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Chronic obstructive pulmonary disease involves substantial health-care service and social benefit costs

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ABSTRACT

INTRODUCTION: The present study compared health carerelated costs and the use of social benefits and transfer payments in participants with and without chronic obstructive pulmonary disease (COPD), and related the costs to the severity of the COPD.

MATERIAL AND METHODS: Spirometry data from a cohort study performed in Denmark during 2004-2006 were linked with national register data that identified the costs of social benefits and health-care services. The cohort comprised 546 participants with COPD (forced expiratory volume in the first sec. (FEV1)/forced vital capacity (FVC) ratio < 0.7 following bronchodilator administration] and 3,995 without COPD (in addition, 9,435 invited participants were non-responders and 331 were excluded). The costs were adjusted for gender, age, co-morbidity and educational level. **RESULTS:** Health care-related costs were 4,779 (2,404-7,154) Danish kroner (DKK) higher for participants with COPD than for those without COPD, and 2,882 (556-5,208) DKK higher than for those for non-responders. The higher costs were mainly due to the cost of medicines and inpatient care. The health-care costs increased with disease severity Global Initiative for Chronic Obstructive Lung Disease (GOLD grade). In participants < 65 years of age, the annual cost of social benefits and transfer payments was 15,901 (5,966-25,837) DKK higher and the total costs were 20,454 (7,559-33,350) DKK higher in those with COPD than in those without COPD; this was due mostly to the high cost of disability pensions.

CONCLUSION: Health care-related costs and costs for social benefits and transfer payments were higher for participants with COPD than for non-COPD participants and non-responders.

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TRIAL REGISTRATION: not relevant.

Chronic obstructive pulmonary disease (COPD) is a major cause of morbidity and mortality globally [1]. It is important to determine the costs associated with COPD in order to inform government bodies and health planners and to guide the allocation of resources.

A few cohort studies have followed groups of individuals with and without COPD and have asked each individual to record all relevant data that relate to the costs of their illness [2-4]. However, such studies require extensive self-registration and are prone to selection and recall bias. In addition, the recorded costs of healthcare expenses, social benefits, etc. may be based on unit prices that do not reflect the actual costs. In contrast, costs that are acquired from registers may reflect the actual costs more accurately than the information obtained from self-registration and unit prices. The use of registers may also allow evaluation of cost profiles for non-responders. However, register-based studies usually identify individuals with COPD on the basis of a physician's diagnosis of COPD. This may exclude a large number of undiagnosed individuals with COPD and may yield cost estimates different from those obtained by cost calculations that are based on identification of individuals with COPD from a population-based sample [5]. Hence, valuable information may be obtained from combining the two approaches and by identifying patients through a population-based sample, while using register data to obtain valid data on costs.

A Danish cohort study [6] that included the use of spirometry made it possible to obtain the COPD status of a population sample and to combine this status with individual data from public registers to calculate the costs and to relate these costs to COPD status.

The aim of the present study was to compare the health-related public costs and the use of social benefits and transfer payments for individuals with COPD and those without COPD, and to relate these costs to the severity of COPD.

MATERIAL AND METHODS

Data from a cohort study on COPD [6] were combined with information from multiple Danish registers. In the earlier cohort study, subjects were sampled from a mixed urban/rural population of 299,000 persons from two counties in Jutland, Denmark. On the basis of the estimated prevalence of COPD in 10-year groups, a target sample size of 4,850 participants was calculated and 14,307 individuals were invited to participate (**Figure 1**). Tested persons with a ratio between forced expiratory volume in the first sec. (FEV1) and forced vital capacity (FVC) of < 0.7 following bronchodilator administration were classified as having COPD. A total of 227 individuals

ORIGINAL ARTICLE

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FIGURE 1

Study description - flow of invited subjects.



COPD = chronic obstructive pulmonary disease.

with a ratio < 0.70 at the first test and no confirmatory bronchodilator test were excluded from the analysis. Severity of disease was classified according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) grades: I (mild: FEV1 \ge 80%), II (moderate: 50% \le FEV1 < 80%), III (severe: 30% \le FEV1 < 50%) and IV (very severe: FEV1 < 30%).

