CHAPTER 3
THE ECONOMIC IMPACT OF COPD IN THE WORKING-AGE POPULATION

Previously published as:
Van Boven JF, Vegter S, van der Molen T, Postma MJ.
COPD in the working age population: The economic impact on both patients and government.
ABSTRACT

Objectives
To explore the full economic impact, on both patients and government, as a result of COPD in the working age population

Methods
The economic impact of COPD due to medical treatment, impaired productivity and early retirement was assessed in a cross sectional cost analysis of the Dutch COPD population aged 45-64 years. The costing year was 2009 and input parameters were derived from both national data sources and the international COPD uncovered survey.

Results
While direct medical costs for COPD patients of working age were relatively low (€91 million), the amount of lost productivity (income) due to early retirement (€223.1 million) exceeded over two times their medical costs. In addition, costs for the government were considerable because of lost tax revenues (€77 million) and COPD related disability pensions paid (€180 million). Apart from lost productivity due to early retirement, costs due to impaired productivity for working COPD patients were €63.1 million.

Conclusion
The costs of COPD for both patients of working age as for the government were considerable, making this population a priority for prevention and intervention programs of healthcare providers, employers and government.
INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a progressive chronic respiratory disease characterized by non-fully reversible airway obstruction and chronic inflammation due to noxious particles and gases. COPD affects over 210 million people worldwide and is predicted to be the third leading cause of death by 2030. In The Netherlands, COPD is estimated to affect over 320,000 patients and 6,000 of these patients die annually from the disease. Currently, no curative treatment is available. The best option to prevent COPD from developing into more severe states is smoking cessation. Besides smoking cessation and some other lifestyle interventions (physical activity, healthy diet), pharmacologic treatment may help to control disease symptoms.

Total direct medical costs for COPD in The Netherlands have been estimated to be around €280 million in 2000 and may rise up to €495 million in 2025. Main cost drivers are hospitalizations (27%), medication (22%) and homecare (19%). Though COPD has long been considered a disease of elderly men, nowadays its prevalence in the younger population of people aged 45-65 years - a population which is still working - is more recognized and increasing in both men and women. Between the age of 45 to 64 years the incidence increases from 1.8 to 7.1 per 1,000 for men and 2.8 to 7.9 per 1,000 for women. This age group represents over one quarter of the total population and many in this group have significant economic and social responsibilities. Two-thirds of the income earned by the working population is earned by those between 45 and 64 years. They are also the group with the greatest spending power and the ones who pay the highest taxes, thereby contributing the most to the costs of healthcare, education and other social and public services.

Recently, results from the international COPD uncovered survey showed that 26% of people with COPD aged 45-68 years reported that they gave up work because of their COPD. For those currently working, 22.9% reported that COPD affected their work productivity. While the direct medical costs of COPD have been extensively studied, relatively few studies have focused on the indirect costs due to COPD. Scarce previous studies did show that indirect costs reflect a high proportion of total costs in The Netherlands as well as in other countries. Moreover, COPD related governmental costs, including disability pensions paid and tax revenues lost, have never been studied before.

Estimates of the economic impact of COPD will enable the exploration of cost implications relating to changes in the key drivers of direct and indirect costs. The objective of this study is to explore the full economic impact, on both patients as government, as a result of COPD in the working age population, using The Netherlands as an example.
ENHANCING ADHERENCE IN PATIENTS WITH COPD

METHODS
A cost calculator was constructed consisting of three separate modules estimating costs of COPD in 2009: direct medical costs, costs due to early retirement and costs of impaired productivity. Technical details and input parameters of the cost calculator are described in the appendix.

Direct medical costs
The direct medical costs for COPD are all costs related to diagnostics, (pharmaco)therapy, hospitalization, revalidation and nursing as a result of COPD. The annual direct medical costs for patients aged 45-64 have previously studied and were therefore obtained from a recent Dutch cost-of-illness study 3,9 and inflated to 2009 values. 10 These costs included costs for primary care, specialist visits, emergency room visits, hospitalizations, nursing, oxygen therapy, lung transplantations, influenza vaccinations and medication.

