Projektbericht Research Report

## Economic burden of chronic respiratory diseases in Austria and Slovenia

Results of a life-cycle model

Markus Pock Thomas Czypionka Miriam Reiss Gerald Röhrling



Projektbericht Research Report

## Economic burden of chronic respiratory diseases in Austria and Slovenia

Results of a life-cycle model

Markus Pock Thomas Czypionka Miriam Reiss Gerald Röhrling

Final report

A study commissioned by GSK - GlaxoSmithKline Pharma GmbH

In collaboration with: VI vis d.o.o., Slovenia Scientific Advisory Boards of Austria and Slovenia

April 2018

Institut für Höhere Studien (IHS), Wien Institute for Advanced Studies, Vienna

Contact: Thomas Czypionka ☎: +43/1/599 91-127 email: czypionka@ihs.ac.at

Markus Pock 畲: +43/1/599 91-210 email: pock@ihs.ac.at

### Contents

Exe	ecutive summary	I
1.	Introduction	1
2.	Background information on chronic respiratory diseases	<b>2</b> 2
	2.2. Asthma	5
3.	Epidemiology of chronic respiratory diseases	6
	3.1. Considerations on methodology in epidemiological studies on chronic respiratory	
	disease	6
	3.2. International epidemiological data on chronic respiratory diseases	8
	3.2.1. COPD	8
	3.2.2. Asthma	13
	3.3. Epidemiological data on chronic respiratory diseases in Austria	18
	3.3.1. COPD	18
	3.3.2. Asthma	22
	3.4. Epidemiological data on chronic respiratory diseases in Slovenia	24
	3.4.1. COPD	24
	3.4.2. Asthma	29
4.	Cost categories	34
5.	International evidence on the economic burden of chronic	
-	respiratory diseases	36
	5.1. COPD	37
	5.2. Asthma	39
6.	Method	42
	6.1. Introduction	42
	6.2. The life-cycle model	42
	6.3. Methods specific to individual cost categories	50
	6.3.1. Direct medical costs	50
	6.3.2. Direct non-medical costs	51
	6.3.3. Indirect costs	57

7.	Data	61
	7.1. Top-down approach vs. bottom- up approach	61
	7.2. Data sources for Austria	
	7.2.1. Key variables	
	7.2.2. Direct medical costs	64
	7.2.3. Direct non-medical costs	71
	7.2.4. Indirect costs	74
	7.3. Data sources for Slovenia	75
	7.3.1. Key variables	75
	7.3.2. Direct medical costs	77
	7.3.3. Direct non-medical costs	
	7.3.4. Indirect costs	
8.	Results	89
	8.1. Economic burden of chronic respiratory diseases in Austria	
	8.2. Economic burden of COPD and asthma in Slovenia	
9.	Sensitivity analysis	100
Ref	erences	106
Ар	pendix Austria	113
Ар	pendix Slovenia	121

### Abbreviations

AMS	Austrian Public Employment Service (Arbeitsmarktservice)	
ATHIS	Austrian Health Interview Survey	
AUVA	Austrian Workers' Compensation Board (Allgemeine Unfallversicherungsanstalt)	
AN	annuity	
ATC	Anatomical Therapeutic Chemical Classification System	
BMASK	Austrian Federal Ministry of Labour, Social Affairs and Consumer Protection ( <i>Bundesministerium für Arbeit, Soziales und</i> Konsumentenschutz)	
BoD	burden of disease	
BOLD	Burden of Obstructive Lung Disease	
CBZ	Slovenian Central Data-base of Medicines (Centralna baza zdravil)	
CEA	cost-effectiveness analysis	
Col	cost of illness	
COPD	chronic obstructive pulmonary disease	
CPAP	continuous positive airway pressure	
CRD	chronic respiratory disease	
DRG	diagnosis related groups	
EHIS	European Health Interview Survey	
FEV <sub>1</sub>	forced expiratory volume in one second	
FVC	forced vital capacity	
GDP	gross domestic product	
GOLD	Global Initiative for Chronic Obstructive Lung Disease	
HC	healthcare functions in SHA	
HP	healthcare providers in SHA	
HV	Main Association of Austrian Social Security Institutions (Hauptverband der österreichischen Sozialversicherungsträger)	
ICD	International Statistical Classification of Diseases and Related Health Problems	

performance-oriented financing system for hospitals in Austria (Leistungsorientierte Krankenanstaltenfinanzierung)	
lower limit of normal	
Slovenian National Institute of Public Health ( <i>Nacionalni inštitut za javno zdravje</i> )	
Organisation for Economic Co-operation and Development,	
regional health insurance fund of Upper Austria (Oberösterreichische Gebietskrankenkasse)	
population attributable fraction	
present value of future earnings	
Austrian Private Hospitals Financing Fund (Privatkrankenanstaltenfinanzierungsfonds)	
present value	
System of Health Accounts	
Statistical Office of Republic of Slovenia (Statistični urad Republike Slovenije)	
World Health Organisation	
Pension and Disability Insurance Institute of Slovenia (Zavod za pokojninsko in invalidsko zavarovanje Slovenije)	
years of potential life lost	
Health Insurance Institute of Slovenia ( <i>Zavod za zdravstveno zavarovanje Slovenije</i> )	

### Tables

Table 1: Chronic lower respiratory diseases according to the ICD-10 classification
Table 2: GOLD classification of severity of airflow limitation in COPD (based on post-
bronchodilator FEV <sub>1</sub> )
Table 3: Number of patients with COPD registered in the offices of primary care physicians in
Slovenia in 1997-2001
Table 4: Number of deaths due to COPD in Slovenia according to Debeljak (2003)
Table 5: Cost categories used in the cost-of-illness study
Table 6: Annual costs of COPD in the Netherlands according to van Boven et al. (2013),
population aged 45-64, 2009 37
Table 7: Annual costs of COPD per patient by disease severity in Germany according to
Nowak et al. (2004), population aged ≥40 years, 2001
Table 8: Annual costs of asthma in the UK according to Mukherjee et al. (2016), financial
year 2011-2012 40
Table 9: Annual costs of asthma in Germany according to Stock et al. (2005), 1999
Table 10: Four costs models split by time horizon and type of reference value, explained on
the basis of invalidity pensions
Table 11: Cost factors in curative and rehabilitative care from System of Health Accounts
(SHA) in million EUR, 2014
Table 12: Costs of hospital care in Slovenia (million EUR)79
Table 13: Number of visits to outpatient physicians in Slovenia in thousands, 2014
Table 14: Cost of outpatient care in Slovenia in million EUR, 2014
Table 15: Value and volume split of R03 drugs used for COPD and asthma in Slovenia 83
Table 16: Number of disability pension beneficiaries and pay-outs in million EUR in Slovenia,
2014
Table 17: Number of old-age pension beneficiaries and pay-outs in million EUR in Slovenia,
2014
Table 18: Number of widow/family beneficiaries and pay-outs in million EUR in Slovenia,
2014
Table 19: Number of disability and assistance allowances beneficiaries and pay-outs in
million EUR in Slovenia, 2014
Table 20: Active population of working age in Slovenia 87
Table 21: Estimated total labour costs in Slovenia 87
Table 22: Costs of chronic respiratory disease (CRD) in Austria according to one-period
model and life-cycle model, 2014
Table 23: Costs of COPD and asthma in Slovenia according to one-period model and life-
cycle model, 2014
Table 24: Results of the sensitivity analysis of the Austrian life-cycle model 100

Table 25: Number of hospital stays with secondary diagnosis CRD (J40-J47) in 2014 in		
Austrian fund hospitals and rough estimation of CRD-attributable stays affected by		
underreporting		
Table 26: Estimated life expectancy gains in months without CRD of the Austrian population		
in 2014, by gender and age		
Table 27: Estimated life expectancy gains in months without COPD and asthma of the		
Slovenian population in 2014, by gender and age123		

## Figures

Figure 1: GOLD classification based on symptoms, breathlessness, spirometric classification
and risk of exacerbations
Figure 2: Prevalence of airflow obstruction (FEV <sub>1</sub> /FVC < LLN) in selected sites of the BOLD
study by sex, population $\geq$ 40 years
Figure 3: Prevalence of COPD from Continuing to Confront COPD International Patient
Survey 2012/2013 by sex, population $\geq$ 40 years
Figure 4: Prevalence of chronic respiratory diseases (excl. asthma) from European Health
Interview Survey (EHIS) 2014 by sex, population ≥15 years
Figure 5: Prevalence of asthma according to different definitions among children aged 13-14
years in EU countries from ISAAC study 14
Figure 6: Prevalence of asthma according to different definitions in EU countries from WHO
World Health Survey 2002-2003, population 18-45 years 16
Figure 7: Prevalence of asthma from European Health Interview Survey (EHIS) 2014 by sex,
population ≥15 years
Figure 8: Prevalence of COPD according to different definitions from BOLD study by sex and
age group, 2004/2005
Figure 9: Prevalence of chronic respiratory diseases (excl. asthma) from Austrian Health
Interview Survey (ATHIS) 2014 by sex and age, percentage per age group and moving
average (MA)
Figure 10: Prevalence of measured lung dysfunction compared to doctor diagnosed COPD
from Austrian LEAD Study by age groups, 2012-2016
Figure 11: Deaths caused by chronic respiratory diseases (CRD, J40-J47) in % of all deaths
in Austria, decomposed into COPD (J44) and CRD other than COPD (J40-J43, J45-J47),
2014
Figure 12: Prevalence of asthma according to different definitions among children aged 6-7
years and 13-14 years in Austria from ISAAC study, 2002/2003
Figure 13: Prevalence of asthma from Austrian Health Interview Survey (ATHIS) 2014 by sex
and age, percentage per age group and moving average (MA)
Figure 14: Self-reported COPD, chronic bronchitis and emphysema prevalence in the
Slovenian population of 25-64 years old by gender, CINDI, Health Monitor 2001-2004-2008
Figure 15: Self-reported COPD, chronic bronchitis and emphysema prevalence in the
Slovenian population of 25-64 years old by age groups, CINDI, Health Monitor 2001-2004-
2008
Figure 16: Prevalence of COPD, chronic bronchitis and emphysema by gender and age,
Slovenian Chapter of EHIS 2014
Figure 17: Number of patients with COPD, chronic bronchitis and emphysema by gender
and age, Slovenian Chapter of EHIS 2014 28
Figure 18: Number of deaths due to COPD in Slovenia by gender and age in 2014

Figure 19: Self-reported asthma prevalence in the Slovenian population of 25-64 years old Figure 20: Self-reported asthma prevalence in the Slovenian population of 25-64 years old Figure 21: Prevalence of asthma by gender and age, Slovenian Chapter of EHIS 2014 ...... 32 Figure 22: Number of patients with asthma by gender and age, Slovenian Chapter of EHIS Figure 25: Decomposition of current expenditure on health excl. long-term care expenditure Figure 26: Total Health Care Expenditures in Slovenia by sources of funding in million EUR, Figure 27: Total Health Care Expenditures in Slovenia by health care provider in million EUR, Figure 29: Annual average population pyramid in Austria in 2014 by gender and age...... 113 Figure 30: Share and number of deaths attributable to CRD, COPD and asthma in Austria in Figure 31: Number of deaths attributable to COPD in Austria in 2014, by gender and age 114 Figure 32: Absolute gains in conditional 5x5 mortality probabilities attributable to CRD in Figure 33: Relative gains in conditional 5x5 mortality probabilities attributable to CRD in Figure 34: Relative gains in conditional 5x5 survival probability function S(t,a) attributable to CRD for males in Austria in 2014 by age, in % ...... 116 Figure 35: Share of COPD, asthma and remainder of CRD in % of CRD group in Austria in Figure 36: Estimated per capita costs of hospitals (HC.1xHP.1) attributable to CRD (J40-J47) in Austria in 2014 by age and gender.....117 Figure 37: Estimated annuities of hospital costs (HC.1xHP.1) attributable to CRD (J40-J47) in Austria in 2014 by age and gender.....117 Figure 38: Estimated per capita costs of inpatient rehabilitative care provided by hospitals (HC.2.1xHP.1) attributable to CRD (J40-J47) in Austria in 2014 by age (males+females).. 117 Figure 39: Estimated per capita costs of outpatient care provided by medical practices (HC.1.3.1xHP.3.1.1) attributable to CRD (J40-J47) in Austria in 2014 by age and gender.. 118 Figure 40: Per capita costs\* of prescribed medicines ATC-Code R03 in Austria in 2014 by Figure 41: Estimated new beneficiaries of care allowances attributable to CRD (J40-J47) in Figure 42: Estimates sick leave days attributable to CRD (J40-J47) in Austria in 2014 by age and gender 119

Figure 43: Estimated costs of sick leave allowances attributable to CRD (J40-J47) paid by
social insurance institutions in Austria in 2014 by age and gender
Figure 44: Estimated new beneficiaries of invalidity pension attributable to CRD (J40-J47) in
Austria in 2014 by age and gender 120
Figure 45: Estimated annuities of old-age, widow/widower, and invalidity pensions
attributable to CRD (J40-J47) in Austria in 2014 by age 120
Figure 46: Estimated annuities of indirect costs (productivity costs) attributable to CRD (J40-
J47) in Austria in 2014 by age and gender 120
Figure 47: Population pyramid in Slovenia as of 01/07/2014 by gender and age 121
Figure 48: Share and number of deaths attributable to COPD and asthma in Slovenia in
2014 by age
Figure 49: Number of deaths attributable to COPD in Slovenia in 2014, by gender and age
Figure 50: Absolute gains in conditional 5x5 mortality probabilities of COPD and asthma in
Slovenia in 2014 by gender and age
Figure 51: Relative gains in conditional 5x5 mortality probabilities of COPD and asthma in
Slovenia in 2014 by gender and age
Figure 52: Relative gains in conditional 5x5 survival probability function S(t,a) of CRD for
males in Slovenia in 2014 by age, in %
Figure 53: Hospital care costs in Slovenia in 2014, base reference (EUR) 124
Figure 54: Hospital care costs in Slovenia in 2014, asthma and COPD (EUR) 125
Figure 55: Rehabilitation costs in rehabilitation centers in Slovenia in 2014, base reference
(EUR)
Figure 56: Rehabilitation costs in rehabilitation centers in Slovenia in 2014, asthma and
COPD (EUR)
Figure 57: Value of all prescribed medicines (all ATC groups) in Slovenia in 2014 126
Figure 58: Value of medicines prescribed for asthma and COPD in Slovenia in 2014 127
Figure 59: Value of medicines prescribed for asthma and COPD in Slovenia in 2014, by
gender
Figure 60: Value of allowances paid by ZZZS for sick leaves and nursing in Slovenia in 2014,
base reference (EUR)
Figure 61: Value of allowances paid by ZZZS for sick leaves and nursing in Slovenia in 2014,
asthma and COPD (EUR) 128
Figure 62: Estimated annuities of old-age and widow/widower pensions attributable to COPD
and asthma in Slovenia in 2014 by age 129
Figure 63: Estimated annuities of indirect costs (productivity costs) attributable to COPD and
asthma in Slovenia in 2014 by age and gender 129

### **Executive summary**

The usual method for evaluating the financial burden of a particular disease is to isolate and figure out the public medical and non-medical costs of a particular reference year. The data for the implementation of such one-period models are either at an aggregated level or an individual level (patients' records). The usual burden-of-disease models describe the realized costs of the morbidity effects of a particular disease in the status quo but do not consequently take into account the counter-factual effect of a reduced mortality translating into an increased longevity and hence into increased life span costs. Generally, the cost effects of morbidity and mortality are counter-running. Whether the overall effect will turn out to be positively valued depends on the relative dominance of morbidity gains, and vice versa.

In this study we tried to estimate the economic burden of **chronic respiratory diseases CRD** (ICD-10: J40-J47) in two European countries, namely **Austria** and **Slovenia**, in the **year 2014**. The two dominant CRD are **COPD** (J44) and **asthma** (J45-J46). For Slovenia we restricted the analysis to COPD and asthma.

We applied a **life-cycle model** (see chapter 6.2) in order to account for the longevity effects and the heterogeneity of age- and gender-specific distributions of the particular cost categories. In our variant of the life-cycle model, each cohort of the status quo population hypothetically lives to the end of life under improved morbidity and mortality conditions. The output of the life-cycle model gives present values of the cost effects of CRD over the whole time span of the age cohorts. The main scenario of the model assumed a discounting factor of 3%. In order to display these cost effects on an annual basis, we transformed the present values into equivalent constant cash flows over the time horizon, the so-called **annuities**. For reasons of comparison we additionally calculated the usual one-period model ignoring mortality effects.

We estimated the following cost categories: **direct medical**, **direct non-medical** and **indirect costs** (see chapter 4). Because data on an individual level have not been available for the purpose of our study, we build up our data set from publicly accessible data sources.

In the case of the category **direct medical costs** we retrieved – whenever possible – the age- and gender-specific cost-profiles for each subcategory (i.e. health expenditures of hospitals, rehabilitation, medical practices, prescribed medicines, patient transportation, and therapeutic appliances). We applied a bottom-up approach and quantified the total medical costs by summing up over the subcategories.

The subcategories of the medical costs in Austria and Slovenia were built up by orientating towards the **System of Health Accounts** (SHA). We recommend this classification of medical costs in the frame-work of cost-benefit-analysis and cost-of-illness studies, because

it renders a better comparability of international results by looking at the ratio of the estimated costs to the standardized SHA category as reference base. We extrapolated wherever justifiable the primary data in order to meet the SHA values published by the national statistical offices, which are usually higher than the totals of the primary data. In case of Slovenia, we refrained from this procedure due to considerable differences between the primary data totals and the published costs of the corresponding SHA categories. Instead, the reference base of each subcategory is taken from the total of the primary data (i.e. data categorised according to the system of health data collection established by the National Institute of Public Health in Slovenia), and, contrary to Austria, the base reference of the overall medical costs is the sum of the subcategories' totals (EUR 1,438 million) and not the official total health expenditures in Slovenia according to SHA (EUR 2,265 million), explaining the considerable deviations between the two countries in relative terms.

We estimated the **overall medical costs** of CRD in **Austria** in terms of annuities at EUR **266.7 million** or **0.9%** of the current total health expenditures excluding long-term care, according to SHA (see Table 22, p.90). The per capita costs were quantified at EUR 31 and the per patient costs at EUR 365, assuming a prevalence rate of CRD of 8.6%.

The major subcategories of medical costs are hospitals, medical practices, and prescribed medicines. In terms of annuities, the costs of curative care provided by Austrian **hospitals** (HC.1 x HP.1) are negative in the base scenario and amount to EUR **-4.5** million (or 0.0% of the corresponding base value), resulting from the dominating effect of improved longevity over the morbidity gains. In contrast, the costs of curative care provided by **medical practices** (HC.1.3.1. x HP.3.1.1 & HC.3.1.3 x HP.3.1.3) are estimated at EUR 40.4 million (or 1.3%). The one-period estimates are in both subcategories substantially higher stemming from the counter-running effects of improved mortality. In contrast, the life-cycle model estimated the costs of **prescribed medicines** (HC.5.1.1) at EUR 162.8 million (or 5.0%) being slightly above the one-period estimates (4.9% of the base value).

In **Slovenia**, the **overall medical costs** of **COPD** add up to EUR 13.6 million or EUR 160 per patient, and the costs of **asthma** to EUR 17.1 million or EUR 165 per patient. In total, costs of the two respiratory diseases were estimated at EUR **30.6 million** or **2.2%** of the base value (see Table 23, p.95) or EUR 15 per capita or EUR 163 per COPD/asthmapatient, assuming a prevalence rate of 9.1%.

The major subcategories of medical costs in Slovenia were quantified in terms of annuities at EUR 3.24 million (or 0.52% of the corresponding base value) for **hospitals**, EUR 1.80 million (or 0.63%) for **medical practices**, and EUR 24.98 million (or 5.78%) for **prescribed medicines**. The one-period results give 0.99%, 3.61%, and 4.93%, respectively.

The category **direct non-medical costs** comprises sick benefits, care allowances, and invalidity pensions. In addition, we incorporated in our life-cycle model old-age and

widow/widower pensions. These cost items are at first glance unrelated to the disease under investigation. But the hypothetical extinction of a specific disease generates non-medical costs by increased longevity of a counter-factual population. These so-called *unrelated future costs* should be included from a theoretical point of view.

Due to data restrictions, care allowances and invalidity pensions were not included in the Slovenian part of the analysis.

Applying the life-cycle model, the overall non-medical costs of CRD were positive for Austria and negative for Slovenia, namely in terms of annuities EUR 3.5 million (or 0.01% of the reference base) and EUR -1.05 million (or 0.03%), respectively, because the old-age pension effects in Slovenia dominate the other cost items in this category. This means that without adapting the actual retirement age the increased longevity of the model's population would burden the pension system with additional costs in Slovenia. For Austria, the net effects of the direct non-medical costs are marginally positive because the costs of invalidity pensions have been considered.

The category **indirect costs** represents the economic costs of productivity losses due to sick leaves, invalidity, and premature mortality of the working force. We implemented a life-cycle model of the *human capital approach*. Hence, the calculated costs are opportunity costs.

The economic costs of CRD in terms of annuities are quantified at EUR 237.9 million (or 0.07% of GDP) and EUR 4.7 million (or 0.012% of GDP) for Austria and Slovenia, respectively. The effects of invalidity are not included in the Slovenian model, because in Slovenia the official numbers of invalidity and care allowance beneficiaries with COPD and asthma are very small and their impact on the results are expected to be neglectable.

**Summing up all cost categories**, the burden of CRD in terms of annuities was estimated at EUR **508.1 million** (or **0.15%** of GDP) in **Austria**. This translates into per capita costs of EUR 59 or per CRD-patient costs of EUR 695.