Register data

The data were made available by Statistics Denmark and were obtained from several national registers by means of the unique personal identification number (CPR number) assigned to all Danish citizens [7]. The index date of 1 May 2005 was applied during the extraction of the register data, and we used data for the three preceding years, except for data from the Coherent Social Statistics register for which data for the calendar years 2002, 2003 and 2004 were used. The analysis of social benefits and transfer payments only included persons below the normal pension age of 65 years.

We obtained information on the vital status of the subjects from The Danish Civil Registration System [8] and on educational level from the Integrated Databank on Research in the Labour Market [9]. Diagnoses acquired from the National Patient Register [10] were categorized in accordance with the Charlson Comorbidity Index [11] (omitting diagnoses of chronic pulmonary disease) and were dichotomized to give a score of 0 (no comorbidity) or \geq 1. With respect to co-morbidity, we used all information made available since the founding of the Danish National Patient Register in 1977.

Health care-related costs

The Danish National Prescription Register [12] supplied data on all prescription drugs sold to the subjects. The Danish National Health Service Register provided data on reimbursements to primary health-care providers, e.g. general practitioners, medical specialists, physiotherapists, chiropractors and dentists. Information on all hospital admissions for the subjects was made available by the Danish National Health Register [13] and included cost information based on diagnosis-related groups (DRG) [14]. We included all costs of admissions regardless of the diagnosis. Co-payment made by individuals for medication were included in the costs, but details of other types of co-payment were not available in the registers. We had no access to records on the use of private medical care.

Social benefits and transfer payments

We obtained information from the Coherent Social Statistics register on income compensation (e.g. unemployment compensation, health-related compensation, social assistance and various types of pension). Such forms of compensation are provided by the state.

Statistics

To analyse the distribution of costs, we performed a least-squares estimation with correction for gender, age, co-morbidity and educational level, and we used non-parametric bootstrapping for tests. Data were presented as arithmetic means with 95% confidence limits (CI) of the mean. Costs were reported in Danish kroner (DKK).

The data were analysed using Stata (Version 11.0, College Station, Texas, USA). The reported probability values were based on two-sided alternative hypotheses. A probability (p-value) of less than 0.05 was regarded as being statistically significant.

Trial registration: not relevant.

RESULTS

Table 1 shows the baseline characteristics for participants with and without COPD as well as for the non-responders. In comparison with participants without COPD (n = 3,995), significantly more participants with COPD (n = 546) were more than 65 years of age, were male, had a lower level of education (i.e. only elementary school), had co-morbidity and had a diagnosis of chronic pulmonary disease recorded in the National Patient Register.

Baseline characteristics of the study population: tested persons with and without chronic obstructive pulmonary disease and non-responders. The values are n (%).

	Tested COPD						
	GOLD grade 1 (n = 199)	GOLD grade 2 (n = 241)	GOLD grade 3-4 (n = 106)	All COPD (n = 546)	no COPDª (n = 3,995)	Non-responders ^a (n = 9,435)	
Age < 65 years	51 (25.6)	55 (22.8)	11 (10.4)	117 (21.4)	1,849*** (46.3)	3,396*** (36.0)	
Men	160 (80.4)	185 (76.8)	85 (80.2)	430 (78.8)	2,517*** (63.0)	5,582*** (59.2)	
Education above elementary school ^b	95 (47.8)	110 (45.6)	45 (42.5)	250 (45.8)	2,312*** (57.9)	4,005 (42.4)	
Co-morbidity registered in the National Patient Register ^c	73 (36.7)	98 (40.7)	50 (47.2)	221 (40.5)	1,066*** (26.7)	3,390* (35.9)	
Chronic nulmonary disease diagnosis in the National Patient Register	26 (13 1)	66 (27 4)	63 (59.4)	155 (28.4)	176*** (4 4)	770*** (8 2)	

COPD = chronic obstructive pulmonary disease; GOLD = Global Initiative for Chronic Obstructive Lung Disease.

a) χ^2 -test of difference from All COPD: *) p < 0.05, ***) p < 0.001; b) For participants with additional education, vocational training was the most common type (31.7%) followed by medium-length higher education (9.1%); c) Co-morbidity was classified in accordance with the Charlson Comorbidity Index [10] except that we excluded the diagnosis of chronic pulmonary disease. The presence of co-morbidity was dichotomized to 0 or \geq 1 co-morbidity.

Annual unadiusted costs in public health-care expenses and the adjusted differences between individuals with chronic obstructive pulmonary disease and tested persons without chronic obstructive pulmonary disease. The values are in Danish kroner (DKK)^a, mean (95% confidence interval of the mean).