To provide a country-level estimate of the direct medical costs of COPD among the entire working age population, the per-patient costs were multiplied by the number of COPD patients of working age (45-64 years). The number of COPD patients of working age was estimated using Dutch age and sex specific prevalence data multiplied by population estimates. The direct medical costs were primarily used as a reference; details of the direct medical cost estimates are provided elsewhere. 9,11

Costs due to early retirement
The economic impact due to early retirement was estimated using a patient flow diagram (appendix figure 1A), which followed COPD patients from age 45 to 64 years. Every five years the patients had a certain probability to retire from a general cause (calculated by proxy using the age and sex specific national labour force participation rates) or specifically due to COPD (calculated by proxy using the age and sex specific successful national disability pension appeals). As COPD is usually accompanied by several comorbidities we took into account all disability appeals with COPD as primary diagnosis but also those with COPD as comorbidity. In a sensitivity analysis we only used those appeals with COPD as primary diagnosis. In addition to the probability of retirement, every five years the patients had a certain age and sex specific probability to die from a general cause or due to COPD.

The analysis was repeated for non-COPD patients entering the patient flow diagram. Those patients had the same transition probabilities with the exception that they had no additional probability to die or retire due to COPD.

Costs for the patient
Costs for the patient included lost productivity (earnings) due to early retirement. This was calculated by subtracting the total time a COPD patient was alive and working from the total time a non-COPD patient was alive and working, multiplied by age and sex specific net annual
TARGETS, INTERVENTIONS AND COST-EFFECTIVENESS

earnings. As COPD patients tend to have lower socio-economic status, \(^{12,13}\) 70% of the average national annual earnings were applied.

Costs for the government
The costs for the government comprises two pillars: tax revenue lost and disability benefits paid.

Tax revenue lost
Annual tax revenue lost was based on the difference in total age and sex specific gross income (earnings and pension(s)) between patients with- and without COPD, multiplied by the Dutch income tax and national insurance rates. Due to the complexity of the tax system all patients were assumed to be civil servants.

Disability pensions
The annual amount paid for disability pensions was based on the difference in age and sex specific time patients were alive and retired between patients with- and patients without COPD, multiplied by the age and sex specific value of the disability pension.

In the base-case scenario we took into account all disability pensions with COPD as primary diagnosis or COPD as comorbidity. In addition, we calculated the costs for disability pensions with COPD as primary diagnosis only.

Impaired productivity
Not all COPD patients will immediately retire because of their COPD. However, COPD may affect the work productivity while being still part of the labour force. The international COPD uncovered survey quantified the impact of COPD on impaired productivity. Impaired productivity included absenteeism (hours of work missed due to illness), presenteeism (impact of illness on productivity while at work), work productivity loss (combined impact of absenteeism and presenteeism) and activity impairment (regular activities). Further details of their methods and results are described separately. \(^5\)

As no specific Dutch data were available in the base-case scenario the UK values were used as they were previously shown to be comparable to The Netherlands. \(^7\) In the UK annual impaired productivity was 6.2% for men (N=45, mean age: 57), 2.9% for women (N=28, mean age: 52) and 5.0% for all. In a sensitivity analysis the German values were used. German annual impaired productivity was 1.7% for men (N=53, mean age: 53) and 1.8% for women (N=93, mean age: 53) and 1.7% for all.

The percentage of work impairment due to COPD in the week prior to the survey and was assumed to remain constant throughout the year. Subsequently, this percentage was multiplied by the average Dutch gross annual earnings for men respectively women aged 45-64 years, resulting in the impaired productivity costs per working COPD patient. The total amount among the working population was calculated by multiplying the costs per patient with the proportion
of COPD patients ‘alive & working’ (derived from the flow diagram presented in appendix).

**Sensitivity analyses**
To assess the uncertainty around our estimates we conducted a sensitivity analysis. Estimates that were varied included the number of COPD patients, direct medical costs, impaired productivity and the mean annual income of COPD patients. The variation of the impaired productivity estimate also provides an indication of the potential economic impact of decreasing the impaired productivity as a result of interventions.