Comparing with the one-period model, which ignores the mortality effects, we calculate the burden of CRD at EUR 643.6 (or 0.19% of GDP) and the per patient costs at EUR 881. We conclude that the mortality effects of CRD calculated by both methods are substantial for Austria.

The total costs of COPD and asthma in terms of annuities in **Slovenia** amount to EUR 15.2 million and EUR 19.0 million, respectively. This translates into EUR 179 per COPD-patient and EUR 184 per asthma-patient. In total, the two diseases cause annual costs of EUR **34.2 million** (or **0.09%** of GDP) or EUR 17 per capita or EUR 182 per COPD/asthma-patient.

The one-period model for Slovenia similarly estimated the burden of COPD/asthma at EUR 35.7 (or 0.10% of GDP) and the per COPD/asthma-patient costs at EUR 189.

In contrast to Austria, the Slovenian outcomes of the life-cycle and the one-period model do not differ much in the case of the medical costs. The overall morbidity gains are more or less compensated by the mortality gains in the Slovenian life-cycle model. One reason for this is the lower relative mortality of COPD/asthma in 2014: approx. 2% of all deaths in Slovenia compared to 3.4% CRD-attributable deaths in Austria.

In summary, the chronic respiratory diseases, led by COPD, have a substantial impact on medical expenses in the investigated countries Austria and Slovenia. Especially the 5% share of the CRD costs of prescribed medicines is a major cost component, whereas the share of hospital costs is below 1% and these costs mainly accrue in elder age cohorts. It seems that COPD and asthma in particular are diseases whose progression is successfully stabilized by the out-patient care provided by medical practices and the therapeutic administration of pharmaceuticals.

### 1. Introduction

Chronic respiratory diseases (CRD) are among the most widespread chronic diseases and causes of death. In 2015, CRD accounted for approx. 3.9 million deaths worldwide (WHO, 2016a). Two of the most common CRD are chronic obstructive pulmonary disease (COPD) and asthma. COPD is currently the fifth leading cause of death worldwide and is predicted to become the fourth leading cause of death by 2030 (Mathers and Loncar, 2006). Asthma is the most common chronic disease among children and also increases in prevalence (WHO, 2013). These developments pose a significant challenge to health systems worldwide.

In order to get a better understanding of the burden of disease, this study aims to analyse, quantify and compare monetary effects of chronic respiratory diseases with a focus on COPD and asthma for the year 2014. The analysis covers two Central European countries, namely Austria and Slovenia, and is the first of its kind for either of these two countries. The study goes beyond the perspective and methodical standards applied in international literature by conducting calculations within the framework of a life-cycle model. This is a more holistic approach compared to a one-period model which merely estimates cross-sectional morbidity costs of a disease. In contrast to a multi-period life-cycle model, the monetary effects of CRD are observed over the entire life-cycle of a specific age cohort or even a whole reference population, capturing lagged health effects of altered morbidity and in addition mortality.

The **cost categories** analysed are direct medical costs, direct non-medical costs and indirect costs. Medical as well as economic costs of CRD are added up with increased expenditures for old-age and surviving dependants pensions due to improved longevity. For the sake of comparability with previous international studies, figures from the one-period model are provided in addition, ignoring these unrelated future costs of pensions.

The report at hand is structured as follows. Section 2 provides medical background information on chronic respiratory diseases. In section 3, evidence regarding the epidemiology of CRD is presented. Section 4 describes the cost categories that are commonly investigated in studies on burden of disease and are used in this study as well. In section 5, existing international evidence on the economic burden of CRD is reviewed. Section 6 provides information on the method applied, in particular the life-cycle model. Section 7 describes the various data sources used for the study. In section 8, the results of the analysis are presented for Austria and Slovenia. Section 9 discusses the results of a performed non-probabilistic simulation analysis of the Austrian model.

# 2. Background information on chronic respiratory diseases

The WHO defines CRD as chronic diseases of the airways and other structures of the lungs. A number of diseases can be categorised under the umbrella term of CRD. The focus of this study is on chronic lower respiratory diseases, which are listed in the ICD-10 (International Statistical Classification of Diseases and Related Health Problems, 10<sup>th</sup> Revision) classification under the codes J40 to J47. The corresponding conditions can be found in Table 1.

J40	Bronchitis, not specified as acute or chronic	
J41	Simple and mucopurulent chronic bronchitis	
J42	Unspecified chronic bronchitis	
J43	Emphysema	
J44	Other chronic obstructive pulmonary disease	
J45	Asthma	
J46	Status asthmaticus	
J47	Bronchiectasis	

Table 1: Chronic lower respiratory diseases according to the ICD-10 classification

Source: WHO (2016b)

The two most common among these conditions are COPD (J44) and asthma (J45-J46). A particular focus will therefore be placed on these two conditions in the course of the analysis. In the following, background information on COPD and asthma is provided.

#### 2.1. COPD

The Global Initiative for Chronic Obstructive Lung Disease (GOLD) defines COPD as follows:

"Chronic Obstructive Pulmonary Disease (COPD), a common preventable and treatable disease, is characterized by persistent airflow limitation that is usually progressive and associated with an enhanced chronic inflammatory response in the airways and the lung to noxious particles or gases. Exacerbations and comorbidities contribute to the overall severity in individual patients." (GOLD, 2016: 2)

The best-studied and most important risk factor for COPD is cigarette smoking. Further risk factors include exposure to particles other than cigarette smoke (e.g. occupational exposures, other types of tobacco, severe air pollution), genetic predisposition and poor lung growth. Chronic inflammation of the respiratory tract in response to exposure to noxious particles or gases may cause pathologic changes: emphysema, as a result of destruction of parenchymal tissue, as well as small airway fibrosis, as a result of disruption of normal repair and defence mechanisms. Together, these lead to air trapping and progressive airflow limitation, causing breathlessness and other symptoms characteristic to COPD. (GOLD, 2016: 4 ff.)

The disease can be classified by several degrees of severity. For this purpose, the GOLD Initiative developed a classification based on post-bronchodilator spirometry (see Table 2). It divides airflow limitation into four stages. This classification, which is often referred to as **GOLD I-IV**, has been widely used in epidemiological literature. An alternative classification, which is similar to GOLD I-IV, is the lower-limit-of-normal (LLN) definition. Instead of a fixed unique value, age-dependent cut-off values below the lower fifth percentile of the FEV<sub>1</sub>/FVC ratio are derived from the general population. While the GOLD criteria tend to over-diagnose COPD, definition via LLN tends to lead to under-diagnosis (Güder et al., 2012).

bronchodilator FEV <sub>1</sub> )		
In natients with FEV./FVC < 70%		

Table 2: GOLD classification of severity of airflow limitation in COPD (based on post-

In patients with FEV <sub>1</sub> /FVC < 70%:		
GOLD I	Mild	$FEV_1 \ge 80\%$ predicted
GOLD II	Moderate	$50\% \leq \text{FEV}_1 < 80\%$ predicted
GOLD III	Severe	$30\% \leq \text{FEV}_1 < 50\%$ predicted
GOLD IV	Very severe	FEV <sub>1</sub> < 30% predicted

Notes: FEV<sub>1</sub> = forced expiratory volume in one second FVC = forced vital capacity

Source: GOLD (2016: 14)

However, based on the insight that forced expiratory volume, symptoms of the disease and impairment of health-related quality of life are only weakly correlated, an alternative classification was recently developed by the GOLD Initiative (see Figure 1). The new classification, which is often referred to as **GOLD A-B-C-D**, allows for measuring risk either by spirometry results or exacerbation history, and combines this with the patient's symptomatic assessment.



Figure 1: GOLD classification based on symptoms, breathlessness, spirometric classification and risk of exacerbations

Notes: CAT = COPD Assessment Test mMRC = Medical Research Council Dyspnea Scale Source: GOLD (2016: 15)

A noteworthy publication in the context of COPD is the report of the **European COPD Audit** by the European Respiratory Society (ERS, 2012). The COPD Audit was a cross-sectional, multi-centre study covering 13 European countries, including Austria (but not Slovenia). It collected data about care provision for COPD in hospitals, as well as clinical data on the process of care and outcomes for COPD patients admitted to hospital with an exacerbation. The report includes data on, e.g., equipment of hospitals, organisation of care, length of stay, mortality, readmission, smoking history of COPD patients, comorbidities and the general health state of COPD patients. Several conclusions could be drawn from the audit, e.g. that there is considerable variation in COPD-related equipment and treatment of COPD in hospitals, as well as treatment and rehabilitation options after discharge across Europe. Length of stay ranged from 5 to 14 days with a median of 8 days. A high proportion of admitted patients were current smokers, and the most common comorbidities were cardiovascular diseases and diabetes. 5% of COPD patients died in hospital, a further 6% in the 90 days after discharge and 35% of survivors were readmitted within this period.

In Austria, 49 hospitals and 823 patients participated in the audit. Hospital mortality of COPD patients was found to be below the European average (4.1%) and 90-day mortality approx. equal to the European average (6.1%). The readmission rate, however, was found to be relatively high at 39.7%. Median length of stay was 9 days. The availability of rehabilitation

and early/supported discharge programmes is relatively low in Austria when compared to the other countries included in the audit.

#### 2.2. Asthma

The WHO defines asthma as follows:

"Asthma attacks all age groups but often starts in childhood. It is a disease characterized by recurrent attacks of breathlessness and wheezing, which vary in severity and frequency from person to person. In an individual, they may occur from hour to hour and day to day. This condition is due to inflammation of the air passages in the lungs and affects the sensitivity of the nerve endings in the airways so they become easily irritated. In an attack, the lining of the passages swell causing the airways to narrow and reducing the flow of air in and out of the lungs." (WHO, n.d.)

Both genetic and non-genetic factors affect development and symptoms of asthma. In this context, it is important to distinguish between the underlying causes of the disease and the triggers of attacks. The underlying causes are not yet fully understood, but genetic predisposition, allergy and certain environmental factors are agreed to play a role in the development of asthma. Common triggers of asthma attacks are, however, well-studied and widely recognised. They include upper respiratory tract infections, physical exercise, inhalation of allergens (e.g. dust mites, animal dander, pollens, moulds) or other irritants (e.g. cigarette smoke, fumes) and certain medications. (Global Asthma Network, 2014: 39 ff.)

### 3. Epidemiology of chronic respiratory diseases

In the following, epidemiological data for COPD and asthma are presented. A subsection containing methodological considerations is followed by further subsections on international evidence and evidence from Austria and Slovenia, respectively.

## 3.1. Considerations on methodology in epidemiological studies on chronic respiratory disease

A large number of studies have been carried out internationally to determine the prevalence of COPD and asthma. However, these vary widely with regard to data sources, definitions, prevalence measures and observed populations.

The most commonly used data sources are

- (1) data from medical examinations, in particular spirometric data,
- (2) medical records and
- (3) survey data.

Data from medical examinations are in general reliable, but are in case of COPD often based on spirometry only. As mentioned above, airflow limitation alone is not regarded a sufficient indicator for COPD anymore. Survey data take into account the respondents' own perspective, but are reliable only to a limited extent. Limited knowledge and awareness with respect to COPD among patients – and possibly also among the physicians treating them – may lead to underreporting in surveys, resulting in prevalence rates that are too low. For asthma, a common problem with survey data is stigma associated with the disease, also possibly leading to underreporting. Furthermore, Torén et al. (2006) found that survey respondents with mild asthma were less likely to report their disease at all.

Medical records rely on the accuracy of diagnostics. Evidence from several countries, however, suggests that especially COPD diagnoses may be subject to misclassification and underestimation. Evidence in this regard has not only been found with respect to medical records, but also for mortality statistics. Romanelli et al. (2016) investigated the reliability of COPD prevalence in several administrative databases in Italy (hospital discharge register, clinical charts, cause-specific mortality register). According to their analysis, 17% of COPD cases were misclassified. A similar study was conducted by Thomsen et al. (2011) in Denmark, who investigated COPD diagnoses in the Danish National Patient Registry. They found a positive predictive value for COPD of 92%, i.e, 92% of registered COPD diagnoses were confirmed after review. The negative predictive value of COPD among patients coded with pneumonia or respiratory failure but not COPD was found to be 81%, i.e. 19% of these

patients also had COPD. Johansson et al. (2009) compared death certificates and hospital discharge diagnostic data in Sweden and found a particularly large discrepancy for COPD. Potential reasons for misclassification and underestimation of COPD are that acute events might be prioritised over chronic conditions in hospital records or mortality statistics (and COPD therefore only recorded as a secondary diagnosis), as well as the difficulty in distinguishing COPD from other (chronic) respiratory diseases.

Definitions of COPD and asthma in epidemiological studies are most commonly based on

- (1) definition based on medical examination (COPD: GOLD I-IV/LLN/GOLD A-B-C-D),
- (2) previous physician diagnosis,
- (3) symptoms or
- (4) combinations of the above.

Again, definition of COPD based solely on spirometry is generally regarded too narrow. The accuracy of physician diagnosis as an indicator for COPD or asthma depends on the physician's knowledge and, if asked in the course of a survey, on the patient's awareness and memory. Determining CRD prevalence on the basis of symptoms asked in a questionnaire might be insufficiently accurate, as symptoms could also be caused by respiratory conditions other than COPD or asthma. Some studies use combinations of the above criteria, most commonly medical examination together with a questionnaire on symptoms. Furthermore, some questionnaires simply include questions like *Do you have/Have you ever had COPD/asthma?* and do therefore not use a specific defining criterion. Another aspect to be taken into account in the context of definitions is the degree of disease severity used as a cut-off point (e.g. GOLD I or GOLD II for COPD).

Prevalence measures generally used in epidemiological literature are

- (1) point prevalence,
- (2) period prevalence (most commonly 12-month prevalence) and
- (3) lifetime prevalence.

Point prevalence measures the proportion of a population suffering from a condition at a certain point in time. In most cases, this refers to the time of data collection, i.e. the time of a medical examination or a survey (e.g. *Do you currently have COPD/asthma?*). Period prevalence measures the proportion of a population suffering from a condition in a defined period of time. A commonly used period is the 12 months preceding a survey (e.g. *Have you had COPD/asthma over the past 12 months?*). Lifetime prevalence measures the proportion of a population at least once over their lifespan (e.g. *Have you ever had COPD/asthma?*).

Epidemiological studies can also be distinguished by which **populations** they observe. In the case of studies on COPD prevalence, common target populations are

- (1) certain age groups (COPD: commonly elderly persons; asthma: commonly children),
- (2) COPD: (former) smokers or non-smokers and
- (3) populations of certain geographical regions.

Since COPD predominantly occurs in elderly populations, epidemiological studies often restrict their target population by age, e.g. only observe persons over the age of 40. Similarly, epidemiological studies on asthma often exclusively target children. Some studies investigate the prevalence of COPD in (former) smokers, or alternatively in non-smokers, due to the close link between smoking and COPD. Furthermore, some studies on COPD or asthma focus on populations of certain cities or regions, e.g. urban areas with high levels of air pollution. In international comparisons based on survey data, it should also be considered that specific diseases may be underdiagnosed in some countries compared to others.

When considering epidemiological data obtained from different studies, it is necessary to take into account the variations listed above. Different definitions and methodologies might be suitable for different research purposes, and results might therefore not be entirely comparable.

## 3.2. International epidemiological data on chronic respiratory diseases

#### 3.2.1. COPD

#### Prevalence

A particularly comprehensive international epidemiological study in the context of COPD is the **BOLD (Burden of Obstructive Lung Disease) study**. The BOLD initiative collects country-specific data on prevalence, risk factors and social and economic burden of COPD based on standardised methods. In addition, its aims include assessing the appropriateness of care provided, facilitating future longitudinal studies and making standardised methods available also to low and middle income countries.<sup>1</sup> Prevalence rates of COPD collected in the course of the BOLD study are point prevalence rates based on spirometry and pertain to the population aged 40 years and older. Burney et al. (2014) give a global overview of results from various BOLD sites, using the LLN for age and sex as the defining criterion for COPD (see Figure 2 for selected sites).

<sup>&</sup>lt;sup>1</sup> See <u>http://www.boldstudy.org/sop.html</u>.

While the COPD prevalence among Austrian men (13.4%) lies around the average, Austrian women exhibit the highest rate of all BOLD sites in Western countries (20.7%). No data from Slovenia are available within the BOLD framework. In general, there is a high degree of variation in the epidemiological data, with prevalence rates ranging from around 5% to around 20% in the selected Western countries. In four sites (Austria, USA, Iceland, Australia), prevalence is higher for women than for men. In the remaining sites, men have higher rates. In view of the strong causality between smoking and COPD, and the higher smoking prevalence rates of men throughout the majority of countries, higher female COPD prevalence rates of the BOLD study should be taken with caution. One explanation for that phenomenon could be gender-specific over- and underreporting in some countries.

## Figure 2: Prevalence of airflow obstruction (FEV₁/FVC < LLN) in selected sites of the BOLD study by sex, population ≥ 40 years



Notes: sites and dates of fieldwork in brackets

FEV<sub>1</sub> = forced expiratory volume in one second

FVC = forced vital capacity

LLN = lower limit of normal for age and sex

Source: Burney et al. (2014: 467), illustration by IHS (2018)

Results of the Continuing to Confront survey are presented by Landis et al. (2014) (see Figure 3). Austria and Slovenia are not included in the survey. Except for the USA, prevalence rates in all countries are higher for men than for women. Prevalence rates for men range from 6.2% in the USA to 13.5% in Brazil, rates for women range from 5.0% in Spain to 10.7% in Brazil. When comparing prevalence rates from countries that participated

in both the BOLD study and the Continuing to Confront survey, considerable discrepancies can be observed. In the United Kingdom, the Netherlands and the USA, prevalence rates from the BOLD study are about twice as high as from the Continuing to Confront survey; in Germany, they are slightly lower. These discrepancies may be due to the different definitions and methodologies, as well as the restricted geographical focus of the BOLD study. However, they also make clear that epidemiological data on COPD in general should be interpreted with caution.





Source: Landis et al. (2014: 601), illustration by IHS (2018)

The **Continuing to Confront COPD International Patient Survey** is another comprehensive epidemiological study on COPD. It was conducted in 12 countries in 2012/2013 as an update of the Confronting COPD International Survey from 1999/2000. Similarly to the BOLD study, the Continuing to Confront survey only included the population aged 40 years and older. Respondents were classified as COPD cases when they met one of the following conditions:

 physician diagnosis of COPD, chronic obstructive airway disease, or emphysema, and either regularly used medication to treat these conditions or had chronic cough with phlegm most days

- physician diagnosis of chronic bronchitis and either regularly used medication to treat this condition or had chronic cough with phlegm most days
- chronic bronchitis defined by symptomatology (cough and sputum production on most days for at least 3 months in the year for at least 2 consecutive years) and either regularly used medication to treat this condition or had chronic cough with phlegm most days

Epidemiological data on various diseases can also be drawn from the **European Health Interview Survey (EHIS)**. EHIS consists of four modules (health status, health care use, health determinants, socio-economic background variables) and is planned to be conducted every 5 years in all EU member states, as regulated by Commission legislation. The second wave was conducted in 2014. The survey targets the population aged 15 years and older.<sup>2</sup> Prevalence rates for chronic diseases are based on a question about the occurence of the respective disease in the past 12 months (*During the past 12 months, have you had any of the following diseases or conditions?*). The survey does not contain a question related specifically to COPD, but rather to "chronic bronchitis, COPD, emphysema". The corresponding prevalence rates are presented in Figure 4.

Although the question covers a broader spectrum of diseases, the prevalence rates from EHIS are considerably lower than from both the BOLD study and the Continuing to Confront survey. The reason for this lies in the age groups covered by the studies: while BOLD and Continuing to Confront exclusively target populations aged 40 years and older, the lower age limit for EHIS is 15 years. Since COPD predominantly occurs in older populations, prevalence rates for the entire population are necessarily lower. Interestingly, according to EHIS, prevalence rates are higher for women than for men in the majority of EU countries as well as in the EU-28 as a whole (4.3% vs. 3.9%). Rates for men range from 0.8% in Malta to 5.7% in Luxembourg, and rates for women range from 1.5% in Malta to 7.3% in Lithuania. Both Austria (4.4% for women, 4.0% for men) and Slovenia (4.3% for women, 4.0% for men) exhibit prevalence rates close to the EU average. Once again, there are discrepancies between the results of EHIS and the previously mentioned studies regarding the relative magnitude of prevalence rates. For example, while prevalence rates in Germany were found to be considerably lower than in the UK in the BOLD study, the opposite is the case in EHIS.

<sup>&</sup>lt;sup>2</sup> See <u>http://ec.europa.eu/eurostat/web/microdata/european-health-interview-survey</u>.



#### Figure 4: Prevalence of chronic respiratory diseases (excl. asthma) from European Health Interview Survey (EHIS) 2014 by sex, population ≥15 years

Notes: Prevalence rates based on the question *During the past 12 months, have you had any of the following diseases or conditions? – Chronic bronchitis, chronic obstructive pulmonary disease, emphysema* 

Source: Eurostat (2017), illustration by IHS (2018)

#### Mortality

According to WHO Global Health Estimates, COPD accounted for 3.17 million deaths worldwide in 2015, corresponding to 5.6% of all deaths. This makes it the fourth leading cause of death worldwide after ischaemic heart disease, stroke and lower respiratory infections. COPD is a more common cause of death in wealthier regions: while the crude mortality rate amounted to 42.6 and 50.4 deaths per 100,000 population in high-income and

upper-middle-income economies (according to World Bank income groups), respectively, it amounts to merely 16.7 in low-income economies. (WHO, 2016a)

#### 3.2.2. Asthma

#### Prevalence

A wide range of epidemiological data on asthma in children can be drawn from the **International Study of Asthma and Allergies in Childhood (ISAAC)**. ISAAC was an international epidemiological research programme investigating asthma, rhinitis and eczema in children in more than 100 countries, based on a standardised methodology. The study aimed at developing environmental measures and disease monitoring with a particular focus on developing countries. The ISAAC programme was formally terminated in 2012, but its work is continued by the Global Asthma Network, which was founded in the same year.<sup>3</sup> In the course of the study, schoolchildren aged 6-7 years and 13-14 years were surveyed by means of a written questionnaire, which was completed by parents of the children in the younger age group. 233 sites in 97 countries collected data for the 13-14 year age group, 144 sites in 61 countries collected data in the 6-7 year age group. Different definitions of asthma – namely lifetime prevalence of asthma, current wheeze (12-month prevalence) and symptoms of severe asthma (12-month prevalence) – are considered in the study. Results from all global sites were published by Lai et al. (2009). Results for the 13-14 year age group from the participating EU countries are presented in Figure 5.