	Unadjusted annual cost		Adjusted difference ^b (COPD – no COPD)				
	COPD (n = 546)	no COPD (n = 3,995)	all COPD	GOLD grade 1	GOLD grade 2	GOLD grade 3–4	
Medicine							
COPD medicine (R03) ^c	2,093 (1,776-2,420)	196 (161-235)	1,801 (1479-2,123)	389 (129–649)	1,502 (1,100-6,203)	5,154 (4,106-6,203)	
All medicine	5,949 (5,406-6,515)	3,182 (3,028-3,339)	1,973 (1,427-2,520)	380 (-447-1,208)	1,432 (756-2,107)	6,219 (4,827-7,611)	
Primary care							
General practice	1,317 (1,226-1,413)	1,013 (982–1,046)	132 (40–224)	-55 (-208-98)	185 (53-316)	363 (150-576)	
All primary care expenses	2,182 (2,043-2,326)	2,037 (1,973-2,101)	-49 (-207-110)	-257 (-470 to -45)	35 (-169-239)	154 (-238-547)	
Hospital care							
Outpatient care	3,878 (3,334-4,452)	3,108 (2,837-3,431)	-54 (-695-588)	-143 (-1,106-820)	-496 (-1,197-205)	1,125 (-640-2,891)	
Inpatient care	11,695 (9,837-13,723)	6,060 (5,558-6,565)	2,908 (1,012-4,805)	1,459 (-1,401-4,319)	2,164 (-284-4,612)	7,347 (2,291-12,700)	
All hospital care	23,705 (13,436-17,850)	14,385 (8,515-15,131)	2,855 (742-4,967)	1,316 (-1,943-4,575)	1,668 (-1,072-4,407)	8,472 (2,291-14,654)	
Total public health-care cost	23,705 (21,278-26,233)	14,385 (13,661-15,131)	4,779 (2,404-7,154)	1,440 (-1,964-4,843)	3,134 (98-6,170)	14,846 (8,070-21,621)	

COPD = chronic obstructive pulmonary disease; GOLD = Global Initiative for Chronic Obstructive Lung Disease.

a) 100 DKK = 13.44 Euro (end of year exchange rate 2004); b) The difference was adjusted for age, educational level and co-morbidity using a multiple regression model;

c) Medicine for obstructive pulmonary disease, but not including prophylactic vaccinations or oral corticosteroids.

Health care-related costs

Health care-related costs were 4,779 (2,404-7,154) DKK higher for participants with COPD than for those without COPD (p = 0.00008; Table 2), and costs were also 2,882 (556-5,208) DKK higher than for the non-responders (p = 0.015). The difference in health care-related costs between participants with and without COPD was due mainly to the high costs of medicine and inpatient care. The total health care-related cost increased with increasing severity of the disease (GOLD grade).

Total annual costs and costs of social benefits and transfer payments in persons less than 65 years of age.

The total annual costs were statistically significantly higher for participants with COPD than for those without COPD (p = 0.002; Table 3).

Among the participants with COPD, those with more advanced disease, i.e. GOLD grades 2-4, did not have higher total costs than persons with mild disease (GOLD grade 1; p = 0.753). The higher total costs for participants with COPD as compared with those without COPD were due mainly to differences in social benefits and transfer payments and, in particular, the former's significantly higher costs of disability pensions (p = 0.016). The differences in social benefits and transfer payments and in total costs between those with COPD and non-responders were 7,977 (-1,628-17,582) and 11,911 (-742-24,564) DKK, respectively.

Hospitalization and outpatient visits

Compared with participants without COPD, those with COPD had 0.485 additional days of hospitalization per year (p = 0.0136) and non-responders 0.539 additional days (p < 0.000001). The differences in outpatient visits were not significantly different between the groups

TABLE 3

Unadjusted annual costs, for persons below 65 years of age, of public health-care expenses, social benefits and other transfer payments and the adjusted estimated differences between individuals with chronic obstructive pulmonary disease and those without chronic obstructive pulmonary disease. The values are in Danish kroner (DKK)^a, mean (95% confidence interval of the mean).