In addition the impact of delayed early retirement was calculated by decreasing the time patients stayed in the ‘alive & retired’ state and adding this time to the time they stayed in the ‘alive & working’ state (more information on states is provided in the appendix).

**RESULTS**
Direct medical costs were €90.9 million, while costs for patients and government due to early retirement, and costs due to impaired productivity were €480.2 million and €63.1 million respectively. Overall, total costs were highly dependent on the number of COPD patients (table 4). An overview of the costs related to COPD is presented in figure 1 and specified in tables 1-4.

![Figure 1: Overview of the annual costs related to COPD in the working age population in The Netherlands (2009 euros)](image)

**Direct medical costs**
Annual direct medical costs were €90.9 million in total. Costs for women were higher compared to the costs for men. (table 1). The per-patient direct medical costs were €832 for men and €1097 for women. Note that these were weighted averages comprising all COPD severity
levels. Actual per-patient costs (men/women, inflated to 2009 euros) per severity level varied between respectively €253/€338 for mild COPD patients up to €6281/€8270 for very severe COPD patients.

Table 1: Population and annual direct medical costs due to COPD (2009 euros* and population estimates)

<table>
<thead>
<tr>
<th>COPD patients</th>
<th>Men</th>
<th>Women</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age group 45-49 yrs</td>
<td>6069</td>
<td>7005</td>
<td>13074</td>
</tr>
<tr>
<td>Age group 50-54 yrs</td>
<td>8981</td>
<td>10278</td>
<td>19260</td>
</tr>
<tr>
<td>Age group 55-59 yrs</td>
<td>12914</td>
<td>13395</td>
<td>26309</td>
</tr>
<tr>
<td>Age group 60-64 yrs</td>
<td>18750</td>
<td>16765</td>
<td>35515</td>
</tr>
<tr>
<td>Total number of patients with COPD aged 45-64 yrs</td>
<td>46715</td>
<td>47443</td>
<td>94158</td>
</tr>
</tbody>
</table>

**Direct medical costs**

<table>
<thead>
<tr>
<th>Per-patient annual medical costs, people with COPD aged 45-64 yrs</th>
<th>Men (€253-€6281)</th>
<th>Women (€338-€8270)</th>
<th>All (€965)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total annual medical costs, people with COPD aged 45-64 yrs</td>
<td>€38.9m</td>
<td>€52.0m</td>
<td>€90.9m</td>
</tr>
</tbody>
</table>

*Cost data were obtained from Hoogendoorn et al (3) and inflated to 2009 values.

**Early retirement due to COPD**

Using the default input values as provided in the appendix, the model calculated that 52% of the COPD patients (men: 42%, women: 62%) retired between age 45 and 64 years. Of those 37% retired due to COPD (men: 39%, women: 37%). Total costs due to early retirement were €480.2 million comprising of lost productivity, disability pensions paid and lost tax revenues.

**Costs for the patient**

Lost productivity due to COPD specific early retirement was €223.1 million per year for all COPD patients together of which the majority of costs for men. In the age groups between 45 and 54 years lost productivity was relatively low and comparable between men and women. Above the age of 55 years lost productivity due to COPD increases steeply, especially in men. The average annual productivity loss per male patient who retired due to COPD was €17629 and the average loss per female patient was €8121. Lost productivity due to early retirement was dependent on the mean income of COPD patients. In the basecase 70% of the mean overall national income was assumed resulting in €223.1 million, however when 100% of the mean overall national income was applied total costs would increase to €300.4 million. Delayed
early retirement for the entire COPD population would result in potential productivity savings of €6.1 million (delay of 1 month) up to €72.9 million (delay of 12 months).