Lifetime prevalence rates range from 2.5% in Lithuania to 25.1%, i.e. ten times as high, in the United Kingdom. The United Kingdom also exhibits the highest prevalence rate of severe asthma at 10.5%. Current wheeze appears to be only weakly correlated with lifetime prevalence of asthma, as it exceeds lifetime prevalence considerably in some countries (e.g. Romania, Finland), while it lies below lifetime prevalence in others (e.g. Italy, Spain). In Austria, lifetime prevalence was found to be relatively low at 7.0%; current wheeze (15.1%) and symptoms of severe asthma (6.7%) are around average among the depicted countries. Slovenia was not included in the ISAAC survey.

<sup>&</sup>lt;sup>3</sup> See <u>http://isaac.auckland.ac.nz/</u>.



## Figure 5: Prevalence of asthma according to different definitions among children aged 13-14 years in EU countries from ISAAC study

Notes: Lifetime asthma prevalence: based on the question *Have you/has your child ever had asthma?* Current wheeze: wheeze in the past 12 months

Symptoms of severe asthma: frequent or severe episodes of wheeze in the past 12 months ( $\geq$ 4 attacks of wheeze or  $\geq$ 1 night per week sleep disturbance from wheeze or wheeze affecting speech)

Source: Lai et al. (2009), illustration by IHS (2018)

Epidemiological data on asthma in adult populations were collected in the course of the **WHO World Health Survey**, which was conducted in 2002-2004 in 70 countries worldwide. Its aim was to strengthen national capacity to monitor critical health outcomes and health system by providing a valid, reliable and comparable household survey instrument. It targeted the population aged 18 years or older and includes data on, e.g., household health expenditure, health state descriptions and valuation, risk factors, health care utilisation and

chronic conditions.<sup>4</sup> With regard to asthma, similarly to the ISAAC study, three definitions are considered: doctor diagnosed asthma (lifetime prevalence), clinical asthma (lifetime prevalence) and symptoms of asthma (12-month prevalence). To et al. (2012) present global asthma prevalence rates collected in the World Health Survey (see Figure 6 for results from EU countries). In order to avoid confusion between asthma and COPD, they limit the sample to the population aged 18-45 years.

Prevalence rates for doctor diagnosed asthma are very close to prevalence rates for clinical asthma in all countries. This is hardly surprising, since persons diagnosed with asthma are also likely to receive treatment for their condition. The rates range from 2.0% in Estonia to 20.2% in Sweden. The prevalence of wheezing symptoms is higher than for doctor diagnosed and clinical asthma in all depicted countries, ranging from 5.9% in Latvia to 22.7% in the Netherlands. Prevalence rates for this definition appear to be correlated with the other definitions to a relatively high degree. Doctor diagnosed asthma and clinical asthma occur in approx. 7.5% of the population, while 9.5% suffer from wheezing symptoms. In Slovenia, prevalence rates according to the World Health Survey are slightly higher, with 8.7% for doctor diagnosed or clinical asthma and 11.9% for wheezing symptoms. Once again, the absolute as well as relative magnitude of prevalence rates in EU countries differs from those observed in the ISAAC study. This may be partly due to the different age groups and different definitions. However, a common pattern is that asthma prevalence tends to be relatively high in Western and North-Western European countries, and relatively low in Baltic and Eastern European countries.

<sup>&</sup>lt;sup>4</sup> See <u>http://apps.who.int/healthinfo/systems/surveydata/index.php/catalog/whs/about.</u>





Notes: \*No sample weights available.

Doctor diagnosed: based on the question *Have you ever been diagnosed with asthma?* Clinical asthma: based on the questions *Have you ever been treated for asthma?* or *Have you been taking any medications or treatment for asthma during the last 2 weeks?* Wheezing symptoms: based on the question *During the last 12 months have you experienced attacks of wheezing or whistling breath?* 

Source: To et al. (2012), illustration by IHS (2018)



#### Figure 7: Prevalence of asthma from European Health Interview Survey (EHIS) 2014 by sex, population ≥15 years

Notes: Prevalence rates based on the question *During the past 12 months, have you had any of the following diseases or conditions? – Asthma (allergic asthma included)* Source: Eurostat (2017), illustration by IHS (2018)

Asthma is also covered in the chronic diseases section of **EHIS** (see section 3.2.1 for further information on this survey). The corresponding prevalence rates are presented in Figure 7. Asthma prevalence rates according to EHIS range from 1.8% in Romania to 8.1% in Ireland for men and from 2.1% in Romania to 11.0% in Finland for women. Women exhibit higher prevalence rates than men in almost all EU countries. On average, 6.6% of women and 5.2% of men suffer from asthma in the EU-28. Both Austria (4.7% for women, 4.0% for men) and Slovenia (5.4% for women, 4.6% for men) have prevalence rates below the EU-28

average. The pattern of Baltic and Eastern European countries having relatively low asthma prevalence rates and Western and North-Western having higher rates also prevails in EHIS.

The overview of prevalence data on COPD and asthma presented above highlights that CRD are a widespread health problem in Western countries. However, considerable discrepancies across the different sources – which particularly arise in the case of COPD – make clear that obtaining reliable and comparable data is a difficult task. Discrepancies may be due to the variations in methodology described above, i.e. different data sources, definitions, prevalence measures and/or observed populations. Moreover, the individual methodological approaches may not yield accurate measures of prevalence. The data presented above as well as in the following subsection should therefore be interpreted with caution.

#### Mortality

The mortality of asthma is considerably lower than the mortality of COPD. In 2015, 380,000 deaths worldwide were caused by asthma. This corresponds to 0.7% of all deaths. In contrast to COPD, asthma as a cause of death is more common in low-income regions: the crude mortality rate of asthma amounts to 1.6 and 2.6 per 100,000 population in high-income and upper-middle-income economies, respectively, but reaches 7.5 in low-income economies. (WHO, 2016a)

#### 3.3. Epidemiological data on chronic respiratory diseases in Austria

#### 3.3.1. COPD

#### Prevalence

In a review study for the Main Association of Austrian Social Security Institutions (*Hauptverband der Österreichischen Sozialversicherungsträger*, HV), Gothe (2012) investigated available prevalence data on COPD for Austria. He identifies publications related to the BOLD study as the sole sources of prevalence data for Austria. Furthermore, he concludes that determining COPD prevalence from administrative data of the social health insurance is difficult, due to the lack of diagnostic data from the outpatient sector and the problem of distinguishing COPD from other (chronic) respiratory diseases based on pharmaceutical prescription data.

Austrian prevalence data from the **BOLD study** were published by Schirnhofer et al. (2007) and are presented in Figure 8 for three definitions: GOLD stage I or higher, GOLD stage II or higher and doctor diagnosed. Total prevalence is 26.1% (26.6% men, 25.7% women) for
GOLD stage I or higher, 10.7% (10.3% men, 11.0% women) for GOLD stage II or higher and 5.6% (5.6% both men and women) for doctor diagnosed chronic bronchitis, emphysema or COPD according to the BOLD study. This suggests that a large share of COPD cases remain undiagnosed. For example, in the age group over 70 years, around one half are classified as GOLD stage I or higher and around one quarter as GOLD stage II or higher, while only around 10% report previous diagnosis by a physician. The large differences between prevalence rates according to the three definitions highlight the significance of the definition chosen when reporting COPD prevalence.



## Figure 8: Prevalence of COPD according to different definitions from BOLD study by sex and age group, 2004/2005

Notes: GOLD stage I+: FEV<sub>1</sub>/FVC ratio of <0.7 GOLD stage II+: FEV<sub>1</sub>/FVC ratio of <0.7 and FEV<sub>1</sub> of <80% predicted FEV<sub>1</sub> = forced expiratory volume in one second FVC = forced vital capacity Doctor diagnosed: Self-reported physician's diagnosis of chronic bronchitis, emphysema, or COPD n=1,258

Source: Schirnhofer et al. (2007), illustration by IHS (2018)

As mentioned in section 3.2.1, prevalence of CRD was also determined in the Austrian branch of EHIS 2014, the **Austrian Health Interview Survey (ATHIS)**. Detailed results by sex and age are presented in Figure 9. Aggregate prevalence rates according to ATHIS are 4.0% for men and 4.4% for women. The actual prevalence rates observed in the data fluctuate strongly in higher age groups. Therefore, a moving average was calculated. For men, the moving average increases consistently with age and reaches approx. 12% for individuals over 85 years of age. Women exhibit higher rates than men in younger age groups – leading to a higher total prevalence rate for women –, but lower rates in older age

groups. The moving average for women reaches its highest value at approx. 9% for individuals over 85 years of age. Overall, prevalence rates according to ATHIS are relatively close to those of doctor diagnosed COPD/chronic bronchitis/emphysema in the corresponding age groups in the BOLD study.





Notes: Prevalence rates based on the question *During the past 12 months, have you had any of the following diseases or conditions? – Chronic bronchitis, chronic obstructive pulmonary disease, emphysema* 

Moving average: average of previous and following data points; 3-year MA for age groups up to 45-49, 5-year MA for age groups from 50-54 onwards n=15.771

Source: Statistics Austria (2014), illustration by IHS (2018)

Considering the problems associated with survey data as a source for epidemiological data (see section 3.1), additional data would be desirable in order to measure COPD prevalence more accurately. The **Austrian LEAD (Lung, hEart, sociAl, boDy) Study** is a promising initiative in this context. The LEAD study is a long-term study on respiratory health in Austria that aims at identifying causes and risk factors of respiratory diseases, developing innovative treatment approaches and avoiding respiratory diseases in the future.<sup>5</sup> It has was initiated in 2012 and is planned to continue for 12 years. In order to determine prevalence of respiratory diseases, comprehensive medical examinations and surveys are conducted in a sample of around 11,000 individuals aged between 6 and 80 years in Lower Austria and Vienna in intervals of four years. Lung function is tested via spirometry and body plethysmography.

<sup>&</sup>lt;sup>5</sup> See <u>https://www.leadstudy.at/en/.</u>

First results indicate that the prevalence of lung dysfunction among younger age groups is higher than previously assumed, while in older age groups there appears to have been an overestimation. This becomes apparent when comparing the prevalence of lung dysfunction as measured in the course of the LEAD study to doctor diagnoses reported by the respondents (see Figure 10). While in doctor diagnosed COPD, there is a clear increase with age, this trend is less pronounced in the measures of the LEAD study, and even reverses in the highest age group of individuals over the age of 70 years. More detailed results of the LEAD study have not yet been published, but these first results already challenge prevailing assumptions on CRD prevalence.





Notes: n=10,882

### Mortality

Of all 78,252 deaths in Austria in 2014, 2,622 or 3.4% were caused by CRD (ICD J40-J47). In particular, 2,098 deaths or 2.7% were caused by COPD. Hence, COPD causes the vast majority of CRD-related deaths. Age group-specific data are depicted in Figure 11. In younger age groups, only a very small number of deaths can be attributed to CRD. CRD-related deaths typically occur in age groups from 60 to 90 years, and are predominantly caused by COPD. In the population aged 65-74 years, 4.2% of deaths were caused by COPD. In older age groups, COPD again becomes less relevant as a cause of death.

Source: Austrian LEAD Study (2016), illustration by IHS (2018)

# Figure 11: Deaths caused by chronic respiratory diseases (CRD, J40-J47) in % of all deaths in Austria, decomposed into COPD (J44) and CRD other than COPD (J40-J43, J45-J47), 2014



Source: Statistics Austria (2015a), illustration by IHS (2018)

### 3.3.2. Asthma

### Prevalence

Only very limited epidemiological data on asthma are available in Austria. Using nationwide patients' records for prescription data, Ghanem (2014, see also Ghanem et al. 2015) determined asthma prevalence in Austria, however focusing on severe asthma only, because the medical guidelines for pharmaceutical treatment of mild asthma and COPD are similar which makes it difficult to identify the diseases by their prescribing patterns. In contrast, patients with severe asthma receive a high-dose inhaled corticosteroids combination treatment which makes these cases generally distinguishable from COPD cases. Unambiguous prevalence data can, however, not be drawn from this study, as two different publications related to the study report diverging results. In his diploma thesis, Ghanem (2014) reports prevalence rates of severe asthma of 0.23%, 0.07% and 0.74%, depending on the asthma criteria, while in a more recent abstract for the ERS International Congress (Ghanem et al., 2015), a prevalence of only 0.027% is stated.

Results from various European sites of the **ISAAC study** were presented in Figure 5 in section 3.2.2. Results from the Austrian sites (Carinthia and Urfahr-Umgebung) for both age groups are presented in Figure 12. In the younger age group of children aged 6-7 years, prevalence rates are generally lower than among children aged 13-14 years. This particularly

holds for symptoms of severe asthma: while 6.7% of 13-14 years olds display such symptoms, only 2.5% of 6-7 year olds do so.





Notes: n=6,876 in 6-7 year age group, n=1,439 in 13-14 year age group Sites: Carinthia (6-7 year age group only) and Urfahr-Umgebung (both age groups) Lifetime asthma prevalence: based on the question *Have you/has your child ever had asthma?* Current wheeze: wheeze in the past 12 months Symptoms of severe asthma: frequent or severe episodes of wheeze in the past 12 months (≥4 attacks of wheeze or ≥1 night per week sleep disturbance from wheeze or wheeze affecting speech)

Source: Lai et al. (2009), illustration by IHS (2018)

In addition to these results from 2002/2003, further data were collected in the course of the ISAAC study in Lower Austria in 2008. The results were published by Haidinger et al. (2011). In a full census of children aged 6-7 years (n=9,885), 4.7% were found to have ever had asthma. Haidinger et al. also provide results by sex: lifetime prevalence was 3.3% in girls and 6.0% in boys.

Finally, asthma-related data for the adult population by sex and age were collected in the course of **ATHIS 2014** and are presented in Figure 13. Similarly to COPD data depicted in Figure 9, a moving average was calculated to smooth out fluctuations in the actual prevalence rates observed in the data. Aggregate prevalence rates according to ATHIS are 4.0% for men and 4.7% for women. A slight increase with age can be observed, which is more pronounced in the male than in the female population. Up to the age of around 65, women mostly exhibit higher prevalence rates than men, while the opposite can be observed in higher age groups. A further aspect that should be taken into account when considering asthma prevalence particularly in higher age groups is the difficulty of distinguishing asthma from COPD.



### Figure 13: Prevalence of asthma from Austrian Health Interview Survey (ATHIS) 2014 by sex and age, percentage per age group and moving average (MA)

Notes: Prevalence rates based on the question *During the past 12 months, have you had any of the following diseases or conditions? – Asthma (allergic asthma included)* Moving average: average of previous and following data point n=15,771

Source: Statistics Austria (2014), illustration by IHS (2018)

### **Mortality**

As mentioned in section 3.2.2, asthma as a cause of death is very uncommon, especially in high-income countries such as Austria. In 2014, only 58 persons (36 women, 22 men) died of asthma in Austria (Statistics Austria, 2015a).

# 3.4. Epidemiological data on chronic respiratory diseases in Slovenia<sup>6</sup>

### 3.4.1. COPD

### Prevalence

Data on COPD prevalence in Slovenia were collected from various sources. One of them is a review article Chronic Obstructive Lung Disease (COPD) by Debeljak (2003). It systemised

<sup>&</sup>lt;sup>6</sup> This chapter was authored by VI vis.

the available data on prevalence and mortality back from 1997 to 2001. The author used medical records from the offices of primary health care physicians and data available in the National Institute of Public Health. Only aggregated data about the number of patients with diagnosis of COPD was reported. Age and gender split was not available, neither the estimation of prevalence. The summary of the findings is presented in Table 3.

Table 3: Number of patients with COPD registered in the offices of primary care physicians in Slovenia in 1997-2001

Year	Number of patients with COPD	Number of patients with COPD per 100,000 inhabitants
1997	16,787	848
1998	19,819	1,001
1999	18,750	946
2000	18,268	919
2001	17,998	903

Source: National Institute of Public Health Slovenia (2003), illustrated by VI vis (2017)

The review article also mentioned the results of the first study with the objective to estimate COPD prevalence in Slovenia. It was conducted among adults of 45-59 years old in the selected cities in 1973. The symptoms of COPD were confirmed in 4% of study participants.

More recent estimations about COPD prevalence are available from a nationwide health behaviour monitoring survey **CINDI**, **Health Monitor 2001-2004-2008**, conducted and published by The National Institute of Public Health in 2012 (National Institute of Public Health Slovenia, 2012). The survey covered population of 25-64 years old, the participants were asked, among other questions, to self-report their health conditions which had been confirmed by their physicians – e.g. "Do you have one of the below conditions, which were diagnosed by your doctor: (1) asthma, (2) COPD or chronic bronchitis or emphysema. The analyses of survey results showed that COPD prevalence, including chronic bronchitis and emphysema, among both genders had increased in the observed period, the highest prevalence was reported in the age group aged 55-64, see Figure 14 and Figure 15 below.





Source: National Institute of Public Health Slovenia (2012), illustrated by VI vis (2017)





Source: National Institute of Public Health Slovenia (2012), illustrated by VI vis (2017)

As mentioned in section 3.2.1, prevalence of COPD was also determined in **the Slovenian Chapter of EHIS 2014 survey** (National Institute of Public Health Slovenia, 2016). Detailed results by gender and age groups were obtained from the National Institute of Public Health and are presented in Figure 16. Overall self-reported prevalence of COPD among men is slightly below 4%, whereas women reported prevalence of 4.3%. Only 6 men aged 90 and above took part in the survey, none of them reported to have COPD, therefore the estimated prevalence for that age group is 0. Prevalence among children was not collected in the survey and we assumed it is 0. Prevalence in the younger age groups, between 15 and 40, for both genders is likely to include people with chronic bronchitis and emphysema, but we did not correct it. The self-reported prevalence is increasing with the age which corresponds well with the trends from other studies such as BOLD. Based on EHIS 2014 data, the estimated number of people with COPD in Slovenia maybe around 72,000 (34,000 men and 38,000 women).



Figure 16: Prevalence of COPD, chronic bronchitis and emphysema by gender and age, Slovenian Chapter of EHIS 2014

Source: National Institute of Public Health Slovenia (2016), illustrated by VI vis (2017)





Source: National Institute of Public Health Slovenia (2016), illustrated by VI vis (2017)

### Mortality

Out of all 18,886 deaths in Slovenia in 2014, 354 or 1.9% deaths were due to COPD according to the data from National Institute of Public Health. <sup>7</sup> 2/3 of deaths due to COPD happened among men. The distribution of deaths by age and gender is presented in Figure 18.



Figure 18: Number of deaths due to COPD in Slovenia by gender and age in 2014

Source: National Institute of Public Health Slovenia (2016), illustrated by VI vis (2017)

<sup>7</sup> Data on mortality due to asthma and COPD were obtained upon request from NIJZ, data are available on file at the Study Sponsor.

The number of deaths due to COPD reported in 2014 is lower compared to the published data from the earlier period. For example, the above-mentioned review article Chronic Obstructive Lung Disease (COPD) written by prof. Andrej Debeljak (2003), reports on average 605 deaths per year due to COPD - twice as many cases as reported by National Institute of Public Health in 2014. The distribution of cases between genders was however the same as in 2014 - 2/3 for men and 1/3 for women, see Table 4 below.

Year	Total number of deaths	Men/100,000 inhabitants	Women/100,000 inhabitants	Total/100,000 inhabitants
1995	632	45	19	32
1996	598	44	17	30
1997	578	40	18	29
1998	591	40	20	30
1999	656	46	21	33
2000	586	42	18	29
2001	600	40	21	30

Table 4: Number of deaths due to COPD in Slovenia according to Debeljak (2003)

Source: Debeljak (2003)

#### 3.4.2. Asthma

### **Prevalence**

Epidemiological data on asthma among children and adult population in Slovenia are limited. Prevalence among children was estimated in the **local epidemiological survey** conducted among children aged 6-7 years in 32 schools of 17 cities in Slovenia in 2002 **by Kopriva et al**. Children with the help of their parents were asked to fill out a study questionnaire. Based on the answers, asthma was confirmed in 232 (17.4%) out of 1,335 children. 3.5% of children with confirmed asthma experienced their asthma symptoms more than 2 years prior to the survey, whereas the remaining 13.9% reported having asthma symptoms within the last two years and at the time of the survey. These findings put Slovenia among the countries with the highest prevalence of asthma in children in Europe. According to ISAAC survey conducted in 1999-2004, see chapter 3.2.2, asthma prevalence among children aged 6-7 years varied from 5% in Albania to 20% in United Kingdom.