	Unadjusted annual cost		Adjusted difference ^b (COPD – no COPD)					
	COPD (n = 117)	no COPD (n = 1,849)	all COPD	GOLD Grade 1	GOLD Grade 2–4			
Unemployment compensation	11,630 (7,037-16,729)	8,154 (7,132-9,213)	3,516 (-1,260-8,292)	4,229 (-3,670-12,128)	2,964 (-3,137-11,297)			
Temporary health-related benefit	3,537 (1,788-5,861)	4,559 (3,914-5,238)	-1,247 (-3,379-885)	-2,875 (-4,502-(-1,248))	13 (-3,406-3,432)			
Social assistance	101 (0-319)	417 (198-682)	-349 (-707-8)	-174 (-689-340)	-485 (-854-(-115))			
Disability pension	25,273 (16,571-34,678)	9,856 (8,457-11,275)	10,803 (2,003-19,603)	13,504 (1,300-25,708)	8,713 (-3,422-20,847)			
Early retirement pension	15,864 (9,049-23,285)	9,148 (7,788-10,524)	3,179 (-2,388-8,746)	484 (-7,364-8,332)	5,264 (-2,536-13,064)			
Cost of social benefits	56,405 (45,991-66,849)	32,133 (29,957-34,285)	15,901 (5,966-25,837)	15,167 (969-29,366)	16,469 (3,092-29,847)			
Cost of public health care	18,916 (13,564-25,830)	11,192 (10,254-12,190)	4,553 (-1415-10,521)	2,972 (-4,027-9,972)	5,776 (-3,341-14,894)			
Total cost	75,321 (61,689-89,704)	43,324 (40,743-45,935)	20,454 (7,496-33,413)	18,140 (1,075-35,205)	22,246 (3,563-40,928)			
Unemployment compensation Temporary health-related benefit Social assistance Disability pension Early retirement pension Cost of social benefits Cost of public health care Total cost	1,630 (7,037-16,729) 3,537 (1,788-5,861) 101 (0-319) 25,273 (16,571-34,678) 15,864 (9,049-23,285) 56,405 (45,991-66,849) 18,916 (13,564-25,830) 75,321 (61,689-89,704)	8,154 (7,132-9,213) 4,559 (3,914-5,238) 417 (198-682) 9,856 (8,457-11,275) 9,148 (7,788-10,524) 32,133 (29,957-34,285) 11,192 (10,254-12,190) 43,324 (40,743-45,935)	3,516 (-1,260-8,292) -1,247 (-3,379-885) -349 (-707-8) 10,803 (2,003-19,603) 3,179 (-2,388-8,746) 15,901 (5,966-25,837) 4,553 (-1415-10,521) 20,454 (7,496-33,413)	4,229 (-3,670-12,128) -2,875 (-4,502-(-1,248)) -174 (-689-340) 13,504 (1,300-25,708) 484 (-7,364-8,332) 15,167 (969-29,366) 2,972 (-4,027-9,972) 18,140 (1,075-35,205)	2,964 (-3,137- 13 (-3,406- -485 (-854-(- 8,713 (-3,422- 5,264 (-2,536- 16,469 (3,092-2) 5,776 (-3,341- 2,2,246 (3,563-4)			

COPD = chronic obstructive pulmonary disease; GOLD = The Global Initiative for Chronic Obstructive Lung Disease.

a) 100 DKK = 13.44 Euro (end of year exchange rate 2004); b) The difference was adjusted for age, educational level, and co-morbidity using a multiple regression model.

(-0.0638 annual visits for participants with COPD (p = 0.867) and -0.002 visits for non-responders (p = 0.993) compared with participants without COPD).

DISCUSSION

The results of the present study showed that health care-related costs were significantly higher for participants with COPD than for those without COPD and for non-responders. The costs increased with disease severity (GOLD grade) which was due mainly to an increased cost of medicine and inpatient care. Furthermore, the costs of social benefits and transfer payments in participants below the retirement age of 65 years were significantly higher for those with COPD than for those without COPD, which was due mainly to the high cost of disability pensions.

In the study, individuals with COPD were identified from a population sample on the basis of spirometry, and the diagnosis was confirmed by a bronchodilator test. Only 28% of those we identified as having COPD were registered with a COPD diagnosis in the National Patient Register. Hence, 72% of the participants with COPD would not have been identified if the study had been based on the records of physician diagnoses in a register. By combining COPD status with register data, it became possible to calculate actual costs at the level of the individual participant. The registers have few missing data and the fact that we also obtained data on nonresponders allowed us to compare non-responders with participants.