Costs for the government
Total governmental costs were €264.1 million comprising disability pensions paid and tax revenues lost. Governmental costs were about three times the direct medical costs. Two-thirds of the costs were due to disability pensions paid and one third due to tax revenue lost. Between the age of 45 and 54 years disability pensions paid were about the same for men as for women. However, in the higher age groups, the cost for disability pensions paid to men were double the amount of disability pensions paid to women. For all age groups the amount of tax revenues lost were about twice the amount in men as compared to women.

Sensitivity analyses (table 4) showed that if we would only include disability pensions with COPD as primary diagnosis, disability pensions costs would decrease to €98.2 million. Total governmental costs were dependent on the mean income of COPD patients. In the basecase 70% of the mean overall national income was assumed resulting in €264.1 million, however when 100% of the mean overall national income was applied total governmental costs would increase to €380.4 million. Delayed early retirement for the entire COPD population would result in potential governmental savings of €7.3 million (delay of 1 month) up to €87.7 million (delay of 12 months).

Table 2: Annual costs due to early retirement from COPD (2009 euros and population estimates)

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity lost due to early retirement from COPD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In age group 45-49 yrs</td>
<td>5.3m</td>
<td>5.6m</td>
<td>11.0m</td>
</tr>
<tr>
<td>In age group 50-54 yrs</td>
<td>18.7m</td>
<td>20.1m</td>
<td>38.8m</td>
</tr>
<tr>
<td>In age group 55-59 yrs</td>
<td>41.3m</td>
<td>30.0m</td>
<td>71.3m</td>
</tr>
<tr>
<td>In age group 60-64 yrs</td>
<td>69.5m</td>
<td>32.5m</td>
<td>102.0m</td>
</tr>
<tr>
<td>Total</td>
<td>134.9m</td>
<td>88.3m</td>
<td>223.1m</td>
</tr>
<tr>
<td>Patients with COPD aged 45-64 yrs (retired due to COPD)</td>
<td>7650</td>
<td>10872</td>
<td>18522</td>
</tr>
<tr>
<td>Average loss per patient 45-64 yrs (retired due to COPD)</td>
<td>€17629</td>
<td>€8121</td>
<td>€12048</td>
</tr>
<tr>
<td>Patients with COPD aged 45-64 yrs (all)</td>
<td>46715</td>
<td>47443</td>
<td>94158</td>
</tr>
<tr>
<td>Average loss per patient 45-64 yrs (all)</td>
<td>€2887</td>
<td>€1861</td>
<td>€2370</td>
</tr>
<tr>
<td>Governmental costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tax revenue lost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In age group 45-49 yrs</td>
<td>2.6m</td>
<td>1.9m</td>
<td>4.5m</td>
</tr>
<tr>
<td>In age group 50-54 yrs</td>
<td>8.1m</td>
<td>6.9m</td>
<td>14.9m</td>
</tr>
<tr>
<td>In age group 55-59 yrs</td>
<td>16.0m</td>
<td>9.2m</td>
<td>25.1m</td>
</tr>
</tbody>
</table>
Impaired productivity

The annual impaired productivity costs were €63.1 million if the per-patient costs were applied to the COPD population aged 45-64 years that is not retired yet (men: 58%, women: 38%). Costs due to impaired productivity were about four times as high in men as compared to women. Percentage of impaired productivity was 6.2% for men and 2.9% for women and 5.0% on average. Assuming 214 workdays per year 5.0% impaired productivity would result in 10.7 impaired workdays per working COPD patient. When multiplied with the total number of working patients in The Netherlands (45137) this would sum up to 482966 days per year for the entire working COPD population.

Sensitivity analyses (table 4) showed that if basecase impaired productivity (men: 6.2%, women: 2.9%) would be decreased with 25% almost 16 million euros would be saved. When the German values were applied impaired productivity dropped to €20.0 million. The German values for impaired productivity were measured in a slightly younger population (mean age 53 years) compared to the UK values (mean age 55 years). Furthermore, impaired productivity was highly dependent on the average income of COPD patients: when 100% of the national average income was applied instead of the basecase (70%), costs due to impaired productivity almost doubled (from €63.1 to €119.5 million).
Table 3: Annual impaired productivity costs due to COPD (2009 euros and population estimates)