WHO World Health Survey, conducted in 2002-2004 in adult population of 18-45 years, reported 8.7% of asthma prevalence in Slovenia according to doctor diagnosed and clinical asthma (lifetime prevalence), and 11.9% of wheezing symptoms (12-month prevalence). For more details, please refer to chapter 3.2.2. Much higher rate of asthma occurrence was determined by Šuškovič et al. (2011) in epidemiological study on prevalence of asthma in adults in Slovenia. The prevalence was evaluated using the combination of population- and recruitment-specific approaches. Population-specific arm was conducted via telephone interviews with randomly selected persons all over the country. Recruitment-specific arm was conducted in 7 bigger cities in Slovenia and included recruitment epidemiological

questionnaire, health questionnaire and medical check-up for diagnosis confirmation. The same epidemiological questionnaire was used in both arms of the study. Prevalence of asthma in persons aged 18-65 was estimated to be 16% that is comparable with prevalence in Denmark, Netherland and Great Britain – countries with the highest asthma prevalence in Europe.

Much lower prevalence of asthma in adults was reported by **CINDI** and **EHIS** surveys. According to CINDI, Health Monitor 2001-2004-2008, conducted and published by the National Institute of Public Health in 2012, asthma prevalence in adults has remained stable and was 4.0% for men and 3.4% for women in 2008. Split of patients by gender and age is presented in Figure 19 and Figure 20 below.



Figure 19: Self-reported asthma prevalence in the Slovenian population of 25-64 years old by gender, CINDI, Health Monitor 2001-2004-2008

Source: National Institute of Public Health Slovenia (2012), illustrated by VI vis (2017)



## Figure 20: Self-reported asthma prevalence in the Slovenian population of 25-64 years old by age groups, CINDI, Health Monitor 2001-2004-2008

Source: National Institute of Public Health Slovenia (2012), illustrated by VI vis (2017)

As mentioned in section 3.2.2, prevalence of asthma was also determined in the Slovenian Chapter of EHIS 2014 survey in adults above 15 years old. Detailed results by gender and age groups were obtained from the National Institute of Public Health and are presented in Figure 21. Overall self-reported prevalence of asthma among men is 4.6%, whereas women reported prevalence of 5.4%. Only 6 men aged 90 and above took part in the survey, none of them reported to have asthma, therefore the estimated prevalence for that age group is 0. Prevalence in children was not evaluated in EHIS. Therefore for the age groups from 0 to 14 we assumed the prevalence to be around 7%. This is twice as low as 13.9% that was evaluated in the epidemiological survey by Kopriva et al. (2002). We reduced the estimation by Kopriva et al. as it seemed to be unreasonably high compared to the prevalence reported in the groups aged 15-19 and 20-24, 5.87% and 4.39% respectively. Furthermore, the data from University Clinic Golnik (the main centre for pulmonary and allergic disease in Slovenia) revealed that in 50% of children, who had been referred to the Centre for the verification of asthma diagnosis, asthma was not confirmed. Combining estimations of prevalence in children aged 0-14 and data from Slovenian Chapter of EHIS 2014 gives us slightly higher prevalence rates in total population of 4.8% for men and 5.6% for women. The obtained prevalence is higher in children, then drops by approximately half around the age of 20 and starts increasing again from 40 years on which corresponds well with the trends from other studies and reflects the opinion of leading medical experts in Slovenia. Based on EHIS 2014, the estimated number of people with asthma in Slovenia maybe around 107,000 (49,000 men and 58,000 women).



Figure 21: Prevalence of asthma by gender and age, Slovenian Chapter of EHIS 2014

Note: Prevalence in the age groups from 0 to 14 is estimated based on data from Kopriva et al. (2002) and unpublished data from the University Clinic Golnik, the main centre for pulmonary and allergic disease in Slovenia.

Source: National Institute of Public Health Slovenia (2016), illustrated by VI vis (2017)



Figure 22: Number of patients with asthma by gender and age, Slovenian Chapter of EHIS 2014

Note: Prevalence in the age groups from 0 to 14 is estimated based on data from Kopriva et al (2002) and unpublished data from the University Clinic Golnik, the main centre for pulmonary and allergic disease in Slovenia.

Source: National Institute of Public Health Slovenia (2016), illustrated by VI vis (2017)

### **Mortality**

Out of all 18,886 deaths in Slovenia in 2014, 13 or 0.07% were due to asthma according to the data from National Institute of Public Health.<sup>8</sup> 12 deaths were in women and only 1 in men. In order to check if the year 2014 was an outlier, we obtained the death records due to asthma in men in the longer period of 2012-2015. The number of deaths among men was 9, 7 and 7 in years 2012, 2013 and 2015 respectively. It was therefore decided to use the mortality data for men from 2015. The distribution of deaths by age and gender is presented in Figure 23.



Figure 23: Number of deaths due to asthma in Slovenia by gender and age in 2014

Note: Number of deaths for men is from 2015, as the data from 2014 seems to be an outlier (only 1 death was reported).

Source: National Institute of Public Health Slovenia (2016), illustrated by VI vis (2017)

<sup>&</sup>lt;sup>8</sup> Data on mortality due to asthma and COPD were obtained upon request from NIJZ, data are available on file at the Study Sponsor.

### 4. Cost categories

In cost-of-illness literature, it is common to categorise costs as direct (medical and nonmedical) costs and indirect costs. This categorisation represents a societal perspective and dates back to one of the first systematic cost-of-illness studies by Rice (1966). An additional category, which is however difficult to operationalise, are intangible costs. Table 5 gives an overview of the cost factors in each category that were incorporated in this study.

**Direct costs** measure resource consumption arising in the healthcare sector as well as other sectors in the case of illness, irrespective of who bears these costs. They can be further divided into direct medical costs and direct non-medical costs.

In general, **direct medical costs** include medical treatment, rehabilitation, as well as prevention measures aimed at avoiding future illness. In our study, direct medical costs are categorised according to the System of Health Accounts (SHA, see section 7.2.2 for further information). The individual cost factors considered in our analysis are hospitals, inpatient rehabilitative care, medical practices, patient transportation, prescribed medicines and therapeutic appliances. Costs of prevention measures are not included in our analysis, as no such data specific to CRD are available.

**Direct non-medical costs** are costs directly arising in case of illness, but outside of the healthcare sector. In our analysis, direct non-medical costs comprise care allowances for persons requiring long-term care, sickness benefits<sup>9</sup>, invalidity pensions and old-age as well as widows'/widowers' pensions. Other examples of direct non-medical costs associated with CRD would be dietary costs, costs for home adaptations as well as unemployment benefits and similar social benefits<sup>10</sup>. However, due to limited data availability, these cost factors are not included in our analysis. Further non-medical costs comprise administration costs of the public health institutions. These costs are overhead costs and usually are not included in burden-of-disease studies. Some diseases are caused by unhealthy behaviours such as smoking which causes additional direct non-medical costs such as fire damage, prevention, law enforcement and tobacco control costs. Although smoking and CRD are strongly intertwined, we will not consider these costs because this study investigates the burden of CRD and not of smoking.

**Indirect costs** are a measure for potential productivity lost due to a disease. This includes costs arising both when a person is not able to work at all and when a person is less

<sup>&</sup>lt;sup>9</sup> In Austria, the first six weeks of continued remuneration in case of sickness have to be covered by the employer. After this period, insurees receive sickness benefits from their health insurance.

<sup>&</sup>lt;sup>10</sup> It can be assumed that after long-term sick leaves, a certain share of employed persons suffering from CRD become unemployed and therefore receive social benefits. In principal, such cases could be identified from adminstrative data in Austria. However, social health insurance institutions refused consent to provide the corresponding data.

productive than a healthy person during work time. The rationale behind considering indirect costs is that society loses income that would have been generated if the regarded person did not suffer from CRD. Indirect costs are difficult to measure and there is no consensus regarding which methodological approaches to use when determining such costs (see section 6.3.3). In our analysis, sick leaves and lost productivity due to invalidity or premature death are considered. Due to lack of data, impaired productivity during work time and care leave<sup>11</sup> taken to care for a relative with CRD could not be included in our analysis. Furthermore, since total wage costs<sup>12</sup> are used as a measure for productivity, activities that create added value but are unpaid cannot be considered in our analysis.

**Intangible costs** are psychosocial costs arising from lower quality of life associated with a disease. They can arise both for the affected individual him- or herself – in the form of pain and physical and/or mental impairment –, but also for relatives. By definition, intangible costs are difficult to quantify, and the value to be assigned to psychosocial wellbeing is a highly controversial issue. Hence, intangible costs are not included in our analysis.

Direct	t costs	Indirect costs	Intensible costs
Direct medical costs	Direct non-medical costs	indirect costs	
<ul> <li>Hospitals (inpatient curative care, day curative and rehabilitative care, outpatient curative care)</li> <li>Inpatient rehabilitative care</li> <li>Medical practices (general, specialised)</li> <li>Patient transportation</li> <li>Prescribed medicines</li> <li>Therapeutic appliances</li> <li>[Prevention]</li> </ul>	<ul> <li>Care allowances</li> <li>Sickness benefits</li> <li>Invalidity pensions</li> <li>Old-age and widows'/widowers' pensions</li> <li>[Dietary costs, home adaptations etc.]</li> <li>[Unemployment benefits etc.]</li> <li>[Administration costs of public institutions]</li> </ul>	<ul> <li>Sick leaves</li> <li>Invalidity</li> <li>Premature death</li> <li>[Impaired productivity during work time]</li> <li>[Care leave]</li> </ul>	<ul> <li>[Pain]</li> <li>[Physical and mental impairment]</li> <li>[Grief, concern for relatives]</li> </ul>

Table 5: Cost categories used in the cost-of-illness study

Notes: Cost factors in brackets are not included in the analysis.

Source: IHS (2018)

<sup>&</sup>lt;sup>11</sup> We thank the scientific advisory board for calling to our attention that the costs of care leave should be included in the cost-of-illness analysis. However, no data on care leave are collected in Austria. After reviewing international literature in this context, we concluded that no reliable estimations for Austria can be made based on this literature. <sup>12</sup> Total wage costs correspond to gross wage costs plus incidental wage costs.

# 5. International evidence on the economic burden of chronic respiratory diseases

To our knowledge, no previous cost-of-illness studies on CRD have been carried out so far in Austria or Slovenia. Therefore, in the following section, we provide a short overview of existing evidence in this regard from other European countries.

In section 3.1, we argued that epidemiological data on CRD should be compared and interpreted with caution due to substantial differences in methodology regarding data sources, definitions, prevalence measures and observed populations. This holds to an even greater extent for studies on the economic burden of CRD, as methodologies in the calculation of costs leave additional room for variation. Important sources of variation in this context include data sources with respect to types and categorisation of costs (e.g. medical costs: SHA vs. other categorisations), methodological approaches (e.g. indirect costs: human capital approach vs. friction cost approach), the time horizon considered (life-cycle costs vs. one-period costs), the cost measure used (i.e. per capita vs. total costs), and finally the selected population (patient cohorts vs. total population). For example, a large share of cost-of-illness studies report costs per patient derived from observational patient studies. In contrast, studies working with macro data provide the total costs and costs per capita. In order to calculate costs per patient, one has to refer to published prevalence rates for the particular disease. If the reported prevalence rates are subjected to large confidence intervals, the calculated costs per patient are unreliable, too.

This study works with macro data. The net costs are given per capita and per patient (see Table 22, p. 90, and Table 23, p. 95). Due to the lack of reliable prevalence data in Austria and Slovenia, the calculated costs per patient should be considered with caution. Thus, the comparability with the results of observational studies is limited.

Ehteshami-Afshar et al. (2016) recently published a narrative review of international cost studies on asthma and COPD. The range of costs presented in their review illustrates the limited comparability of different cost studies: annual direct costs of asthma per patient, for example, range from USD 140 to USD 3,210, those for COPD from USD 500 to USD 6,210. The review includes studies from several high-income and middle-income countries worldwide, using a variety of data sources and methodological approaches. Ehteshami-Afshar et al. categorise the included studies by region, type of costs, data sources and target population, but explaining the large differences in results would require an even more detailed analysis of the methods used in the various studies.

Such a comprehensive analysis would go beyond the scope of this study. Thus, in the following, we will present results of only a small selection of cost-of-illness studies from European countries.

### 5.1. COPD

**Van Boven et al. (2013)** conducted cross-sectional analysis of costs related to COPD in the working age population (age 45-64) in the Netherlands. The study reports direct medical costs, costs due to early retirement and costs due to impaired productivity for the year 2009.

Direct medical costs were obtained from a previously performed Dutch cost-of-illness study and include costs for primary care, specialist visits, emergency room visits, hospitalisations, nursing, oxygen therapy, lung transplantations, influenza vaccinations and medication. Costs due to early retirement were estimated from national statistics using a patient flow diagram that compared the probability of persons aged 45-64 years with COPD to retire or die to that of persons of the same age who do not suffer from COPD. Costs for the patient were then calculated using age- and sex-specific net annual earnings (set to 70% of average national annual earnings as COPD patients were assumed to have below-average socio-economic status). Costs for the government comprised tax revenue lost and disability benefits paid, which were also based on the patient flow diagram. Costs due to impaired productivity were estimated based on UK data from the international "COPD Uncovered" survey.

Results from the study by Van Boven et al. (2013) are presented in Table 6. The study reports total societal costs, which we additionally relate to reference values: current health expenditure (obtained from OECD Health Statistics 2016) and GDP (obtained from Eurostat). Direct medical costs of COPD amounted to 0.14% of Dutch current health expenditure in 2009, while costs due to early retirement and costs due to impaired productivity amounted to 0.08% and 0.01% of GDP, respectively.

	Total costs			
Cost factor	In million EUR	In % of current health expenditure 2009	In % of GDP 2009	
Direct medical costs	90.9	0.14%	-	
Costs due to early retirement	480.2	-	0.08%	
Costs due to impaired productivity	63.1	-	0.01%	

Table 6: Annual costs of COPD in the Netherlands according to van Boven et al.(2013), population aged 45-64, 2009

Source: Van Boven et al. (2013), OECD Health Statistics 2016, Eurostat

Another cost-of-illness study on COPD was conducted by **Nowak et al. (2004)** for Germany. The study reports individual costs per patient, based on the analysis of resource consumption of 321 randomly selected COPD patients aged 40 years or older with varying disease severity grades. Data were collected in in face-to-face interviews with the selected patients' physicians based on patient records. Costs were then weighted with frequencies of

severity grades from a larger sample to determine average costs per COPD patient. The cost factors taken into account mostly comprise medical costs, but also include invalidity and early retirement.

The results are presented in Table 7. The sum of the included cost factors amounts to EUR 2,364 for mild COPD cases, EUR 3,332 for moderate cases and EUR 3,027 for severe cases. On average, annual costs per COPD patient are EUR 3,027. The largest cost factors are hospitalisations (EIR 780 on average), pharmaceuticals (EUR 689), early retirement (EUR 515) and invalidity (EUR 362).

Cost fastor	Costs per pa	Average costs			
	Mild	Moderate	Severe	EUR	
Hospitalisations	541	934	1,953	780	
Pharmaceuticals	618	796	903	689	
Physician consultations	190	256	332	221	
Oxygen therapy	41	226	350	117	
Therapeutic appliances	19	163	89	60	
Rehabilitation	36	19	163	45	
Long-term care	20	151	1,377	191	
Invalidity	418	227	309	362	
Transportation	6	20	69	16	
Smoking cessation (pharmaceutical)	14	17	26	16	
Smoking cessation (non- pharmaceutical)	11	0	1	7	
Other therapies	5	8	44	10	
Emergency room	0.2	0.1	0.7	0.3	
Early retirement	445	516	968	515	
Total	2,364	3,332	6,585	3,027	

Table 7: Annual costs of COPD per patient by disease severity in Germany according to Nowak et al. (2004), population aged ≥40 years, 2001

Notes: <sup>1</sup>Disease severity according to American Thoracic Society Source: Nowak et al. (2004), translated from German

A more recent study for Germany was conducted by **Wacker et al. (2016)**. Data of a sample of COPD patients aged 40 years or older in GOLD stages I-IV were compared to those of a sample of lung-healthy control subjects. Using multiple generalised linear models, the authors investigated healthcare utilisation, work absence and resulting costs while controlling

for patient characteristics. The study reports adjusted excess costs of COPD, which range from EUR 2,595 to EUR 8,924 for direct costs (depending on GOLD stage) and from EUR 8,621 to EUR 27,658 for indirect costs.

Further cost-of-illness studies for COPD from European countries include Dal Negro et al. (2008, Italy), Foo et al., (2016, several European countries), Jansson et al. (2002, Sweden) and Jensen et al. (2013, Denmark).

### 5.2. Asthma

A recent study by **Mukherjee et al. (2016)** investigates epidemiology and public sector costs of asthma in the UK for the financial year 2011-2012. Costs were estimated using an economic model. Medical costs were estimated based on NHS data on healthcare utilisation. For those utilisation data that did not include a direct measure of costs, the authors applied standard UK price weights to estimate costs for the respective form of healthcare. Costs were based on a sample in each of the four UK nations and were extrapolated to population levels by rescaling per head of age-sex stratified population. Furthermore, the study includes costs of disability living allowance attributable to asthma, which were obtained from national statistics. Indirect costs are not included in the study.

Results of the study by Mukherjee et al. (2016) are presented in Table 8. The study reports total costs in GBP, so we converted the numbers in EUR and relate them to current health expenditure and GDP (both obtained from OECD Health Statistics 2016) as reference values. Total medical costs of asthma amounted to EUR 1.2 billion or 0.68% of total current health expenditure, more than two thirds of which are attributable to pharmaceutical prescriptions. Disability living allowance accounts for another EUR 182.1 million, yielding a total of EUR 1.38 billion of public sector costs. This corresponds to 0.07% of GDP in 2012.

Another cost-of-illness study on asthma was conducted by **Stock et al. (2005)** for Germany. The study covers both direct costs and indirect costs for the year 1999. Costs for hospital care, medication and sickness benefits are based on claims data from all insured persons of six large German sickness funds. Asthma patients were identified using the corresponding ICD-9 and ATC codes. Cost data were stratified according to age- and sex-specific national statistics in order to extrapolate to the national level. Physician outpatient care is not included in the study as German sickness funds do not have access to the corresponding data. Costs for rehabilitation, premature death and early retirement were estimated by means of a human capital approach from national statistics.

Cost factor	Total costs		
	In million EUR <sup>1</sup>	In % of current health expenditure 2012	In % of GDP 2012
GP consultations	133.8	0.08%	
Practice nurse consultations	64.0	0.04%	
Community prescribing	826.0	0.47%	
Calls to out-of-hours	1.9	0.00%	
Ambulance trips	41.1	0.02%	
Accident and emergency	16.2	0.01%	
Hospital episodes (excl. intensive care units (ICU))	106.2	0.06%	
ICU episodes	6.5	0.00%	
Total NHS costs	1,195.9	0.68%	
Disability living allowance	182.1		0.01%
Total public sector costs	1,378.0		0.07%

### Table 8: Annual costs of asthma in the UK according to Mukherjee et al. (2016), financial year 2011-2012

Notes: 1Numbers based on monthly average exchange rate June 2012 (EUR/GBP=1.24) Source: Mukherjee et al. (2016), OECD Health Statistics 2016

Cost factor	Total costs		
	In million EUR	In % of current health expenditure 1999	In % of GDP 1999
Hospital treatment	48.2	0.02%	
Rehabilitation (inpatient)	62.5	0.03%	
Drug prescription	579.7	0.29%	
Total direct costs	690.4	0.34%	
Sickness benefits	1,194.8		0.06%
Productivity loss due to early retirement	610.2		0.03%
Productivity loss due to premature death	244.5		0.01%
Total indirect costs	2,049.5		0.10%

Source: Stock et al. (2005), OECD Health Statistics 2016, Eurostat

Results of the study by Stock et al. (2005) are presented in Table 9. Once again, we related the cost estimates to current health expenditure or GDP for reference. Total direct costs

(excl. physician outpatient care) amounted to EUR 690 million or 0.34% of total current health expenditure in 1999. These costs are almost entirely attributable to prescribed pharmaceuticals. Total indirect costs made up 0.1 % of GDP, at EUR 2.0 billion, more than half of which was attributable to sickness benefits.

Another example of a cost-of-illness study on asthma from a European country would be the report by Hoogendoorn et al. (2004), covering both COPD and asthma.

The following chapter explains the applied methods for estimating the burden of CRD in Austria and Slovenia.

### 6. Method

### 6.1. Introduction

The usual approach for evaluating the social costs of a specific disease is to isolate and figure out the medical and non-medical effects (s. chapter 4, p.34). The so-called burden-of-disease (BoD) or cost-of-illness (CoI) studies usually are one-periodic. This means that the costs of a designated disease are evaluated at a certain point or period in time. The implicit assumption behind these studies is the counter-factual of the hypothetical eradication of the disease under investigation without competing health risks "filling" up the morbidity gap. Such BoD studies usually capture the morbidity gains but do not take into account the mortality effects. Since diseases are generally the source of limiting quality and quantity of humans' life, one-periodic BoD studies neglect the effects of improved mortality which hypothetically translate into a prolonged life span. As a consequence, one-periodic BoD studies tend to overestimate the social costs of a specific disease.

In order to account for the improved longevity, so-called **life-cycle models** are applied in the health economics' literature. Life-cycle models hypothetically follow the age cohorts over their life-cycle and measure their net costs in each stage. Curing one specific disease decreases its demand for health care resources, but simultaneously increases health care expenditures of other diseases as a result of living longer (assuming that competing health risks do not fully compensate for the longevity gains). Generally, the medical costs of morbidity and mortality are counter-running. Whether the overall effect will turn out to take on a positive value depends on the relative dominance of morbidity gains, and vice versa. In contrast, improvements of the longevity of the labour force never curtail its productivity gains. Within the framework of the human capital method (which assumes full employment) we always see productivity increments. The friction cost approach evaluates longevity to a smaller extent but still positive.

