findings of this study very difficult. The majority of available data on COPD-related healthcare resource consumption in these countries related to frequency of use. For example, in the Breathe study, the reported rates of healthcare resource use were 60% in subjects who underwent physician consultations, 20% for those who made emergency room visits, and 20% for those who underwent hospitalisation [25]. In this study, medications accounted for over half of direct medical costs, substantially more than functional/imaging tests, labouratory tests or hospitalisations. This difference may be explained by local specificities regarding the healthcare system and the heterogeneous distribution of healthcare resources within countries. For example, the healthcare insurance system differs between countries (being principally public in Vietnam and principally private in the US). One aspect of this is healthcare resource consumption, which may differ between countries. For example, the costs of consulting doctors and hospitalisations are low in Vietnam.

Our findings highlight the cost outcomes associated with hospitalization at two hospitals in Southern of Vietnam. The costs of treating chronic diseases are seldom examined from the provider perspective because most studies use administrative data containing charges billed to third-party payers, which may be more or less than the actual costs. This study sheds light on the actual costs incurred patients, payers and providers. Strength is the large sample size of the encounter categories.

Although this study is valuable because it included a large number of outpatients and inpatients, it also had certain limitations. First, the retrospective design may have led to data loss, which precludes a definitive conclusion. The data used for this study came from a public hospital database, and therefore, the results of this analysis are primarily applicable to public care settings and may

not be generalisable to other settings, such as private hospitals. Furthermore, this result reflected COPD-related costs in Vietnam, which complicated the generalisation of these data to other countries. In addition, the accuracy of the diagnosis and management was sensitive to the diagnostic criteria used by the reporting doctors. Those people aged under 30 years with a diagnosis of COPD may have been misdiagnosed. Furthermore, although J44 is by far the most common diagnosis used in COPD, several diagnoses derived from J40 (bronchitis), J41 (simple and muco-purulent chronic bronchitis), J43 (emphysema) and J47 (bronchiectasis) were also used to some unknown extent.

CONCLUSION

This analysis, for the first time, stated the specific costs of COPD, which will provide state public health practitioners with estimates of the economic burden of COPD within their borders and illustrate the potential medical cost savings for nations via the implementation of programs designed to prevent the onset of COPD (e.g., tobacco prevention and cessation). The range of evidence-based strategies to prevent COPD and decrease its effects provides opportunities for clinical and public health practitioners to work together at the national level to decrease the economic impact of COPD and improve quality of life for people with COPD.

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