The costs of hospitalization and outpatient care were calculated on the basis of the DRG system. It established costs from average costs of similar patient groups and included both variable and fixed costs. We do not know how accurately this reflected the costs of the patients in our study. However, these costs were

used for reimbursement of hospitals, and the DRG system is the most feasible and reliable method to calculate costs across diagnoses and hospitals available. However, given that we only had access to the data available in the registers, some costs were not recorded. We had no data on the use of community services such as long-time nursing care and personal assistance in the home. The costs of rehabilitation in community centres were also not registered, but such rehabilitation was uncommon at the time. We had no data on the use of private health care, but, again, this cost was probably negligible. In all, the total costs relating to primary care may have been slightly underestimated, but this applies equally to those with and those without COPD, as well as to nonresponders. A few other studies have evaluated the costs of COPD, using different approaches. In a large register-based study from Denmark, the costs of treating patients with COPD were compared with those of non-COPD controls for the year 2002 [15]. The authors reported a cost of 32,922 DKK attributable to COPD, of which hospital costs constituted 97%. The study was based on the identification of patients with COPD in the National Patient Register and compared those with a diagnosis of COPD with a control group (the Danish population more than 40 years of age). The estimated costs were much higher than those found in the present study, which was probably so because of differences in the methods by which patients were selected.

A Swedish population-based study (the OLIN study) calculated the costs of those who had been diagnosed with COPD by a physician and compared them to the costs of those who had not [5]. The authors found that the costs per person were 82% higher for those who had a physician's diagnosis than for those who did not. Despite methodological differences, the Swedish study reported average costs that were quite similar to those of the present study [2]. In the Swedish study, 212 participants with COPD were interviewed every three months in 1999, all COPD-related expenses were recorded, and the costs were calculated on the basis of unit prices. As also shown in the present study, the authors showed that indirect costs (disability pensions, etc.) exceeded the direct costs (health-care costs), and that the costs increased with disease severity [2]. They estimated the expenses that were related to COPD, whereas we estimated the differences in costs between individuals with and without COPD. The direct costs per participant with COPD were 4,779 DKK in our study and 5,592 Swedish kronor (4,613 DKK) in the earlier Swedish study. In both studies, the major drivers of the direct costs were the costs of drugs and hospitalization. Indirect costs are more difficult to compare across social systems; however, disability pensions were the most substantial costs in both the Swedish and Danish studies. Hence, public expenses are taken into account and it is beyond the scope of this study to calculate the lost earnings for each patient as in the human capital approach or, alternatively, to calculate the production losses during the time it takes to replace a worker as in the friction cost approach.

In yet another approach, Nielsen et al used disease modelling to estimate the costs of COPD in Iceland and Norway for the year 2005 [16] as part of the Burden of Obstructive Lung Disease (BOLD) initiative [17]. The model combined estimates of prevalence from population-based random samples using the same criteria for COPD as were used in the present study (FEV1/FVC ratio < 0.7 after bronchodilation); unit prices; and surveybased and expert estimates to calculate the COPD-related health-care costs. As in the present study, the authors found that costs increased with disease severity, but the estimated average costs of 478 Euro (3,555 DKK) in Iceland and 284 Euro (2,112 DKK) in Norway were lower than the estimated costs in the OLIN [2] and our study. Given that the Nordic countries have rather similar health-care systems, these large differences are surprising. However, there were also significant differences between the estimates from Iceland and Norway although a similar methodology was used, and the authors argued that differences in unit prices (e.g. the price of a period of hospitalization) and treatment patterns might be part of the explanation. When compared with the present study, there were other notable differences. The patient sample in the present study was significantly older and the costs were based on tangible individual costs retrieved from registers, whereas the calculations of Nielsen et al were based on unit prices and disease "modelling". Other studies with even more dissimilar methodologies and health-care systems have yielded much greater differences in costs [3, 18-20].

COPD

Chronic obstructive pulmonary disease increases the cost of health-care services and social benefits.