In the following, the methodology of the life-cycle model is outlined. For a more detailed explanation of the methodology, see the previous study (written in German) on the economic burden of smoking by Pock et al. (2008).

### 6.2. The life-cycle model

When selecting a model for the evaluation of health policy measures, as for CRD, the question occurs to which reference values and in which dimensions the measure should operate. The reference values are given by the cost-benefit analysis: healthcare expenditures per capita, care and sickness allowances per capita, invalidity pensions, early

retirement, etc. of the reference population. Due to the availability of data we selected 2014 as base year.

### Model conception

When evaluating the economic burden of a given disease mathematically, different approaches to determining the effects of a change in morbidity and mortality can be chosen: effects can be determined for a particular calendar year (one-period model), or alternatively over the entire life cycle of the individual age cohorts of a population (life-cycle model). In the latter case, each age cohort of the current population is followed while hypothetically ageing at current mortality rates. This corresponds to a longitudinal analysis of cross-sectional data. The life-cycle model is preferably used in demographic and economic literature, as it is better suited to model the accumulation and latency of health policy effects than the one-period BoD studies. The one-period model, however, is easier to implement and thus more commonly applied. In addition, the single-period results, which are usually reported in annual terms, can be related to annual base values such as GDP or public health expenditures. For the sake of comparability with evidence from existing BoD literature, we therefore report the results of the one-period model in addition to the annualised present values of the cost categories calculated by the life-cycle model.

In our ceteris paribus scenario we compare the status quo concerning CRD prevalence of the population in 2014 with a **hypothetical population** exhibiting the same demographic structure but **in which no individual ever suffered from CRD**. In our variant of the life-cycle framework the Austrian and Slovenian populations of 2014 continue to live with the life expectancy of 2014, without any new birth cohorts to follow. In contrast to simulated population models, we do not estimate or implement future demographic, fertility or migration trends. Our variant of the life-cycle model actually takes a middle position between single-period analysis and full population models.

During his/her life, an individual experiences different health conditions influencing his/her earning capacity. Statistically speaking, there occurs a flow into and out of temporary incapacity to work (sick leaves) as well as there are transitions into permanent inactivity (e.g. invalidity, retirement). The described population dynamics are independent of the observed time period and open up another dimension for the reference values. As an example we look at invalidity pensions: In case the age-specific **stock** of this reference value is used, the model will calculate the realized effects of all permanent transitions into invalidity of **former generations**. In contrast, the **flow concept** calculates the effects of the flows into invalidity for each age cohort, and by summing-up one ends up with a future hypothetical stock of invalidity pensioners of the **current population** under consideration.

The relationship between stock and flow of a specific reference value is illustrated by the following simple equation. By ignoring migration, the current stock  $v_t$  is given by sum of new entries  $n_t$  in the current period *t* and the surviving stock of the previous period:

$$v_t = n_t + v_{t-1}S(t+1,t)$$

with the probability of surviving S(t+1,t) the period [t,t+1), (see further below). After recursively plugging in, the current stock  $v_t$  can solely be expressed in terms of a series of the past new entries entering the current period *t*:

$$v_t = \sum_{i=0}^t n_t S(t+1,i)$$

Thus, the current stock of a specific reference value such as invalidity pensioners is the result of past new entries, whereas summing up a series of future new entries generated out of today's population returns the stock at some future point in time.

Table 10 shows four different calculation models based on time horizon and type of reference value, explained on the basis of invalidity pensions. In the **one-period** model all payments of the Austrian public purse to invalidity pension recipients are summed up over all age cohorts and over one period, naturally the calendar year. In the **life-cycle** model each age cohort is simulated until the end of its life *T* by applying their age-specific mortality rates and summing-up over time and age cohorts. The present value of future public payments of invalidity pension to the current population can be calculated by discounting the costs of each age cohort over their time horizon. This present value is a measure of future costs of a specific cost category of a given population. These costs are hypothetical because not yet realised and partial because no other population factors than mortality are considered (birth rates, immigration, etc.).

The second dimension in Table 10 is determined by the difference between stock and flow of the reference variable. In epidemiological terminology the stock can be interpreted as **prevalence** and the flow or new entry as **incidence** of a disease or health condition. As mentioned, the **prevalence** model uses the age-specific invalidity pension payments of all current pensioners. In contrast, the **incidence** model takes into consideration only the new entries into invalidity. In the frame-work of the life-cycle model this is a reasonable approach because this setting generates its own prevalence during the life-cycle of the age cohorts, as shown above. Using prevalence data within the life-cycle model would carry on the effects of the past new entries into the future. This is not compatible with our ceteris paribus calculation within the frame-work of the life cycle model which constructs a counter-factual population starting in the present. This methodical approach will be clear if we think of a current reference population which solely consists of the single cohort at 0. The individuals of this reference population start their hypothetical life at birth and life till reaching the given terminal age cohort in the model.

	one-period	life-cycle
prevalence	$\sum_{a=0}^{T} pens(a)iz(a)S(a,a)$	$\sum_{a=0}^{T} pens(a) \sum_{t=a}^{T} \beta^{-(t-a)} iz(t) S(t,a)$
incidence	$\sum_{a=0}^{T} new(a)iz(a)S(a,a)$	$\sum_{a=0}^{T} new(a) \sum_{t=a}^{T} \beta^{-(t-a)} iz(t) S(t,a)$

## Table 10: Four costs models split by time horizon and type of reference value,explained on the basis of invalidity pensions

Legend: *pens(a)...*number of people (=stock) in invalidity pension at the age *a*  new(a)...number of flows into invalidity pension at age *a*  iz(a)...average invalidity pension payment per recipient at age *a*  S(t,a)...survival probability for period *t-a*  $\beta=(1+r)...$ discount factor; *r* ... interest rate (or similar); *T*... terminal age group

Source: IHS (2018)

Generally, the life-cycle model is preferable when health effects of a specific political health intervention differ across age periods. In the following cost-benefit analysis we apply both, the **life-cycle incidence model** as well as the **one-period incidence model**. As mentioned before, the life-cycle incidence model generates prevalences at future points in time. By annualising, the results of this approach are comparable with the results of the common one-period models using current prevalences.

The one-period incidence model, however, methodically differs from common BoD studies which can be categorized as one-period prevalence models. Prevalence and incidence models give identical results whenever a particular health status and hence their costs are temporary (sick leave allowances and sick leaves of the category indirect costs). However, their results differ if the health status entered is of permanent nature Thus, the reader should be aware that the results of our one-period incidence model for the cost categories care allowances, invalidity pensions, and old-age-/widower pensions, and indirect costs are not comparable with common BoD studies which usually apply one-period prevalence models.

The medical costs are a special case because they result from a mixture of temporary and permanent health states such that a pure incidence model cannot be implemented anyway. Instead, we use the common model with per capita medical costs (which can be called a *population mean model*) as explained in the following.

### Model simplifications

The cost variables of cost-benefit analysis in the field of health economics are direct medical costs (primary health care, hospitals, rehabilitation, etc.), direct non-medical costs (invalidity pensions, sick leave allowances, old-age pension, etc.), indirect costs (productivity losses) and intangible costs (s. chapter 4, p.34). When implementing the life-cycle incidence model

the researcher has to ensure that no cost variable entails prevalence values whenever the difference to incidence values matters.

The differentiation between prevalence and incidence variables is relevant in those cases where the cost measure is caused by a permanent subpopulation, e.g. **invalidity pensioners**. The health status "invalidity" acts here as a kind of absorbing state<sup>13</sup> in the sense of an Absorbing Markov Chain. Once the invalidity status is entered, the probability of leaving is de facto very small and set to zero in the model. Only those individuals of a specific age cohort entering invalidity receive invalidity pension as long as they are entitled to. In Austria, this is usually till end of life.

Now, if we would like to evaluate the cost effects of hypothetically eradicating CRD, we cannot simply apply the difference in mortality rates (between status quo and policy measure leading to eradication of CRD) to the observed prevalence of invalidity pensioners, because this prevalence is already a status quo outcome of the past flows of CRD patients into invalidity (as explained above). Instead, the counter factual invalidity prevalence has to be calculated out of the model using decreased transition probabilities into invalidity. This rationale justifies the application of the life-cycle incidence model in cost-benefit analysis.

The following formula translates this rationale of the life-cycle incidence model using the example of invalidity pensions. At some point in time *t* the share  $n(a) \cdot IQ(t)$  of the age group *a*, with  $t \ge a$ , becomes invalidity pensioners and receives from that time on invalidity pension till end of life. In each period these invalidity pensioners are subject to the age-specific survival probability. The present value of the status quo of a particular age group *a* is given by:

$$PV(a) = n(a) \sum_{t=a}^{T} \beta^{-(t-a)} S(t,a) iq(t) \sum_{i=t}^{T} \beta^{-(i-t)} iz(i) S(i+1,t) =$$
$$= n(a) \sum_{t=a}^{T} \sum_{i=t}^{T} \beta^{-(i-a)} iq(t) iz(i) S(i+1,a)$$

with the status quo survival probability function S(i+1,a) living from the beginning of age a until beginning of age i+1, number of individuals n(a) of age group a, terminal age group T, discounting rate  $\beta$ , average invalidity pension iz(a), status quo rate of new invalidity pensioners iq(a), and with the definition  $S(a,a) \equiv I$  (see below).

In the case of **direct medical** costs the differentiation between prevalence and incidence models is not straight forward. Looking at one specific disease in the one-period model, the prevalence and incidence approaches coincide if the disease is of temporary nature (e.g. flu) and differ if the disease is chronic (e.g. COPD). However, this does not hold when switching to the life-cycle model including mortality effects, because by implementing the counterfactual the model has to take the differences between status quo and counterfactual

<sup>&</sup>lt;sup>13</sup> An absorbing state is a state that, once entered, cannot be left.

population mean of medical costs (otherwise the mortality effects cannot be modelled<sup>14</sup>). The medical costs are generated by a mixture of temporary and permanent health states such that this model represents neither the incidence nor the prevalence approach but would be a hybrid of both. Therefore, we draw on the **population mean** for modelling medical costs (see chapter 6.3.1), which is commonly applied in burden of disease studies. This simplification is also owed to data restrictions because age- and gender-specific incidence and prevalence data of each disease are not available.

The life-cycle model entails two dimensions: age and time. A further simplification represents the pooling of all model inputs into 5-year age groups (except the newborns, the age group 1-4, and the terminal age group 90+) and time period duration of 5 years. For instance, the expected survival probability is calculated as 5x5 survival probabilities, meaning that all individuals assigned to a particular 5-year age group remain 5 years within this age group being subject to one single 5x5 survival probability. The age-specific 5x5 survival probabilities are calculated as an approximation from the 5x1 mortality rates prevailing in the year 2014, applying life-table methods (see Preston et al., 2001).

Other variables which are necessary for the life-cycle analysis are converted into 5x5 tables as well. An example are the 5-year per capita hospital costs of the age group 20-24 which are by definition the average hospital costs of individuals aged 20 to 24 over a 5-year time period. As an approximation, we multiplied the average value of this age group in the year 2014 by a factor 5.

This procedure pursues two targets: It simplifies the data requirements and utilizes the cross-section information of the base year 2014 for the longitudinal dimension of the life-cycle model which is in line with a ceteris paribus analysis.

### Present value and annuities

In the life-cycle model, the cumulative monetary effects are reported by means of the present value, which usually takes on high monetary values. In order to transform the present value into an annual measure, annuities due are calculated for each age cohort and summed up. In similar fashion to the results of the one-period model, the sum of these annuities can be compared to annual reference values like GDP and health expenditure.

An **annuity due** *A* is defined as a series of constant *N* payments at the beginning of each period made at equal intervals (e.g. annually) over a specified time period whose present value *PV* equals a predefined value:  $PV = A \sum_{i=0}^{T-1} \beta^{-i}$ . In the case of our analysis, this

<sup>&</sup>lt;sup>14</sup> We cannot simply multiply the age-specific disease costs  $\Delta c$  under consideration by the mortality gains  $\Delta S$  because if some hypothetical policy measure improves merely morbidity but not mortality, such models would calculate zero cost effects. Thus, the correct approach is to model  $\Delta(cS) = \Delta cS + c\Delta S$ , requiring the population mean of the medical costs *c*.

predefined value is the present value of the cumulative monetary effects calculated in the life-cycle model. The reciprocal of the summation term in the above formula is referred to as the annuity factor *f* of an annuity due:  $f(N) = \left(\sum_{t=0}^{T-1} \beta^{-t}\right)^{-1}$ , depending on the final time period *N* and discounting rate  $\beta$ . In a different interpretation, the annuity factor f(N) can be used to transform a predefined present value into a series of constant annual payments AN (the annuities) over the period *N*:  $AN = PV \cdot f(N)$ .

For our model we choose age-cohort specific **annuity due factors** which are given by (e.g. Kruschwitz, 2000, tab. 2.20, p. 72):

$$f(a) = \left(\sum_{t=a}^{T-1} \beta^{-(t-a)}\right)^{-1} = \frac{(1-\beta)}{\beta} (\beta^{-(T-a)} - 1)^{-1}$$

with the remaining life-cycle *T*-*a* at the age *a* with the assumed terminal age of *T*= 95 years. The overall life-cycle of 95 years is given by the mortality table of Statistics Austria for 2014. In the course of the 5x5-year age-cohort analysis we simplify by concentrating the 5-year cohort members at the class midpoints. As a result, the maximal effective discount period is *T*= 92 years. With a remaining lifespan *T*-*a* of e.g. 92 or 30 years and a discount rate *r* of 3% (or equivalently a discounting factor  $\beta$  of 1.03%) the annuity due factor amounts to 32.07 or 20.19, respectively. With ascending discount rates and shorter calculation periods *T* the **anticipative annuity value factor** decreases and the corresponding annuity factor increases.

#### Survival function

The main input to each life-cycle model is the **survival probability function** S(t, a) with t > a, which is the expected probability to survive the period t - a (i.e. the left-closed, right-open interval [a,t) lasts from the beginning of age a just until the beginning of age t)<sup>15</sup>, conditional on surviving until the beginning of age a:  $S(a,i) \equiv 1, \forall a > i$ , with the past periods i. The survival probability of a single point in time is set to one by definition:  $S(a,a) \equiv 1$ . The survival probability from any age a until the end of the terminal age group T is naturally set to zero:  $S(T+1,a) \equiv 0$  due to 1 - q(T) = 0.

Future cash flows are weighted by the expected survival probability, which can be interpreted as a type of discounting. We operationalize the expected survival probability by the following discrete version with the expected mortality probability q(i) for the period [i,i+1) (for the sake of readability we drop in all formulae the index for gender):

$$S(t,a) = \prod_{i=a}^{t-1} (1-q(i)) S(t,a) = \prod_{i=a}^{t} (1-q(i))$$

<sup>&</sup>lt;sup>15</sup> We followed the actuarial science literature by using the syntax S(t,a) instead of the more natural syntax S(a,t).

The index *i* runs from *a* to *t*-1 (and not *t*) because the mortality probability q(i) defines a period whereas the parameters of the survival function *a* and *t* define single points in time. Thus, the survival probability for the single period [a,a+1) lasting from *a* to a+1 is given by: S(a+1,a)=1-q(a), and the survival function over many periods can be decomposed into: S(t,a)=S(t,a+1)S(a+1,a)=S(t,t-1)S(t-1,a), and so forth.

We calculated the age- and gender-specific 5x5 mortality probability q from the raw mortality rates in 2014 published by the federal statistical offices of Austria and Slovenia (see chap. 7.2.1, p. 63 for Austria and chap. 7.3.1, p. 75 for Slovenia) using common 5x5 life-table methods (e.g. Preston et al., 2001). Smoothing processes have not been applied. For the scenario calculation of a CRD-free society in comparison to the status quo society we had to construct the counter factual survival probability function  $S^N(t,a)$  of people who never suffered from CRD. This was simply done by subtracting the disease-specific raw mortality rates of the ICD-10 categories of CRD  $q^{CRD}$  from total raw death numbers q, assuming diminishing competing risks:

$$S_N(t,a) = \prod_{i=a}^{t-1} (1 - q_N(i))$$
 with  $q_N(a) = q(a) - q_{CRD}(a)$  and  $S_N(t,a) \ge S(t,a)$ 

Five-year cohorts (except of new-borns, 1-4 year olds and the terminal age group 90+) live through a hypothetical life in five-year intervals. Due to the 5x5 algorithm which underlies our life-cycle analysis, the number of persons of a five-year cohort a, which is theoretically at the class midpoint, has to be treated with the 5x5 survival probability of their period first. Those who survive generate costs like medical costs, invalidity pensions, etc. They move to the class midpoint of the next period and become subject to the survival probability of the next period and so forth.

### Model characteristics

This algorithm is applied to the status quo as well to counter factual society. Following the ceteris paribus approach, the base year of the input data is 2014. The cost effects of CRD are estimated by taking the difference between status quo and the counter factual setting. Due to the long time horizon of the life-cycle model, any data errors or model misspecifications will heavily influence the present values of the two model scenarios. These effects are non-linear. But by **differencing**, this procedure cancels out or at least moderates such errors.

Because the **counter factual survival probability** could never be smaller than the status quo survival probability, a higher number of individuals enter higher age cohorts. The partial cost effect is a surge in costs because more individuals cause more costs, ceteris paribus. On the other hand, the **morbidity** effect is counter running. As an example, the average direct medical costs per capita decrease if morbidity improves. Thus, one cannot predict in advance which effect will prevail.

Another factor influencing the outcome is the **discounting rate**. The effect accrues over the long time horizon of the model and makes the model outcomes sensitive to this model input factor. Age profiles of costs displaying a cost shift towards older ages are affected more by discounting, ceteris paribus. In the one-period model discounting naturally plays no role.

For comparison reasons with one-period BoD studies, we calculate age- and gender specific **annuities** out of the present values of the two scenarios (s. above). Whereas the present value of costs mathematically represents the discounted sum of future cost flows of a specific cohort, the annuity of the present value is an annual amount equally distributed over the time horizon, taking into account discounting. Figuratively speaking, the present value is distributed back into future cost flows of identical value in each time period, evaluated at present value. This operation moderates the higher discounting effect of elder age groups. Thus, there could be a counter-intuitive constellation where the effect measured as present value is positive and the annuity is negative. These results are caused by the high non-linearity of the model and input data.

The following chapters explain the method applied to each cost category examined in this BoD study (s. chapter 4, p.34, for further information on cost categories).

### 6.3. Methods specific to individual cost categories

### 6.3.1. Direct medical costs

As described in chapter 7.1, we used age- and gender-specific profiles of the individual medical cost categories wherever available. These cost categories comprise e.g. costs of hospitals, out-patient health care and prescribed medicines. The formulae given below present the life-cycle and one-period model, respectively, applied to the cost variables of the direct medical costs.

The **one-period model** usually applied in BoD studies ignores mortality effects. The only input variable affecting the costs is the decreased average per capita cost-profile caused by improved morbidity. Summing up over all age groups the **one-period incidence model** is given by (the gender index is dropped for readability reasons):

medical costs<sub>one-period</sub> = 
$$\sum_{a=0}^{T} n(a)c_{CRD}(t) = \sum_{a=0}^{T} n(a)(c(t) - c_N(t))$$

with the number of individuals n(a) of age group a, terminal age group T (age group 90+, midst 92 years), medical costs per capita of CRD  $c_{CRD}$ , status quo medical costs per capita c, counter-factual medical costs per capita  $c_N$ .

In contrast, the **life-cycle incidence model** implements the effects of improved morbidity and mortality. The life-cycle model captures the effects over the entire lifespan of the status quo population and generates the prevalence of a specific disease at some future point in time out of future new entries (incidences). The burden of CRD due to medical costs is the difference between the status quo and the counter factual scenario which assumes a CRDfree population. For a better comparability with annual measures and one-period BoD studies we transform the **present values** (PV) of the life-cycle model into the one-period measure **annuities** (AN):

medical costs PV = 
$$\sum_{a=0}^{T} n(a) \sum_{t=a}^{T} \beta^{-(t-a)} (c(t)S(t+1,a) - c_N(t)S_N(t+1,a))$$
  
medical costs AN =  $\sum_{a=0}^{T} f(a)n(a) \sum_{t=a}^{T} \beta^{-(t-a)} (c(t)S(t+1,a) - c_N(t)S_N(t+1,a))$ 

with the age-dependent annuity due factor  $f(a) = (1-\beta)(\beta(\beta^{-(T-a)}-1))^{-1})$ , discounting rate  $\beta = (1+r)$ , the interest rate *r* (main scenario 3%), status quo and counter factual survival probability function S(t+1,a) and  $S_N(t+1,a)$ , respectively (see equations above).

All variables are adjusted to the 5x5 perspective. This implies that each 5 years cohort remains 5 years in this age group and generates annual medical costs for 5 years, except age groups 0 and 1-4.

### 6.3.2. Direct non-medical costs

As listed in chapter 4, this category contains the government transfers invalidity pensions, sickness benefits, care allowances, and widow/widower pensions. The results of the one-period incidence method applied to this cost category differ from those of common BoD studies.

#### Invalidity pensions

Incapacity for work exists if the insured person is physically or mentally unable to pursue a regular activity as a result of illness or weakness. A pension entitlement arises only when the person cannot carry out regular work due to his/her state of health.

To compute the effects of CRD on invalidity pensions we use data on new entries into invalidity. For the one-period incidence model we compute:

invalidity costs<sub>one-period</sub> = 
$$\sum_{a=0}^{T} n(a)iz(a)(iq(a) - iq^{N}(a))$$

with the number of individuals n(a) of age group a, terminal age group T, average invalidity pension iz(a), and status quo and counter factual rate of new invalidity pensioners iq(a) and

 $iq_N(a)$ , respectively. The number of new entrants as a measure for incidence is captured in above formula by *new entrants*= $n \cdot iq$ .