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impaired productivity</td>
<td>6.2%</td>
<td>2.9%</td>
<td></td>
</tr>
<tr>
<td>Annual impaired productivity,</td>
<td>€54.5m</td>
<td>€8.6m</td>
<td>€63.1m</td>
</tr>
<tr>
<td>All working COPD patients aged</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45-64 yrs (not retired)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working patients with COPD</td>
<td>27185</td>
<td>17952</td>
<td>45137</td>
</tr>
<tr>
<td>aged 45-64 yrs (not retired)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual impaired productivity</td>
<td>€2004</td>
<td>€479</td>
<td>€1397</td>
</tr>
<tr>
<td>per working COPD patient aged</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45-64 yrs (not retired)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients with COPD aged 45-64</td>
<td>46715</td>
<td>47443</td>
<td>94158</td>
</tr>
<tr>
<td>yrs (all)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average impaired productivity</td>
<td>€1166</td>
<td>€181</td>
<td>€670</td>
</tr>
<tr>
<td>per patient aged 45-64 yrs (all)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Sensitivity analyses (2009 euros and population estimates)

<table>
<thead>
<tr>
<th>Parameter (men/women)</th>
<th>Direct medical costs</th>
<th>Impaired productivity</th>
<th>Lost productivity due to early retirement</th>
<th>Disability benefits paid</th>
<th>Tax revenue lost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of COPD patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+25%</td>
<td>113.6m</td>
<td>77.8m</td>
<td>276.8m</td>
<td>227.5m</td>
<td>94.7m</td>
</tr>
<tr>
<td>Basecase (46715/47443)</td>
<td>90.9m</td>
<td>63.1m</td>
<td>223.1m</td>
<td>180.2m</td>
<td>76.9m</td>
</tr>
<tr>
<td>-25%</td>
<td>68.2m</td>
<td>48.3m</td>
<td>169.5m</td>
<td>132.8m</td>
<td>59.2m</td>
</tr>
<tr>
<td>Direct medical costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+25%</td>
<td>113.6m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basecase (€832/€1097)</td>
<td>90.9m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-25%</td>
<td>68.2m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impaired productivity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+25%</td>
<td>78.8m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basecase (6.2%/2.9%)</td>
<td>63.1m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-25%</td>
<td>47.3m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>German values (1.7%/1.8%)</td>
<td>20.3m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COPD patients’ income (% of average national annual income)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basecase (70%)</td>
<td>63.1m</td>
<td>223.1m</td>
<td>180.2m</td>
<td>76.9m</td>
<td></td>
</tr>
<tr>
<td>80%</td>
<td>72.1m</td>
<td>249.4m</td>
<td>205.9m</td>
<td>92.1m</td>
<td></td>
</tr>
<tr>
<td>90%</td>
<td>81.1m</td>
<td>275.0m</td>
<td>231.7m</td>
<td>107.5m</td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>119.5m</td>
<td>300.4m</td>
<td>257.4m</td>
<td>123.0m</td>
<td></td>
</tr>
<tr>
<td>Parameter</td>
<td>Direct medical costs</td>
<td>Impaired productivity</td>
<td>Lost productivity due to early retirement</td>
<td>Disability benefits paid</td>
<td>Tax revenue lost</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------</td>
<td>-----------------------</td>
<td>----------------------------------------</td>
<td>--------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Disability pensions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COPD as primary diagnosis only</td>
<td></td>
<td></td>
<td></td>
<td>98.2m</td>
<td></td>
</tr>
<tr>
<td>COPD as primary diagnosis or comorbidity</td>
<td></td>
<td></td>
<td>180.2m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Savings due to delayed early retirement with:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 month</td>
<td></td>
<td>6.1m</td>
<td>5.3m</td>
<td>2.0m</td>
<td></td>
</tr>
<tr>
<td>3 months</td>
<td></td>
<td>18.2m</td>
<td>15.9m</td>
<td>5.1m</td>
<td></td>
</tr>
<tr>
<td>12 months</td>
<td></td>
<td>72.9m</td>
<td>63.4m</td>
<td>24.3m</td>
<td></td>
</tr>
</tbody>
</table>
DISCUSSION

This study uncovered the full economic impact of COPD in the population of working age on both patient and government. The results of this study showed that indirect costs in COPD patients of working age were considerable and several times higher than the direct medical cost of COPD. In addition to the indirect costs of COPD patients, the economic impact on the government is substantial.