Across the studies, the most substantial direct health care-related costs are the costs of medicine and hospitalization. Thus, it will be interesting to observe whether new initiatives to reduce the number of hospitalizations in patients with COPD, such as the use of Telecare and disease management programmes, will succeed in reducing the costs of inpatient care. However, in Nordic welfare societies, such as those of Denmark and Sweden, the indirect costs of COPD exceed the direct health-care costs, with disability pensions being the most important cost driver. In Denmark, citizens with a permanent disability that renders them unable to generate an income that will sustain their costs of living are eligible for a disability pension. The stage of COPD morbidity that elicits a pension depends on many other factors that are of importance to the job market, e.g. educational level and co-morbidity. Therefore, it may be worthwhile to investigate whether broader social rehabilitation programmes can enable individuals with COPD to remain on the labour market and thereby reduce the indirect costs of the disease.

CONCLUSION

The results of the present study showed that health care-related costs were higher for participants with COPD than for those without COPD, and the costs increased with disease severity (GOLD grade). The increased costs were due primarily to the high costs of medicine and inpatient care.

However, the costs of social benefits and transfer payments exceeded the direct health-care costs and could be attributed mainly to disability pensions. These findings point to the importance of efforts to prevent disease progression, reduce the incidence of hospitalization and retain individuals with COPD in the labour market. CORRESPONDENCE: Martin Bach Jensen, Algade 11, 9300 Sæby, Denmark. E-mail: mbj@rn.dk

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LITERATURE

- From the Global Strategy for the Diagnosis, Management and Prevention of COPD, Global Initiative for Chronic Obstructive Lung Disease (GOLD). 2011. www.goldcopd.org/ (14 Nov 2012).
- Jansson SA, Andersson F, Borg S et al. Costs of COPD in Sweden according to disease severity. Chest 2002;122:1994-2002.
- Nielsen R, Klemmetsby M, Gulsvik A. Economics of COPD: literature review and experiences from field work. Clin Respir J 2008;2 (Suppl 1):104-10.
- Macedo LG, Smeets RJ, Maher CG et al. Graded activity and graded exposure for persistent nonspecific low back pain: a systematic review. Physther 2010;90:860-79.
- Jansson SA, Lindberg A, Ericsson A et al. Cost differences for COPD with and without physician-diagnosis. COPD 2005;2:427-34.
- Hansen JG, Pedersen L, Overvad K et al. The Prevalence of chronic obstructive pulmonary disease among Danes aged 45-84 years: population-based study. COPD 2008;5:347-52.
- Thygesen LC, Daasnes C, Thaulow I et al. Introduction to Danish (nationwide) registers on health and social issues: structure, access, legislation, and archiving. Scand J Public Health 2011;39:12-6.
- 8. Pedersen CB. The Danish Civil Registration System. Scand J Public Health 2011;39:22-5.
- Jensen VM, Rasmussen AW. Danish education registers. Scand J Public Health 2011;39:91-4.
- Lynge E, Sandegaard JL, Rebolj M. The Danish National Patient Register. Scand J Public Health 2011;39:30-3.
- Charlson ME, Pompei P, Ales KL et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:373-8.
- 12. Kildemoes HW, Sorensen HT, Hallas J. The Danish National Prescription Registry. Scand J Public Health 2011;39:38-41.
- Nickelsen TN. Data validity and coverage in the Danish National Health Registry. Ugeskr Læger 2001;164:33-7.
- Mayes R. The origins, development, and passage of Medicare's revolutionary prospective payment system. J Hist Med Allied Sci 2007;62: 21-55.
- Bilde L, Rud Svenning A, Dollerup J et al. The cost of treating patients with COPD in Denmark - a population study of COPD patients compared with non-COPD controls. Respir Med 2007;101:539-46.
- Nielsen R, Johannessen A, Benediktsdottir B et al. Present and future costs of COPD in Iceland and Norway: results from the BOLD study. Eur Respir J 2009;34:850-7.
- Buist AS, Vollmer WM, Sullivan SD et al. The Burden of Obstructive Lung Disease Initiative (BOLD): rationale and design. COPD 2005;2:277-83.
- Menn P, Heinrich J, Huber RM et al. Direct medical costs of COPD an excess cost approach based on two population-based studies. Respir Med 2012;106:540-8.
- Menzin J, Boulanger L, Marton J et al. The economic burden of chronic obstructive pulmonary disease (COPD) in a U.S. Medicare population. Respir Med 2008;102:1248-56.
- Teo WS, Tan WS, Chong WF et al. Economic burden of chronic obstructive pulmonary disease. Respirology 2012;17:120-6.