The accrued costs of invalidity pensions in the framework of the life-cycle incidence model calculated as present value (PV) and annuity (AN) are given by:

invalidity costs PV = 
$$\sum_{a=0}^{T} n(a) \sum_{t=a}^{T} \sum_{i=t}^{T} \beta^{-(i-a)} iz(i) (iq(t)S(i+1,a) - iq^{N}(t)S^{N}(i+1,a))$$
  
invalidity costs AN =  $\sum_{a=0}^{T} f(a)n(a) \sum_{t=a}^{T} \sum_{i=t}^{T} \beta^{-(i-a)} iz(i) (iq(t)S(i+1,a) - iq^{N}(t)S^{N}(i+1,a))$ 

with the age-dependent annuity due factor  $f(a) = (1-\beta)(\beta(\beta^{-(T-a)}-1))^{-1})$ , discounting rate  $\beta = (l+r)$ , the interest rate *r* (main scenario 3%), status quo and counter factual survival probability function S(t+1,a) and  $S_N(t+1,a)$ , respectively.

In the counter factual scenario the monetary effects of the decrease of invalidity entrants is partly compensated by the lower mortality. But we additionally see an economic effect which is taken into account in the indirect costs calculations, because less invalidity entrants mean a larger working population.

### Care allowances

If an individual needs long-term nursing care, the public grants care allowances to the beneficiary. The calculation of the one-period and life-cycle model follows the same line as mentioned above. We use data on new entries into long-term care. For the one-period incidence model we compute:

care costs<sub>one-period</sub> = 
$$\sum_{a=0}^{T} n(a)cz(a) (cq(a) - cq^{N}(a))$$

with the number of individuals n(a) of age group a, terminal age group T, average care allowance cz(a), and status quo and counter factual rate of new care allowance beneficiaries cq(a) and  $cq_N(a)$ , respectively.

The accrued costs of care allowances calculated as present value (PV) and annuity (AN) are given by:

care costs PV = 
$$\sum_{a=0}^{T} n(a) \sum_{t=a}^{T} \sum_{i=t}^{T} \beta^{-(i-a)} cz(i) (cq(t)S(i+1,a) - cq^{N}(t)S^{N}(i+1,a))$$
  
care costs AN =  $\sum_{a=0}^{T} f(a)n(a) \sum_{t=a}^{T} \sum_{i=t}^{T} \beta^{-(i-a)} cz(i) (cq(t)S(i+1,a) - cq^{N}(t)S^{N}(i+1,a))$ 

with the age-dependent annuity due factor  $f(a) = (1-\beta)(\beta(\beta^{-(r-a)}-1))^{-1})$ , discounting rate  $\beta = (1+r)$ , the interest rate r (main scenario 3%), status quo and counter factual survival probability function S(t+1,a) and  $S_N(t+1,a)$ , respectively.

A disease classification of the Austrian and Slovenian data of care allowances is not available. For Austria, we indirectly calculated the share of care allowance beneficiaries caused by CRD applying the epidemiologic concept of **population attributable fraction** (**PAF**). The PAF quantifies the contribution of the risk factor under consideration to the total burden of disease. It combines the population prevalence rate of a risk factor with the excess risk of that risk factor in order to estimate the share of the disease cases observed in the population attributable to that risk factor.

Here, the risk factor is the disease CRD and the realised risk (i.e. burden of disease) are the care allowances. The excess risk of people suffering from CRD compared to people without CRD is measured by the **relative risk**  $RR_{CRD}$ . Thus, the age-specific PAF for CRD is given by:

$$PAF(a) = \frac{p_{CRD}(a)(RR_{CRD} - 1)}{p_{CRD}(a)(RR_{CRD} - 1) + 1}$$

with the population prevalence rate of CRD  $p_{CRD}$  and the relative risk of becoming a care allowance beneficiary of the exposed  $RR_{CRD}$ . Multiplying the total number of new entrants of care allowance beneficiaries by the PAF, we get an estimation for the number of entrants caused by CRD.

Prevalence rates of CRD are usually available but not the relative risks for CRD. Thus, we draw on the relative risk of smoking in Austria, as smoking is the major cause for COPD and other chronic obstructive respiratory diseases (see chapter 7.2.3).

Due to data restrictions, we refrained from estimating the cost effects of care allowances for Slovenia.

### Sick leave allowances

Sick leave allowances (sick leave benefits) serve as replacement for the loss of earnings during temporary incapacity for work caused by ailments. In Austria for instance, they are paid to the entitled person by the responsible health insurance carrier from the fourth day of sick leave onwards for the duration of a minimum of 26 weeks.<sup>16</sup>

<sup>&</sup>lt;sup>16</sup> The amount conforms individually to the assessment basis of the income. From the fourth day onwards one receives 50% and form the 43rd day onwards 60% up to a maximum of 75% of the assessment basis.

The calculation of the one-period and life-cycle model follows the same line as mentioned above. The one-period incidence model is given by:

sick leave costs<sub>one-period</sub> = 
$$\sum_{a=0}^{T} n(a)sz(a)(sq(a) - sq_N(a))$$

with the number of individuals n(a) of age group a, terminal age group T, average sick leave allowance sz(a), and status quo and counter factual rate of new sick leave allowance beneficiaries sq(a) and  $sq_N(a)$ , respectively.

The accrued costs of sick leave allowances calculated as present value (PV) and annuity (AN) are given by:

sick leave costs PV = 
$$\sum_{a=0}^{T} n(a) \sum_{t=a}^{T} \sum_{i=t}^{T} \beta^{-(i-a)} s_{z}(i) \left( sq(t)S(i+1,a) - sq^{N}(t)S^{N}(i+1,a) \right)$$
  
sick leave costs AN =  $\sum_{a=0}^{T} f(a)n(a) \sum_{t=a}^{T} \sum_{i=t}^{T} \beta^{-(i-a)} s_{z}(i) \left( sq(t)S(i+1,a) - sq^{N}(t)S^{N}(i+1,a) \right)$ 

with the age-dependent annuity due factor  $f(a) = (1-\beta)(\beta(\beta^{-(r-a)}-1))^{-1})$ , discounting rate  $\beta = (1+r)$ , the interest rate r (main scenario 3%), status quo and counter factual survival probability function S(t+1,a) and  $S_N(t+1,a)$ , respectively.

The aggregated Austrian data provided by HV covers cases of sick leaves separated by age, disease, and duration, but all three dimensions are not covered jointly. However, these data are available from the regional health insurance fund of Upper Austria (OÖGKK). This insurance and region specific dataset is used as an approximation for Austrian conditions and applied to the Austrian demographic structure and morbidity situation under the assumption of equal wage levels. For further details see chapter 7.2.3.

The Slovenian health insurance institute (ZZZS) pay sick leave allowances to employed people fallen sick longer than 35 calendar days. The data are given in sick leave days by gender, age and ICD (for details see chapter 7.3.3) and are multiplied by an average daily allowance of EUR 30.8 in order to derive the profiles of the sick leave allowances.

### Old-age and widow/widower pension

Old-age, widow/widower and orphan pensions are at first glance not affected by changes in health risk. Therefore, common BoD studies do not include pensions effects except invalidity pensions. But actually a higher longevity induces a longer period of drawing an old-age pension.

The inclusion of so-called **unrelated future costs** in cost-effectiveness analysis (CEA) has been broadly discussed in the health literature (e.g. Meltzer, 1997; Garber and Phelps, 1997;
Weinstein and Manning, 1997; Lee, 2008; van Baal et al., 2016). From a theoretical point of view, unrelated future cost should be included.

From a practical point of view, unrelated costs should not be taken into consideration because e.g. old-age pension effects dominate not only the non-medical but sometimes also the total costs. Within a life-cycle model these effects aggravate due to the high degree of non-linearity and elasticity of such models. And an ethic argument objects to negatively valuing an increase in longevity per se. On the other hand, these unrelated future costs are sometimes a big issue in public debates, e.g. smoking regulations. The opponents of restrictive smoking laws argue that the old-age pension effects of a prolonged life span exceed the direct health effects by far.

Taking all arguments together, we decided to include old-age and widow/widower pensions in our life-cycle incidence model. We excluded orphan pensions because the effects are negligible. The reason for including widow/widower pensions becomes clear if one interprets them as a continuation of old-age pension claims. In the special case of Austria these widow/widowers pension effects strongly reduce the "positive" old-age pension effects of premature death of smokers (for further details see the cost-benefit analysis of smoking in Austria in Pock et al., 2008).

As explained earlier, from a methodical point of view, the implementation of a prevalence model would be incorrect. The one-period incidence model calculates no effect because this model merely captures morbidity effects - the old-age pension effects however work through the mortality effects.

The life-cycle incidence model follows the same line as mentioned above. The accrued costs of old-age pensions calculated as present value (PV) and annuity (AN) is given by:

old-age pension costs PV = 
$$\sum_{a=0}^{T} n(a) \sum_{t=a}^{T} \sum_{i=t}^{T} \beta^{-(i-a)} az(i) (aq(t)S(i+1,a) - aq^{N}(t)S^{N}(i+1,a))$$
  
old-age pension costs AN =  $\sum_{a=0}^{T} f(a)n(a) \sum_{t=a}^{T} \sum_{i=t}^{T} \beta^{-(i-a)} az(i) (aq(t)S(i+1,a) - aq^{N}(t)S^{N}(i+1,a))$ 

with the age-dependent annuity due factor  $f(a) = (1 - \beta)(\beta(\beta^{-(T-a)} - 1))^{-1}$ , discounting rate  $\beta = (1+r)$ , the interest rate r (main scenario 3%), status quo and counter factual survival probability function S(t+1,a) and  $S_N(t+1,a)$ , respectively, number of individuals n(a) of age group a, terminal age group T, average old-age pension az(a), and status quo and counter factual rate of new old-age pension beneficiaries aq(a) and  $aq_N(a)$ , respectively.

According to this model a 5x5 age cohort "lives" through its life-cycle where in each period a share of the surviving persons enters the old-age pension system and from that time on draws old-age pension until the end of life.

The surviving dependants – here widow and widower – are entitled a widow or widower pension till their end of life. The amount depends on the country-specific pension system.<sup>17</sup> The following model captures this flow into widow/widower pensions over time.

Starting from a particular male cohort  $n_M(a)$  with age *a*: in the course of the cohort's life cycle, new widow pension entrants being in different ages *j* are induced in each period *i* with probability  $wq_F(j,i)$  whenever individuals of the cohort  $n_M(a)$  die. The age of the widow *j* differs from the age *i* of the deceased male. Once receiving widow pension this entitlement is valid till end of life of the widow (absorbing status). In case of an additional income, the amount of the widow pension can be reduced or even suspended. By using period-specific average widow pension  $wz_F$  this circumstance is implemented into the model. The present value of total widow pensions generated by a particular male cohort with age *a* is given by (the corresponding formula for widower pension is obtained by exchanging the subscripts *F* by *M* and vice versa):

$$widow PV_F(a) = n_M(a) \sum_{i=a}^T \beta^{-(i-a)} S_M(i,a) \left(1 - S_M(i+1,i)\right) \sum_{j=0}^T wq_F(j,i) \sum_{i=j}^T \beta^{-(i-j)} wz_F(i) S_F(i+1,j)$$

with the number of individuals of the male cohort  $n_M(a)$  at age *a*, discounting factor  $\beta$ , the probability of a widow at age *j* receiving widow pension  $wq_F(j,i)$  entitled by the death of her husband at age *i*, the average net widow pension wz(t) at age *t*, and the survival probability of a widow  $S_F(t+I,j)$  to survive from the age *j* to the age *t*.

The probability of receiving a widow pension  $wq_F(j,i)$  is approximated by the observed ratio of new widow pension entrants at age *j* and deceased males at age *i*, and is set equal in both scenarios. The expression  $S_M(i,a)(1 - S_M(i+1,i)) = S_M(i,a) - S_M(i+1,a)) = S_M(i,a)q(i)$  is the conditional probability q(i) for the individuals in the male cohort to die in the period between age *i* and *i*+1, conditional on surviving the time between age *a* and *i*.

The above formula simplifies to:

$$widow PV_F(a) = n_M(a) \sum_{i=a}^{T} \sum_{j=0}^{T} \sum_{t=j}^{T} \beta^{-(i-a+t-j)} w q_F(j,i) w z_F(t) (S_M(i,a) - S_M(i+1,a)) S_F(t+1,j)$$

Accordingly, the expenditures for widow pensions increase if the mortality (measured as survival probability) of women improves or the mortality of men deteriorates. Which of these effects dominates depends on the extent of the mortality reduction in each single age group for both genders.

In the next step we calculate the present value over all age cohorts, and take differences between the status quo and the counter factual scenario. Thereby both scenarios have the

<sup>&</sup>lt;sup>17</sup> In Austria the widow/widower receives up to 60% of the deceased spouse's income.

same observed age-dependent probability profile of entry into widow pension  $wq_F(j,i)$ . This guarantees that only pension effects regarding CRD are captured.

The total present value (PV) and the corresponding annuity (AN) of the effects of CRD are calculated by (the corresponding formula for the present value of the widower pension is obtained by replacing the subscripts F by M und vice versa):

widow pension costs 
$$PV = \sum_{a=0}^{T} n_{M}(a) \sum_{i=a}^{T} \sum_{j=0}^{T} \sum_{i=j}^{T} \beta^{-(i-a+t-j)} w q_{F}(j,i) w Z_{F}(t) \Big( SS_{MF}^{N}(i,a;t,j) - SS_{MF}(i,a;t,j) \Big)$$

widow pension costs AN =  $\sum_{a=0}^{T} f(a) n_M(a) \sum_{i=a}^{T} \sum_{j=0}^{T} \sum_{i=j}^{T} \beta^{-(i-a+t-j)} w q_F(j,i) w Z_F(t) \left( SS_{MF}^N(i,a;t,j) - SS_{MF}(i,a;t,j) \right)$ 

where

$$SS_{MF}(i,a;t,j) = \left[S_M(i,a) - S_M(i+1,a)\right]S_F(t+1,j)$$

$$SS_{MF}^{N}(i,a;t,j) = \left[S_{M}^{N}(i,a) - S_{M}^{N}(i+1,a)\right]S_{F}^{N}(t+1,j)$$

with the age-dependent annuity due factor  $f(a) = (1-\beta)(\beta(\beta^{-(T-a)}-1))^{-1})$ , discounting rate  $\beta$ , status quo and counter factual survival probability function  $S(\cdot, \cdot)$  and  $S^{N}(\cdot, \cdot)$ , respectively,

#### 6.3.3. Indirect costs

In this section an estimation of economic costs of CRD resulting from lower labour productivity will be conducted. This corresponds to the common approach of a health evaluation in the context of the human capital method. The value of working force for the production process of an economy is measured by the corresponding wage. According to economic theory, marginal costs of the worker (i.e. the individual wage) equal marginal productivity in the theoretical optimum. In reality, this general equilibrium of an economy is strongly levelled due to labour market structures.

Nevertheless, for our calculations we assume that the income of a representative individual corresponds to the monetary value of the working force.<sup>18</sup> The wage level in a particular year represents an approximation of the current economic output of the employed working force. Therefore, the average gross wages and incidental wage costs are considered. Health improvements due to a cure of CRD resulting in lower mortality, higher participation rates, less invalidity and fewer sick leaves are estimated on the basis of this reference value. While reduced sick leaves increase economic output by improving productivity, lower mortality rates and reduced invalidity increase economic output by increasing the factor input labour.

This model is based on the unrealistic assumption of full employment. This means, a prematurely deceased employee cannot be replaced and therefore represents a loss to the

<sup>&</sup>lt;sup>18</sup> As we aim for the manpower of an average employee, economic performance of unpaid work is not considered in the model. E.g. when a housewife prematurely deceases because of CRD the economy loses unpaid manpower. The calculated effects therefore are an underestimation.

economy. To bypass this assumption, a second approach exists in public health literature called friction cost approach. This approach tries to measure the actual instead of the potential work loss on the aggregated production. Economic costs result only from the work stoppage during the time it takes to recruit and train a new employee. Due to the unsatisfactory data situation, only few empirical studies follow the friction cost approach (e.g. Wegner et al., 2005). The methodical disadvantage of this approach is the implicit assumption of a constant labour demand. This might be true in the short term; however, when comparing public policy scenarios the long term perspective should be applied. In the long run labour demand increases when labour supply increases. In summary, these two approaches represent opposite border cases: perfectly inelastic versus perfectly elastic labour demand.

Before we turn towards the modelling in the next section, some remarks regarding the two different terms of economic productivity are important. The first one refers to the work efficiency measured by the output quantity per actually performed working hour. The other term measures total economic output in relation to total factor input, i.e. employment measured in full-time equivalents (FTE). If employees have fewer absences, economic productivity increases due to an output increase while the labour input remains unchanged.

In this study the term productivity is solely used in the statistical sense of the national accounts. This means that possible effects linked to improved work efficiency of people not suffering from CRD are not considered. Only productivity gains caused by reduced sick leaves, premature invalidity and mortality of persons suffering from CRD are included. The practical relevance of differences in the individual work efficiency between persons with and without CRD seems evident. However, a comprehensive set of data is not available for Austria and Slovenia. Furthermore, restricted productivity due to CRD during the working time could not be considered.

The starting point is a particular life-cycle model within the human capital approach called PVFE model (*present value of future earnings*), which has been augmented by the employment rate and attendance rate and thus has advantages over other variants like the years of potential life lost (YPLL) (for further details see Pock et al., 2008, appendix). The model evaluates the *value of labour*, because it estimates the expected productivity potential of an individual.

The age-dependent expected productivity function P(a) of a representative individual belonging to a particular age cohort *a* is given by:

$$P(a) = \sum_{t=a}^{T} \beta^{-(t-a)} w(t) eq(t) h(t) S(t+1,a)$$

with the discounting factor  $\beta$ , the average annual income w(t) at the age t, the agedependent labour force participation rate eq(t), the attendance rate h(t), and the survival probability function S(t+1,a).

In our model we define the attendance rate *h* as the ratio of the average actual attendance at the workplace in days in relation to the effective working days (and not calendar days). For Austria, the effective working days in 2014 amounted to 225 days (= 365 calendar days - 25 holidays - 52 Saturdays - 52 Sundays - 11 public holidays on working days). If the official data on sick leave covers the whole duration of a particular sick leave, i.e. calendar days rather than effective working days, as it is the case for Austria and Slovenia, the sick leave data must be adjusted by the factor 225/340 and 233/345 for Austria and Slovenia, respectively.<sup>19</sup> Thus, the attendance rate h(t) of age group t is calculated as h(t)=1-kt(t)/340, with the official sick leave days per capita kt(t) by age group t.

The cohorts of the employable age consist of individuals being employed, unemployed, in education, unwilling to work and incapable of working (e.g. invalidity pension beneficiaries). According to the labour force concept of the International Labour Organization ILO, the labour force participation rate *eq* measures the share of the labour force (employed plus unemployed people) in the population and therefore the probability of being economically active. Unemployed people are included, because in reality a permanent flow into and out of employment status takes place. If the number of invalidity pension beneficiaries is reduced, the labour force participation rate increases.

As discussed in the context of direct medical costs, any mortality improvement reduces the effects calculated by the life-cycle model, because more people surviving imply more medical costs. In the context of indirect costs, this is not case. According to the model assumption of full employment, a higher number of workers implies more productivity, and in consequence more tax revenues and social insurance contributions. The latter effects are incorporated into the model by augmenting the individual's gross wage with the employer's social insurance contributions (**gross<sub>2</sub> wage**). The second reason for taking the gross<sub>2</sub> wage as the model's productivity measure is simply the fact that the employer's labour costs include social insurance contributions.

Concerning wages, a further model adaption has to be conducted before we can estimate the model: If we rely on the concept that the real productivity of the labour force is measured by their wages, the age-specific term w(t) in above formula represents the hypothetical wages under full attendance, ie. h(t)=1. However, the observed data on average wages  $\overline{w}(t)$  are observed with h(t) < 1; hence,  $\overline{w}(t) = w(t) \cdot h(t)$  and above formula simplifies to:

<sup>&</sup>lt;sup>19</sup> Austria: 255 days represent the effective working days and 340 days referring to the basis of the official sick leave data (= 365 calendar days – 25 holidays).

Slovenia: 233 effective working days (= 365 calendar days - 20 holidays - 52 Saturdays - 52 Sundays - 8 public holidays on working days) and 345 days basis (= 365 calendar days – 20 holidays).

$$P(a) = \sum_{t=a}^{T} \beta^{-(t-a)} \overline{w}(t) eq(t) S(t+1,a)$$

with the observed average wages  $\overline{w}(t)$  of age group *t*, age-dependent labour force participation rate eq(t), and survival probability function S(t+1,a).