Interpretation

Total yearly costs of COPD patients’ direct medical costs were estimated at around €90 million (€965 per patient) for the working age population. Per patient costs are in line with a previous Dutch study, which estimated total direct costs per patient (indexed to 2009 euros) at €1,052. Direct medical costs per patient are relatively low compared to the medical costs in older COPD patients in which costs will increase to €1,725 for patients aged 85 and older.

Lost productivity due to early retirement was found to be four to five times higher than the direct medical costs. Although direct medical costs for women are slightly higher than the costs for men, the indirect costs for women are significantly lower than for men. This is mainly explained by the fact that the overall labour participation and salaries of women were lower, resulting in less potential productivity to lose. The high amount of lost productivity is mainly influenced by the fact that about 52% of the COPD patients retired before the age of 65 and of those retiring early 37% retired due to COPD. These results are supported by a previous Dutch study based on 617 questionnaires that found that 45% (260 of 580) of COPD patients between 45 and 60 years with a working history retired early of which 39% retired because of their COPD.

Impaired productivity was estimated at about €63 million. However, when applying the German values for impaired productivity, this decreased to less than one third. Impaired productivity has been shown to be highly dependable on the severity of COPD and the age of the patient. Severe COPD patients have an approximately four to five times higher impaired productivity. A Dutch study that in particular focused on patients’ impaired productivity (n=4,715 of which 243 with respiratory diseases) showed that 11 additional working days per patient are annually lost because of respiratory diseases. This number did include days off work but also days at work with impaired productivity which is comparable to our definition. Assuming an employee has 214 working days per year, based on 1540 hours and a 36 hour workweek, this would result in an impaired productivity of 5.1%, which is comparable to our value for productivity impairment (5.0%). This may support our assumption that the UK data for impaired productivity are representative for the Dutch situation. The costs of the impaired productivity and costs due to early retirement together were previously studied and in this study per patient costs were estimated (index to 2009 values) at €623 (men) and €248 (women). These costs are lower than calculated in our study, which may be explained by the relatively high mean age of their study (61 years) and the use of the friction cost method instead of the human capital method
18 to estimate costs due to early retirement.

In addition to the high economic impact on patients, COPD in the working age population has a considerable impact on governmental expenses. With an estimated €180 million, COPD accounts for 2.0% of the total governmental expenses on disability pensions of 8.8 billion. The number of disability pensions for COPD is 2.4% of the total number of pensions granted. Although disability pensions paid and tax revenues lost due to COPD have not been calculated before, they have been applied in recent cost studies in other fields like IVF and cardiovascular diseases. From a societal perspective, these type of costs may be solely seen as transfer of money and not as lost money. However, they can help to understand the full impact and fiscal benefits derived from health investments in the field of COPD.

**Strengths**

Using a novel broad approach this study is the first - to our knowledge - to uncover the size of the economic impact of COPD in the population of working age on both patient and government. By using recent national data combined with data from COPD uncovered we were able to show the full economic impact of COPD in this relatively young age group. Moreover, this study not only demonstrates the impact of COPD in people of working age but also provides an example of the impact of illness in a working age population across the spectrum of disease burden. Further studies are recommended to see if comparable cost patterns are observed in other countries.

The results of this study provide a useful dataset and method when considering including productivity and early retirement in cost-effectiveness studies.

**Limitations**

A factor potentially causing an underestimation of the cost estimate is the problem of underdiagnoses as COPD is easily misdiagnosed as the cough and sputum are considered to be normal in smokers. Also we may have to consider including the loss of productivity among family members and others who provide informal care.

Furthermore, we may have to consider changing future scenarios like smoking patterns, which will influence COPD prevalence and costs, or an increasing retirement age, which will increase costs as a result.

A factor which may have caused an overestimation of the lost productivity costs is the human capital approach, which takes into account all costs of missing work due to illness from start till return to work or retirement age. One can argue that after some weeks a person will be replaced by another employee and therefore lost productivity is limited to a certain friction time. However, especially in countries outside The Netherlands, the friction cost method is still controversial and the human capital method is more widely applied.

Lastly, this study focused on the costs for COPD patients between the age of 45 and 64 only and showed that governmental costs in this age category are considerable. However, on the
same time governmental costs for the population above 65 years are expected to be lower due to the lower amount of governmental old age pensions paid as a result of excess mortality due to COPD.

**Recommendations**

Governmental campaigns should focus on the awareness of people to take appropriate action to maintain good lung health and provide them with information on how they should understand risks and recognize disease symptoms.

Special attention should be given to prevention programs to discourage people from start smoking, as this will prevent them from developing COPD in the first place. Other governmental policies that are likely to add to the benefits of a prevention program are the raising of taxes for tobacco and the raising of the legal purchase age of tobacco. \(^{26}\)

Healthcare professionals should focus on effective diagnosis, education and management of COPD at an early stage. After diagnosis, healthcare professionals should, in collaboration with the patient, discuss the importance of smoking cessation, an active lifestyle and healthy diet. Besides, healthcare professionals should focus on optimization of pharmacotherapy by developing and running interventions like inhalation techniques improvement. \(^{27}\) In particular, multidisciplinary interventions have been shown to be highly effective. \(^{28}\)

Preferably, national implementation and reimbursement of these interventions should focus on those which are besides effective also cost-effective. \(^{29,30}\) For this part, there may be a significant role for healthcare insurance companies.

Employers can play an important role by creating a workplace which minimizes exposure to known risks (e.g. tobacco) and should collaborate with health and social care providers to manage the condition of their employees and to stimulate them to remain in their workplaces. The ability to work is dependent on the nature of the work and the flexibility of both employee and employer. Effort should be made to adapt the type and intensity of work to the capacity of the COPD patient.

Overall, COPD has an enormous economic impact on society and a joint effort of all stakeholders is required to develop (cost)effective interventions, prevention and disease management programs, especially focusing on the working age population. When provided with optimal work environment and therapy, people will improve quality of life and disease control, stay productive for longer and will contribute to the financial wellbeing of themselves, their families and the economic growth of society as a whole.
CONCLUSIONS
Societal costs in COPD patients of working age were considerable and several times higher than the direct medical cost of COPD, making this population a priority for prevention- and intervention programs of healthcare providers, employers and government.

ACKNOWLEDGEMENTS
This work was funded by The Dutch Lung Foundation (previously known as the Dutch Asthma foundation) and Novartis Pharma AG.

DECLARATION OF INTEREST: The authors report no conflict of interest
APPENDIX - Technical note on the COPD cost calculator

Model program
The model was a spreadsheet driven model created in Microsoft Excel.

Model input values
The data inputs for the model were of three kinds: COPD-specific, demographic and financial which are listed in table A1. We assumed all earnings of COPD patients to be 70% of the average Dutch earnings as COPD is known to have a higher incidence among lower socioeconomic groups with lower incomes on average. (12,13)

Table A1: COPD model inputs and their sources

<table>
<thead>
<tr>
<th>COPD-specific inputs</th>
<th>National Health Compass (RIVM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>en-sterfte-uit-de-vtv-2010/. Accessed May 2012</td>
</tr>
<tr>
<td>Mortality among people with COPD</td>
<td>National Health Compass (RIVM)</td>
</tr>
<tr>
<td></td>
<td>en-sterfte-uit-de-vtv-2010/. Accessed May 2012</td>
</tr>
<tr>
<td>Extent of early retirement among people with COPD</td>
<td>Employee Insurances Implementing Agency (UWV)</td>
</tr>
<tr>
<td></td>
<td>ssed July 2012</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Demographic inputs</th>
<th>Central Bureau of Statistics (CBS)</th>
</tr>
</thead>
</table>
Marital status estimates 2009
Central Bureau of Statistics (CBS)