Note that the observed wages cover the continued payment of wages in case of illness. Hence, a reduction of sick leave days does not change the paid-out wages. But nevertheless the productivity in our model increases due to a higher attendance rate of the employee. Alternatively explained, relying on the concept that the real productivity of the labour force is measured by their wages, the observed wages will hypothetically shift to a new wage level  $\overline{w}^{N}(t)$ . In either case, as a measure of the increase of productivity due to attendance rate we define:

$$\overline{w}^{N}(t) = \overline{w}(t) \frac{h^{N}(t)}{h(t)}$$

By substituting, we implement the one-period and the life-cycle incidence model along the same lines of the other cost categories already described:

$$\begin{aligned} \operatorname{economic\ costs}_{one-period} &= \sum_{a=0}^{T} n(a) \overline{w}(a) \left( \frac{h_{N}(a)}{h(a)} eq_{N}(a) - eq(a) \right) \\ \operatorname{economic\ costs\ PV} &= \sum_{a=0}^{T} n(a) \sum_{t=a}^{T} \beta^{-(t-a)} \overline{w}(t) \left( \frac{h_{N}(t)}{h(t)} eq_{N}(t) S_{N}(t+1,a) - eq(t) S(t+1,a) \right) \\ \operatorname{economic\ costs\ AN} &= \sum_{a=0}^{T} f(a) n(a) \sum_{t=a}^{T} \beta^{-(t-a)} \overline{w}(t) \left( \frac{h_{N}(t)}{h(t)} eq_{N}(t) S_{N}(t+1,a) - eq(t) S(t+1,a) \right) \end{aligned}$$

with the age-dependent annuity due factor  $f(a) = (1-\beta)(\beta(\beta^{-(T-a)}-1))^{-1}$ , discounting rate  $\beta = (l+r)$ , the interest rate r, status quo and counter factual survival probability function S(t+1,a) and  $S_N(t+1,a)$ , respectively, number of individuals n(a) of age group a, terminal age group T, average observed wage  $\overline{w}(t)$  of age group t, status quo and counter factual of age-dependent labour force participation rate eq(t) and  $eq_N(t)$ , respectively, and status quo and counter factual attendance rate h(t) and  $h_N(t)$ , respectively.

The following chapter describes the collected and processed data fitting into our one-period and life-cycle model.

# 7. Data

# 7.1. Top-down approach vs. bottom- up approach

For the implementation of the one-period and life-cycle model given in the previous chapter, one faces some challenges regarding data sources. Before starting the process of gathering data we had to decide on which data level we would build up the particular cost categories. Patients' record data are on the individual level. Such data granularity is preferable but not always available from public institutions due to data protection or missing disease reference. Individual data for direct medical costs basically exist and are usually provided by the health insurance carriers for health services research (e.g. Ghanem, 2014, for Austria) upon application.

Figure 24: Visual representation of approaches to measure direct medical costs



Source: IHS (2018)

Because the Austrian health insurance carriers declined our request to provide patients' record data for this project and because disease-specific individual data for direct non-medical and indirect costs are not available in Austria or Slovenia, we decided to build up our

data set from publicly accessible data sources which are basically aggregated individual data.

Concerning the cost category **direct medical costs**, we did not simply estimate the share of CRD costs out of the total current public health expenditures profiles per capita (s. Figure 24). Instead, we collected data – if available – from each cost item of the medical cost category, calculated the model and summed up the cost effects of CRD obtaining the overall direct medical cost effects of CRD.

In order to provide comparability of our results with international studies, we used the international categorization system SHA (**System of Health Accounts**, OECD) for classifying the cost items of the direct medical cost category; but only for the Austrian model (for more details see the following chapter 7.2.2), because the structure of the available Slovenian health expenditure data for most cots items were not compatible with SHA.

For each cost item of the cost categories given in Table 5, p. 35, we collected data from Austria and Slovenia. The Slovenian data were collected by VI vis d.o.o., Slovenia.<sup>20</sup> As explained in the method chapter 6.2, implementing the life-cycle model requires **age**-, **gender**- and **disease**-specific profiles of model inputs. CRD comprise the ICD-10 groups J40-J47. The available age profiles are rebuilt into 5-year age groups (e.g. 20-24, 25-29, 85-89, etc.) except the age groups 0, 1-4, and 90+. Wherever single or 5-year age groups are not available but higher aggregated age groups are, we estimated the 5-year age groups applying cubic spline interpolation methods (e.g. labour force participation rate).

**Disease-specific** cost information must be available in order to calculate the burden of CRD. Due to data restrictions, we decided for the Austrian model not to differentiate between the CRD groups J40-J47. Wherever Austrian data have not been available or without disease categorization, we resorted to international literature (care allowances) or German DESTATIS data (inpatient rehabilitative care, patient transportation, therapeutic appliances) because these two countries show similar social systems, population pyramids, per-capita health expenditures, etc. In the case of inpatient rehabilitative care, we applied the German age-, gender- and disease-specific profiles to the Austrian total costs. In the case of patient transportation and therapeutic appliances, we applied the German cost share of CRD to the Austrian total costs. Because disease-specific data of informal care allowances are not available, we estimated the cost effects of care allowances due to CRD by referring to international literature.

Because the Slovenian data exhibit a higher granularity for some cost items with respect to COPD and asthma, the Slovenian model calculates the cost effects of COPD (J44) and asthma (J45-J46) separately, rather than of the entire CRD group J40-J47. Wherever

<sup>&</sup>lt;sup>20</sup> See http://www.vi-vis.eu/.

Slovenian data were not available by disease categorization or were of marginal impact, we either excluded this cost item from our analysis (patient transportation and emergency rescue, invalidity pensions and informal care allowances) or extrapolated from related Slovenian cost items (therapeutic appliances).

In the following chapters, the various data sources consulted in the course of the analysis are described for Austria and Slovenia, respectively.

# 7.2. Data sources for Austria

## 7.2.1. Key variables

The "driving horses" of the life-cycle model (see chapter 6.2) are the disease-, age- and gender-specific profiles of raw mortality rates and the age- and gender-specific profiles of population for the year 2014, retrieved form Statistics Austria (2015a). Figure 29, p. 113, illustrates the gender-specific population pyramids for Austria for the year 2014. The higher mortality in elder age cohorts of males compared to females is directly visible in the figure.

The official deaths numbers of COPD (J44), asthma (J45-J46) and CRD (J40-J47) are given in Figure 30, p. 114. Generally, the official reported asthma deaths in Austria are on a low level. The share of male and female asthma deaths related to CRD amounts to 1.5% and 3.2% in 2014, respectively. The share of COPD is given at 83.4% and 75.6%, and the share of the residue of CRD at 15.2% and 21.2%, respectively.

The peak of the number of deaths of COPD and CRD is located between the age 85 and 89, whereas the share of COPD and CRD deaths related to total deaths climaxes between age 65 and 74 (Figure 30, p. 114). One interpretation is that there exists an early onset of CRD mortality compared to other chronic diseases like cerebrovascular diseases or cancer. Another interpretation aims at the presumed underreporting of CRD in the cause-specific mortality registers in elder age groups where multimorbidity increases.

One of the key inputs of the life-cycle model is the conditional 5x5 survival probability function S(t,a) representing the probability of surviving for a 5-year age cohort from age a till t in discrete 5-year steps (see chapter 6.2), given to have survived till age a. This function is calculated by the conditional 5x5 mortality probabilities which in turn are calculated by the conditional 5x1 raw deaths rates in 2014 described above by applying life-table calculation methods (see Preston et al, 2001). By subtracting deaths caused by CRD from total deaths and recalculating, we derived the gains in 5x5 mortality and survival probabilities for the

Austrian population, hypothetically assuming the extinction of CRD. These gains in mortality (i.e. absolute differences in 5x5 conditional mortality probabilities between status quo and counter-factual without CRD) are given in Figure 32, p. 115, by gender and age. Generally, the absolute gains increase with age. However, the absolute gains for females are only approximately one half of the corresponding gains for males, but relating the gains to the level of status quo mortality probabilities, we observe a peak of the relative gains at the age cohort 65-69 in both genders (see Figure 33, p. 115): 5.3% for females and 4.7% for males. After age 70, the relative gains decrease faster for females. At the age 80-84, for example, the gains amount to 2.5% and 3.8%, respectively.

The gains in conditional 5x5 mortality probabilities can be used for calculating life expectancy at different ages applying life-table methods (see Preston et al., 2001). We estimate a prolongation of life at birth of 3.0 months for females and 4.3 months for males. For the age group 60-64, we calculated an increased longevity<sup>21</sup> of 2.9 and 4.4 months, respectively (see Table 26, p. 115). The nearly identical gains in life expectancy over a large range of age groups is owed to the characteristics of the age- and gender profiles of mortality gains which peak at the age group 65-69, as mentioned above.

Finally, we calculated the age- and gender-specific 5x5 survival probability functions S(t,a) that a particular individual in age cohort *a* survives till age *t*, conditional on the survival of the individual till age *a*. The improvements of the survival probabilities between status quo and counter-factual without CRD are illustrated for the elder cohorts in Figure 34, p. 116. Although the effects of S(t,a) are cumulative over the time span, the relative increases of the survival probabilities of the intermediate age groups turn out to be negligible but steeply rise starting from age  $t \ge 65$ . Again, this characteristic of S(t,a) is caused by the official mortality gains climaxing at the age group 65-69.

#### 7.2.2. Direct medical costs

Data on direct medical costs used in the analysis are categorised according to and partly derived from System of Health Accounts (SHA). SHA follows a comprehensive, consistent and internationally comparable framework for the systematic description of financial flows related to healthcare. It was introduced by the OECD in 2000 and has since been promoted in a collaborative effort by OECD, Eurostat and WHO. It has been widely implemented in national and international health accounting. Within SHA, health expenditure is classified by healthcare functions (HC), healthcare providers (HP) and health care financing schemes (HF) (OECD/Eurostat/WHO, 2011). This classification allows for a detailed and multi-

<sup>&</sup>lt;sup>21</sup> The life expectancy at a particular age t is the expected value of further years to live, conditional on surviving to that age t.

dimensional analysis of health expenditure. In Austria, Statistics Austria is responsible for the collection and preparation of SHA data.<sup>22</sup>

Categorising direct medical costs in burden of disease studies provides for comparability with international studies using SHA. Unfortunately, we are not aware of any BoD studies which categorise according to SHA. The difficulties lie within the system of health accounts by itself. The various national primary data sources have to be merged, prepared and fit into the accounting system by the national statistical offices. This task requires taking assumptions and sometimes rough estimations due to lack of data. Because researchers conducting BoD studies mainly work with primary data sources split into ICD, age, gender, etc., they face the problem that the reference base of a particular BoD cost item deviates from the official SHA base.

For comparability reasons, reference bases are important for illustrating the magnitude of the cost effects of a specific disease. The economic or productivity costs are naturally referred to GDP, but the medical costs should preferably be referred to their specific cost base, e.g. hospital costs, in order to get a grasp of the magnitude of the cost effect. Thus, there are two possibilities for choosing a cost base: firstly, the underlying base of the primary data, or secondly, the corresponding SHA base. By applying the second approach, the researcher usually has to gross up the calculated cost effect to the SHA base. Otherwise, the effects are underestimated in relative terms in cases where the primary data do not cover all costs of the specific SHA category.

For instance, the Austrian data of inpatient hospital costs, split by ICD, age and gender, stem from the so-called "fund hospitals", which are publicly financed by a state fund (see below). They cover approx. 94% for all inpatient hospital DRG points. No age- or gender-profiles were provided by the private and accident hospitals. Thus, we extrapolated from the fund hospital data. Because the data of fund hospitals are split into in- and outpatient data, in contrast to private and accident hospitals, we summed up over the three hospital and provision types. This sum differed from the SHA base "inpatient, daily and outpatient curative care provided by hospitals" (HC.1 x HP.1), which we built up out of the corresponding SHA subcategories from official SHA data. In order to meet this SHA reference base, we multiplied the constructed age- and gender-profiles by a mark-up. In the case of hospitals, this mark-up amounts to +5.3%, which is in our opinion an acceptable approximation.

Generally speaking, the researcher has to judge on the trade-off between minimizing the extrapolation uncertainty by splitting and adding SHA subcategories in order to map the base reference of the primary data as closely as possible on the one hand, and preserving the comparability between international studies and covering the corresponding major SHA cost

<sup>22</sup> See

http://www.statistik.at/web\_de/statistiken/menschen\_und\_gesellschaft/gesundheit/gesundheitsausgaben/index.html.

category as much as possible by choosing a SHA base at a higher level on the other hand. In cases where the structure or quality of the primary data is not suitable for extrapolating to the SHA base, the researcher should refrain. The decision must be taken ad hoc. In the case of Austrian data, we decided for the SHA base, whereas in the Slovenian case the reference base remained at the primary data base as agreed with Slovenian experts of *VI vis d.o.o.*, which provided the Slovenian data for the BoD calculations in this research report.

Table 11 shows how three of the cost factors used in our analysis (hospitals, rehabilitation and medical practices) are extracted from a SHA cross table of healthcare functions (HC) and healthcare providers (HP) for Austria. Expenditures on "inpatient curative care, day curative and rehabilitative care and outpatient curative care provided in hospitals" (HC.1 x HP.1) amount to EUR 11.9 billion, while expenditures on "inpatient rehabilitative care provided by hospitals" (HC.2.1 x HP.1) and "general & specialised outpatient curative care provided by medical practices" (HC.1.3.1 x HP.3.1.1 + HC.1.3.3 x HP.3.1.3) amount to EUR 1.2 billion and EUR 3.0 billion, respectively.

 
 Table 11: Cost factors in curative and rehabilitative care from System of Health Accounts (SHA) in million EUR, 2014

				HPTOT: All providers						
							HP3:	HP3: Providers of		
							ambulat	ory health	car	e
			Total	HP1:				HP31:		
				Hospitals			Total	Medical		
								practices		
HC1HC2: Curativ	e and rehabilitative care		20,012.49	13,149.94			6,413.01	3,038.24		
HC11HC21: Inpa	tient curative and rehabilitative of	are	11,327.73	11,033.47			-	-		
HC11: Inp	atient curative care		9,824.86	9,811.95			-	-		
HC21: Inpatient rehabilitative care		1,502.87	1,221.52			-	-			
HC12HC22: Day curative and rehabilitative care		280.72	280.72			-	-			
HC13HC23: Outpatient curative and rehabilitative care		8,385.53	1,835.76			6,394.50	3,038.24			
HC13: Ou	tpatient curative care		7,686.00	1,835.76			5,694.97	3,011.76		
НС	131: General outpatient curative	care	1,521.07	-			1,400.08	1,400.08		
нс	132: Dental outpatient curative of	care	1,814.70	-			1,814.70	-		
HC133: Specialised outpatient curative care		4,350.22	1,835.76			2,480.18	1,611.68			
HC23: Outpatient rehabilitative care		699.53	-			699.53	26.48			
HC14HC24: Home-based curative and rehabilitative care		18.51	-			18.51	-			
Hospitals	Sum HC1 x HP1	11,928.43		•			•			
B 1 1 111 11	C 11024 1104	4 994 59	<b>.</b>							

 Rehabilitation
 Sum HC21 x HP1
 1,221.52

 Medical practices
 Sum HC131xHP311 + HC133xHP313
 3,011.76

Source: Statistics Austria (2016), IHS (2018)

In Table 11, the cost categories of direct medical costs considered in our analysis are presented as a share of total current expenditure on health (excl. long-term care expenditure). Hospitals make up the largest share at 42%, followed by medical practices and prescribed medicines at 11% each. Therapeutic appliances, inpatient rehabilitative care and patient transportation account for 5%, 4% and 2%, respectively. Together, the categories considered in our analysis make up three quarters of total current expenditure on health.





Source: Statistics Austria (2016), IHS (2018)

#### Hospitals (HC.1 x HP.1)

Of 279 hospitals in Austria in 2014, 123 were so-called "fund hospitals", which are financed by the federal state health funds and therefore have public status (BMGF, 2016). They represent the Austrian acute care sector and share comparable tasks, the same payment mechanism as well as the same legal framework. Fund hospitals are financed on the basis of a performance-oriented financing system (*Leistungsorientierte Krankenanstaltenfinanzier-ung*, LKF), which follows a DRG framework. In the LKF system, points are allocated for inpatient hospital stays according to diagnosis-related case groups (*Leistungsorientierte Diagnosefallgruppen*, LDF). These case groups take into account medical procedures, ICD-10 diagnoses, age and involved hospital departments. Each diagnosis-related case group is assigned a point score, which is based on average costs for a hospital stay with the respective characteristics. These points are associated with a monetary value, which is determined by the individual state and can therefore vary from state to state (BMG, 2010).

Data on inpatient costs of fund hospitals (*stationäre Endkosten*) were acquired from the Federal Ministry of Health and Women's Affairs (*Bundesministerium für Gesundheit und Frauen*, BMGF) in the form of LKF points by age, sex and ICD-10 diagnosis. The latter allows for a distinction between COPD, asthma and other CRD, as well age and gender. Since there is no unique point value in force for all Austrian states, we divided total public expenditure (= total inpatient costs minus private out-of-pocket payments and private health insurance expenditures) on inpatient services in fund hospitals (EUR 8,907.48 million in 2014) by total inpatient LKF points in fund hospitals (approx. EUR 7,180.62 million in 2014) to determine an over-all implicit point value of EUR 1,042.6 which is applied to the ICD-, age-and gender-specific LKF profiles. By dividing each category by the corresponding population number, we derived the costs-per-capita profiles. Our estimates represent an

underestimation of the true CRD hospital costs because the LKF points attributable to CRD amount to 1.1% in contrast to the hospital days with 1.6%. By relating the CRD-attributable hospital days per stay to the total days per stay, the average CRD patient stays 43.2% (7.3 days per stay) longer than the overall average days per stay in hospital.

COPD is the major cost component within CRD. COPD accounts for 76.3% of the CRDattributable hospital stays, for 83.4% of the hospital days, and 82.3% of the LKF points (see Figure 35, p. 116).

Fund hospital cost profiles of daily and outpatients were not available. We approximated age and gender profiles for the relevant ICD groups J40-J47 by applying the corresponding profiles of the OÖGKK (federal social health insurance of Upper Austria) FOKO (*Folgekosten*) data base to the total public outpatient expenditures of the fund hospitals (EUR 1,879 million in 2014). The average daily/outpatient costs per capita amount to EUR 220.0.

In addition to fund hospitals, the analysis also takes into account costs arising in private hospitals, which are partly financed by the Private Hospitals Financing Fund (*Privat-krankenanstaltenfinanzierungsfonds*, PRIKRAF), and accident hospitals, which are financed by the Austrian Workers' Compensation Board (*Allgemeine Unfallversicherungsanstalt*, AUVA) and the social health insurance funds. For these hospital types only total expenditures and total PRIKRAF and LKF points, respectively, are available. These costs comprise in-, outpatient and daily care. The latter two categories account only for a small amount of the costs. The PRIKRAF earnings and the expenditures of the AUVA hospitals (AUVA, 2015) for the year 2014 amount to EUR 109.00 million and EUR 165.90 million, respectively. These costs are divided as an approximation among the ICD, age and gender profiles of the inpatient fund hospital costs.

The money values of the four constructed cost per capita profiles (inpatient fund hospitals, daily/outpatient fond hospitals, PRIKRAF and AUVA hospitals) were summed up by each age group and gender category. These profiles are corrected for the difference to the SHA base of EUR 11,928.43 million. The mark-up amounts to 5.3%. We derived profiles of the sum of all ICD groups as well as of the ICD-group J40-J47. Finally, the difference between these two values for each age and gender category represents the constructed total hospital cost profile **without** the ICD group J40-J47 under consideration. Figure 36, p. 117, shows the age- and gender-specific per capita hospital cost profiles (HC.1 x HP.1) attributable to CRD in Austria in 2014. The profiles increase at age 50+ and climax in the age group 80-89. The costs of females are approximately two thirds of the costs of males.

#### Inpatient rehabilitative care (HC.2.1 x HP.1.1)

The SHA base for public and private costs of "rehabilitative inpatient care provided by hospitals" (HC.2.1 x HP.1.1) amounts to EUR 1,221.52 million in 2014. For inpatient rehabilitation centres in Austria, there is no up-to-date register recording the number of beds by medical specialisation. Furthermore, inpatient rehabilitation centres do not record ICD diagnoses. Therefore, it was not possible to determine costs of inpatient rehabilitative care based on Austrian data. Instead, we used German data on length of stay and daily costs of inpatient rehabilitation facilities from 2015, which are available by age, gender and ICD-10 disease groups (DESTATIS, 2016). From our experiences, we can state that the German cost profiles in the health sector are similar to Austria. We extracted costs of inpatient stays caused by CRD (ICD-10 codes J40-J47) and estimated cost profiles for Austria based on the German cost structure (see Figure 38, p. 117).

#### Medical practices (HC.1.3.1 x HP.3.1.1 + HC.1.3.3 x HP.3.1.1)

In Austria, the outpatient sector is not required to record any diagnostic data. In principle, it would be possible to identify a large share of CRD patients from social health insurance claims data by their medication prescriptions and by connecting data from the outpatient sector to diagnostic data from the inpatient sector. However, almost all social health insurance institutions declined our request to provide such claims data for the current analysis. Therefore, we used publicly available, aggregated data on per-capita expenditure of social health insurance on medical practices of all specialisations by age and gender (LIVE data base), provided by the Main Association of Austrian Social Security Institutions (HV, 2015a). However, these data do not include diagnosis information. In order to determine the share of this expenditure attributable to CRD, we drew on the gross share of outpatient costs in Germany attributable to ICD-10 codes J40-J47 (2.2%). This information stems from the German cost-of-illness calculation by DESTATIS from 2008, which provides estimates of health expenditure associated with specific diseases by age and gender (DESTATIS, 2008). Because the sum of the aggregated available HV cost profiles of the medical practices did not match the SHA base, we adapted the HV cost profiles accordingly. The chosen SHA base is the sum of general and specialised outpatient curative care (without dental curative care) provided by medical practises (HC.1.3.1 x HP.3.1.1 + HC.1.3.3 x HP.3.1.1), totalling EUR 3,011.76 million in 2014. Figure 39, p. 118, illustrates the per capita cost profiles attributable to CRD by age and gender. In contrast to the inpatient costs, the outpatient costs provided by medical practices steadily increase till end of life.