Labour participation 2009
Central Bureau of Statistics (CBS)

Default retirement age 2009
65 years (for both men and women)

Financial inputs

Annual earnings 2009
Central Bureau of Statistics (CBS)

% with occupational pension

Value of occupational pension
Assumption (pension=earnings[n/80], where n=age minus 18) (31)

Dependent’s pension
Assumption (50% of occupational pension) (31)

Tax & national insurance 2009
Dutch Government

Value of disability pension
National Institute for Budget Information (Nibud)

**Dutch COPD population**
The estimated number of people with COPD in The Netherlands was 320,000 of which 94,158 aged 45 to 64 years (46,715 male and 47,443 female).

**Model description and structure**
In the model description all variables that are listed in table A1 are *Italic*.

A patient flow diagram was constructed to follow a hypothetical person with COPD from age 45 to 64 years (figure A1). The age range of interest (45-64 years) was divided into four quinquennia in each of which a person with COPD could spend time in one or more of three states: alive & working; alive & retired; dead. At start (45 years) the person was assumed still to be
working. The default retirement age (ie the age after which retirement was considered neither early nor due to COPD) was 65 years and was a flexible parameter.

State transition probabilities
Movement through the flow diagram depended on age-group and sex-specific mortality and the probability of retiring early during the quinquennium, both included all cause and COPD specific probabilities. All-cause early retirement was derived from national labour participation rates and COPD specific retirement was based on successful COPD disability pension appeals, both assumed to be permanent.
State-specific monetary value

Each of the three states was associated with a monetary value, as follows.

**Alive and working:** age-group- and sex-specific Dutch *mean annual earnings* (70%)

**Alive and retired:** occupational- and disability pension, calculated as follows:

where,

- **occupational pension**
  - age-group- and sex-specific *mean annual earnings*
  - \( \frac{n}{80} \) where \( n = \) midpoint of age group minus 18yrs
  - sex-specific \% persons who have occupational pension

- **disability pension**
  - age-group- and sex-specific *mean annual disability pension*
  - \% disability pension applicants who are successful

**Dead:** *dependents’ pension*, calculated as 50% of occupational pension (calculated as above).

As a proxy for the probability of there being a dependent the dependents’ pension is multiplied by the age group- and sex-specific *percentage of persons married*.

The values were combined (as shown in the formula below) to obtain quinquennium-specific estimates for productivity (earnings) and total income (earnings + pensions), and divided by 5 to obtain an average annual estimate for persons in the age-group corresponding to each quinquennium, and then summed across quinquennia as shown in the formula in the appendix.

The calculation was repeated with input values appropriate to a person without COPD. Therefore, we changed the mortality probability to *all-cause* (minus COPD) *mortality only* and there was no early retirement due to COPD possible.

The impact of early retirement due to COPD was estimated by subtraction, resulting in a cross sectional estimate.

**Value of the disability pension**

In The Netherlands there are three types of disability pensions which are all part of the disability act (‘WIA’) from 2006.

- Full permanent disability pension (‘IVA’): 75% of the *average age and sex specific income*
- Full temporary disability pension (‘full WGA’): 70% of the *average age and sex specific income*
- Partly disability pension (‘partly WGA’): assumed 50% of the full WGA

The weighting of the pensions was based on the distribution of *successful pension appeals*. 

---

*Note: The formula for calculating the state-specific monetary value is not fully visible in the image.*
Tax revenues
In The Netherlands all people have to pay income tax as well as national insurance over their earnings to the government. Income tax was calculated based on average age and sex specific income. National insurance (employees part) included AOW, ANW and AWBZ. National insurance (employers part) included WGA, WAO/WIA, WW, sectors premium and ZVW.
REFERENCES


TARGETS, INTERVENTIONS AND COST-EFFECTIVENESS

---

3
75