#### Patient transportation (HC.3.4 x HP.4.1)

For patient transportation, no data by ICD, age or gender are available in Austria. Similarly to medical practices, we drew on the share of expenditure for patient transportation attributable to ICD-10 codes J40-J47 from the German cost-of-illness calculation (2.4%; DESTATIS, 2008) and applied it to Austrian data on expenditure on patient transportation according to the SHA category HC.3.4 x HP.4.1 ("patient transportation provided by providers of patient

transportation and emergency rescue"), given by EUR 585.76 million. Here, we refrained from estimating profiles needed for the life-cycle model. Thus, the estimated one-period costs of patient transportation are set equal to the corresponding category of the life-cycle method.

#### Prescribed medicines (HC.5.1.1)

For the cost factor prescribed medicines, we received data on costs (net of value added tax) and volumes of medical prescriptions invoiced by dispensing pharmacies and doctors in 2014 from the Main Association of Austrian Social Security Institutions (HV, 2016), covering all 19 Austrian social health insurers. The data of the special social health insurances *"Krankenfürsorgeanstalten"* were not available. The cost base is the reimbursement price net of value added tax and deductibles. Prescriptions being cheaper than the patient's contribution are not included in the data unless the patient is exempted. Privately paid pharmaceuticals which are fully or partly reimbursed to the patient were not available either.

In particular, we used data on prescriptions classified under the ATC code R03, which comprises drugs for obstructive airway diseases. Individual data for linking the diagnosis to the ATC code were not available. There exists literature trying to identify the diagnosis of COPD or asthma by means of the observed pattern of individually prescribed pharmaceuticals (with Austrian data: Ghanem, 2014, for severe asthma, Filzmoser and Mert, 2012, for COPD). However, the scientific advisory board which supervised the Austrian part of this study stated that such probabilistic algorithms for identifying COPD and asthma are afflicted with a high degree of misidentification. Therefore, we desist from assigning the Austrian ATC data to the ICD diagnoses COPD and asthma. In contrast, the Slovenian advisory experts agreed upon splitting the ATC data into J44 and J45-J46 according to Filzmoser and Mert (2012), among others (see chapter 7.3.2).

We extrapolated from the resulting cost per capita profiles (needed for the life-cycle model) in order to arrive at the official reference value according to SHA category HC.5.1.1, amounting to EUR 3,240.46 million for public and private expenditures. This implied a mark-up of 3.2%. The resulting per capita cost profiles are given in Figure 40, p. 118. We see an onset of rising pharmaceutical costs attributable to CRD at the age 40. The per capita costs of males peak between 65 and 89 at around EUR 60, whereas those of females climax at age group 65-69 at EUR 40, and contrary to males steadily decrease till the terminal age group. The overall per capita pharmaceutical costs of females are 17.3% below the costs of males (EUR 15.5 vs. EUR 18.9, respectively).

#### Therapeutic appliances (HC.5.2)

Therapeutic appliances typically used by CRD patients include ventilators, especially continuous positive airway pressure (CPAP) masks, and oxygen concentrators including

corresponding accessories. For such therapeutic appliances, claims data from social health insurance institutions exist but were not provided. Furthermore, manufacturers' organisations were not able to provide us adequate data. Therefore, we drew on the German cost-ofillness calculation (DESTATIS), which states a share of 2.4% of expenditure on therapeutic appliances being attributable to CRD. The corresponding Austrian SHA category HC.5.2 ("therapeutic appliances and other medical durable goods") amounts to EUR 1,458.71 million in 2014. We refrained from estimating profiles needed for the life-cycle model, and the estimated one-period costs are set equal to the corresponding life-cycle category.

#### 7.2.3. Direct non-medical costs

#### Care allowances

We received data on care allowances in the federal nursing scheme from the Main Association of Austrian Social Security Institutions (HV, 2014a). These data give the number of new entries, status quo of current recipients and average money value of allowances by age, gender and care level for 2014. However, diagnoses of recipients of care allowances are not recorded. Therefore, we conducted a rough estimation of the share of new entries attributable to CRD. In order to calculate age- and gender-specific epidemiological **population attributable fractions** (see chapter 6.3.2, p. 53), which are a well-known concept in epidemiological literature, we used prevalence rates from the Austrian Health Interview Survey (ATHIS, see sections 3.3.1 and 3.3.2) as well as a value of 1.2 for the relative risk of being in need of care when suffering from CRD J40-J47.

The chosen value of the relative risk for the age groups 35-39 onwards is a rule-of-thumb estimate, combining the German estimate by van den Bussche et al. (2013) of 1.1 and findings of a previous study concerning the economic effects of smoking in Austria (Pock et al., 2008). The latter study performed a multivariate logistic regression on data of ATHIS 2006/2007, estimating the odds ratio of the significant partial effect of smoking on the status of care needed to 1.51 with lower and upper bound of 95%-significance level of 1.2 and 1.9, respectively. Due to the direct and strong causality effects of smoking on CRD and especially on COPD (Thun et al., 2013), the assumption of a relative risk value of 1.2 seems conservatively chosen.

Figure 41, p. 119, gives the age- and gender-specific profiles of new beneficiaries of care allowances attributable to CRD in Austria in 2014. The profiles peak at the age-group 80-84 for both sexes with 295 and 199 attributable cases of females and males, respectively. The level of the female profile runs above that of males because the rough estimate of 1.2 relative risk of CRD is applied to both sexes and the number of female new beneficiaries in elder age groups exceeds that of males. In sum, we estimate 1,893 attributable CRD cases in Austria in 2014.

#### Sick leave allowances

Figure 42, p. 119, shows the estimated CRD-attributable **sick leave days** (including civil servants) by age and gender from the data source HV (2015b, see chapter 7.2.4 below for information on the method for estimating). Note that in some economic branches, short sick leaves lasting to 3 days are usually not reported to the social insurance institutions.

The social insurance institutions are financially liable for the continued wage payments only after a sick leave period of 6 or 4 weeks per year, depending on the amount of recurring sick leave episodes. The data on **sick leave allowances** paid by the social institutions were provided by the OÖGKK<sup>23</sup> and the AUVA<sup>24</sup>. The latter institution is responsible for the continued payment of wages in case of illness for companies with a maximum of 49 employees. The OÖGKK data stem from the FOKO data base (*Folgekosten*) on sick leave days and sick leave allowances paid. They are jointly categorised by age, gender and ICD-10 diagnoses (OÖGKK, 2016).

We extrapolated from the ÖOGKK profiles to the total sum of sick leave allowances paid, totalling EUR 674.03 million in 2014.<sup>25</sup> The share of CRD-attributable sick leave allowances is estimated to 0.64% of total costs or EUR 4.34 million. We assume that this represents an underestimation due to underreporting, because persons suffering from COPD are susceptible for respiratory infections being reported as a common cold, influenza or other respiratory infections which are not located in the ICD group J40-J47 and secondary diagnoses are not designated. In Figure 42, p.119, the estimated cost profiles of sick leave allowances paid by social insurance institutions are shown by age and gender for the year 2014. The costs peak at age group 45-49 at EUR 213.074 for females and EUR 381.045 for males.

#### Invalidity pensions

We received data on new entries into invalidity pension by age and gender in 2014 from three sources: the HV for beneficiaries according to the General Social Security Act (*Allgemeines Sozialversicherungsgesetz*, ASVG), the AUVA providing invalidity pensions due to occupational diseases<sup>26</sup> (*Versehrtenrenten*) and the Federal Chancellery (*Bundeskanzleramt*, BKA) for federal civil servants (HV, 2014b; BKA, 2014a). Based on staff data of the Federal Chancellery (BKA, 2014b), we extrapolated from federal civil servants to obtain an estimate of invalidity pensions in civil servants employed by the states and municipalities,

<sup>&</sup>lt;sup>23</sup> The aggregated Austrian data of HV covers cases of sick leaves separated by age, disease, and duration, but all three dimensions are not covered jointly.

<sup>&</sup>lt;sup>24</sup> We would like to give thanks to Mag. Beate Mayer, head of statistics department, AUVA, for kindly providing the data.

<sup>&</sup>lt;sup>25</sup> Handbuch der österreichischen Sozialversicherungsträger 2015.

<sup>&</sup>lt;sup>26</sup> We would like to give thanks to Mag. Beate Mayer, head of statistics department, AUVA, for kindly providing the data.

excluding outsourced public companies. The mark-up of 1.8 was roughly estimated from the head counts and full time equivalents of the civil servants being employed by states and municipalities (Statistics Austria, 2015c) in relation to the federal civil servants.

The data from HV also included new entries into invalidity pension by age and a classification of main level disease groups (however not by age) following at large the ICD-9 classification scheme. With respect to respiratory diseases, a distinction is made between "diseases of the upper respiratory tract" and "other respiratory diseases". According to these data, 4.5% and 2.3% of new entries into invalidity pension in 2014 were attributable to "other respiratory diseases" in males and females, respectively. We applied these fractions to all age groups to receive an estimated age profile of new entries into invalidity pension due to CRD (see Figure 44, p. 120). The profiles peak at age group 55-59 with 295 male beneficiaries. In sum, we estimated 171 female and 601 male new cases of invalidity beneficiaries.

In order to assign a monetary value to these new beneficiaries of invalidity pension, we drew on age and gender profiles of average gross disability pensions per month from HV data. These data include all employee types, including the self-employed, but excluding civil servants. Because civil servants receive higher pensions on average, this procedure underestimates the effect of invalidity pensions.

Contrary to the calculation of the indirect costs (where we used the gross wages as the theoretical equivalent of marginal productivity), we applied an average tax deduction rate to get the **net invalidity pension** by age and gender, because the taxes of pensioners are pass-through components for the public budget. The corresponding values were extracted from the wage tax statistics (*Lohnsteuerstatistik 2014*) provided by Statistics Austria (2015b).

The reference base for the calculated disability effects due to CRD amounts to EUR 3,936.0 million and was taken from the annual expenses for invalidity pensions provided by the data sources of HV, supplemented by the ESSOSS, which is the database of the Federal Ministry of Labour, Social Affairs and Consumer Protection (*Bundesministerium für Arbeit, Soziales und Konsumentenschutz*, BMASK) and Statistics Austria (BMASK/Statistics Austria, 2014a). ESSOSS contains the expenses of all civil cervants.

#### Old-age and widow/widower pensions

For old-age pensions, we consulted the same data sources as in the previous case of invalidity pensions, as these data sources also contain the required information on new entries into old-age pension (except for disease-specific data).

The developed variant of a life-cycle model (see chapter 6.3.2) has the advantage of accounting for pension payments arising from widow/widower claims. These claims

decrease the monetary effects of old age pensions due to increased longevity within the lifecycle framework. After applying a transition probability of mortality for each age and gender group in each time period, the model uses age- and gender-specific transition probabilities into a widow/widower status. Finally, these widows/widowers exhibit varying age and gender specific transition probabilities of mortality as they proceed over the time horizon.

For widow/widower pensions, the latest available data on new entries by age and gender are from the year 2011 (HV, 2011). By using these transition probabilities of widow/widower claims, we rigorously assume that these transition probabilities are the same for the year 2014.

Both old-age and widow/widower pensions were valued using data on average old-age and widow/widower pensions per month, respectively, from the previous mentioned HV data base. Again, we applied the average tax deduction rate to receive the **net pension** per age and gender, and used the total sum of old-age and widow/widower pension expenses for reference purposes, provided by the data sources of HV, supplemented by ESSOSS for the civil servants.

#### 7.2.4. Indirect costs

For the estimation of the indirect costs, we need age- and gender-specific profiles of average gross wages plus employers' social contributions, attendance rates and labour force participation rates<sup>27</sup>, which we retrieved from Statistics Austria (2015b), HV (2015b) and the Austrian Public Employment Service (*Arbeitsmarktservice*; AMS, 2015), respectively.

The average gross wages data stem from the wage tax statistics. We calculated weighted average wages out of the perennial and the non-perennial employees. The age groups were not uniformly given by 5-year age groups. Thus, we applied a cubic spline interpolation method. Finally, the gross wages are multiplied by a mark-up of 1.217 representing the formal rate of the employers' social contributions for blue-collar workers. These so-called "gross<sub>2</sub> wages" (*Brutto<sub>2</sub>-Bezüge*) are used in our model as the approximation for the theoretical economic concept of the marginal productivity of labour. In the chapter reporting on the sensitivity analysis (see chapter 9), we will switch to GDP per capita employed as an alternative productivity measure.

The average attendance rate profiles are derived from sick leave data (including civil servants) provided by HV. First, the average sick leave days per employee are related not to 365 but to 340 days, because the holiday entitlements in Austria usually encompass 25 working days and are prioritised over sick leave days. Sundays and public holidays are not

<sup>&</sup>lt;sup>27</sup> In contrast to the employment rate (employed and self-employed), the labour force participation rate is the ratio between the employed, self-employed plus unemployed and the population.

subtracted, because the sick leave reports by the companies encompass them, too. This procedure delivers the reference base profiles of the attendance rates (see chapter 6.3.3). Second, CRD-attributable sick leave days have to be estimated (see Figure 42, p. 119). The data provided by HV are categorised by main level disease groups – however, these categories are very broad (HV, 2015b). The disease group relevant for this analysis, "respiratory diseases", includes both chronic and acute conditions. It can be assumed that a large share of sick leaves due to respiratory diseases is caused by acute infections. Hence, the share of sick leaves attributable to CRD had to be approximated by means of other data sources. As mentioned above, we received data on sickness benefits by age, gender and ICD-10 diagnosis from OÖGKK (2016). Contrary to the sickness benefits data – which are only paid in case of long-term sick leave (more than six weeks, see above) – the FOKO database of the OÖGKK additionally contains data for all reported sick leave days<sup>28</sup>, split by age, gender and ICD-10. We used these profiles for calculating the share of sick leave days attributable to CRD. Third, these shares are applied to the attendance rate profiles calculated in step one.

The age groups of the labour force participation rates were not uniformly given by 5-year age groups. Thus, we applied a cubic spline interpolation method in order to receive continuous 5-year age group profiles.

# 7.3. Data sources for Slovenia<sup>29</sup>

#### 7.3.1. Key variables

The key variables of the life-cycle model are the disease-, age- and gender-specific profiles of raw death rates and the age- and gender-specific profiles of population for the year 2014 (see Figure 47, p. 121). The data were obtained partially from NIJZ (disease specific data) and SURS<sup>30</sup> (population specific data).

The official deaths numbers of COPD (J44) and asthma (J45-J46) are given in Figure 48, p. 121. Because the statistics report merely one deceased male person due to asthma in 2014, we enlisted in this case the data of 2015 with seven deceased males in sum. Similar to Austrian data, the official reported asthma deaths in Slovenia are on a very low level and are dominated by COPD deaths. The share of male and female asthma deaths related to COPD deaths amounts to 3.0% and 9.8% in 2014, respectively.

<sup>&</sup>lt;sup>28</sup> As mentioned above, some companies do not report sick leaves lasting only up to three days.

<sup>&</sup>lt;sup>29</sup> This chapter was authored by VI vis d.o.o, Slovenia, and reviewed by IHS, Vienna. VI vis d.o.o. collected and processed the Slovenian data.

<sup>&</sup>lt;sup>30</sup> Age- and gender specific population and mortality data were obtained from the public data bank of SURS available on <u>http://www.stat.si/statweb</u>.

Similar to Austrian data, the peak of the number of deaths of COPD is located at elder cohorts, namely between the ages 85 and 89, whereas the share of COPD and CRD deaths related to total deaths climaxes between ages 65 and 79 (Figure 47, p. 122). One interpretation is that there exists an early onset of the COPD mortality compared to other chronic diseases like cerebrovascular diseases or cancer. Another interpretation aims at the presumed underreporting of COPD and asthma in cause-specific mortality registers in elder ages where multimorbidity increases.

One of the key inputs of the life-cycle model is the conditional 5x5 survival probability function S(t,a) representing the probability of surviving for a 5-year age cohort from age a till t in discrete 5-year steps (see chapter 6.2), given to have survived till age a. We calculated this function along the same lines (see chapter 7.2.1, p. 63) by the conditional 5x5 mortality probabilities resting on the conditional 5x1 raw deaths rates in 2014 described above by applying life-table calculation methods (see Preston et al., 2001).

The gains in mortality, namely the absolute differences in 5x5 conditional mortality probabilities between status quo and counter-factual without COPD and asthma, are given in Figure 50, p. 122, by gender and age. Generally, the absolute gains increase with age. Similar to the Austrian calculations, the absolute gains for the females are very low, namely only approximately one third of the males; but when relating the gains to the level of status quo mortality probabilities, we observe a peak of the relative gains at the age cohort 65-69 for females (5.3%) and at 70-74 for males (3.2%) (see Figure 51, p.123). Contrary to Austrian data, the relative mortality gains of females exceed those of the males till age 80. After age 70 the relative gains decrease faster for females. At the age 80-84, for example the gains amount to 2.5% and 3.0%, respectively.

By calculating life expectancy at different ages applying life-table methods (see Preston et al., 2001), we estimate a prolongation of life at birth of 3.0 months for females and 2.7 months for males in Slovenia. For the age group 60-64, we calculated an increased longevity<sup>31</sup> of 2.9 months for both genders (see Table 27, p. 123115). The estimates for females correspond to the Austrian data. However, the Slovenian males surprisingly do not profit as much as the Austrian males by hypothetically eradicating CRD. One reason is of course the excluded ICD groups J40-J43 and J47, but what makes the difference is that the male COPD mortality gains are on a lower level in Slovenia.

Finally, we calculated the age- and gender-specific 5x5 survival probability functions S(t,a) that a particular individual in age cohort *a* survives till age *t*, conditional on the survival of the individual till age *a*. The improvements of the survival probabilities between status quo and counter-factual without COPD and asthma are illustrated for the elder cohorts in Figure 50,

<sup>&</sup>lt;sup>31</sup> The life expectancy at a particular age t is the expected value of further years to live, conditional on surviving to that age t.

p.122. The surface diagram exhibits a similar shape compared to the Austrian data (see Figure 52 vs. Figure 34), but the survival gains are generally on a lower level.

#### 7.3.2. Direct medical costs

Data on direct medical costs used in the analyses are categorised according to the system of health data collection established by the National Institute of Public Health in Slovenia. As we applied the bottom-up approach for data collection, we assumed that this way of data categorisation would give us more precise estimations of the costs related to asthma (J45-46) and COPD (J44) compared to the top-down approach (see Table 5, p.35). Given that not all health care expenditures in Slovenia are reported with ICD split, we collected the following J45-46 and J44 direct medical cost categories: in- and outpatient care, rehabilitation provided by the special centres, medicines and medical devices.

Expenditures were estimated from the perspective of obligatory and additional health insurances as well as out-of-pocket payments to the full price of health care source in case the additional health insurance is either missing or does not cover the premium.

For comparability reasons, we used the same data categorisation approach while collecting the reference sets of data. This however means that our reference base of EUR 1,438 million is by far lower than the total health expenditures reported in Slovenia in 2014 of EUR 3,189 million that besides health care insurances expenditures includes government, household and non-profit institutions serving household (NPSIH) expenditures. Contrary to the Austrian model, we therefore do not apply a mark-up to the collected Slovenian data in order to meet the corresponding base references of the SHA classification (System of Health Account, see chapter 7.2.2).

Split of total health care expenditures in Slovenia by sources of funding and by health care providers is presented in Figure 26 and Figure 27 below. Most health care financing is provided by public social security funds and health insurance institution, 68% and 15% respectively. 40% of total financing was spent for inpatient or hospital care, while outpatient care and medical goods (medicines and medical devices) consumed 22% each of total health expenditures in Slovenia in 2014.





Source: Statistical Office of Republic of Slovenia (2016), illustrated by VI vis (2017)





Source: Statistical Office of Republic of Slovenia (2016), illustrated by VI vis (2017)

In Slovenia, data were collected from public sources and upon special requests to the relevant institutions that are systematically collecting and processing various health data and statistics such as:

- National Institute of Public Health / NIJZ
- Health Insurance Institute of Slovenia / ZZZS

- Pension and Disability Insurance Institute of Slovenia /ZPIZ
- Statistical Office of Republic of Slovenia / SURS
- Central Data-base of Medicines / CBZ

Each data category is obtained by gender and 5-year age groups for all population, base reference, and separately for J45-46 and J44.

## Hospital care

In Slovenia, hospitals report on realized hospital care to the National Institute of Public Health (NIJZ). Acute hospital care is reported following the DRG framework. For all hospitalisations, main diagnoses are reported. We collected data on hospitalisations for main diagnoses asthma and COPD, as well as data on all diagnoses as base reference; in terms of number of cases and number of days. Hospital care includes "cases" of:

- acute hospitalisations based on DRGs (divided into following types: hospitalisations with overnight, daily, long-term daily and other types)
- non-acute hospitalisations such as long-term nursing care and palliative care (divided into the same types: hospitalisations with overnight, daily, long-term daily and other types)

In order to estimate the cost of hospital care, value was assigned to the collected volume data on hospitalisations. For reference base the weighted average DRG cost/case of EUR 1,841.88 was applied (av. DRG cost x av. number of realised weights/DRG).<sup>32</sup> For acute daily DRG, an average DRG cost of EUR 1,212.64 was applied, and for non-acute cases, an average hospital day of EUR 111.37 was applied. For asthma and COPD related hospitalisations we obtained the data by DRG type and therefore used the corresponding monetary value for each DRG. The estimated costs of hospital care are given in Table 12, while the age distribution of hospital care costs for base reference, as well as asthma and COPD are shown in Figure 53 and Figure 54 in the Appendix.

	COPD	Asthma	Total	% of base reference	Base reference
Acute hospitalisations	3.71	1.86	5.57	0.9%	611.87
Non-acute hospitalisations	0.31	0.27	0.58	7.7%	7.46
Total	4.02	2.13	6.15	1.0%	619.32

Table 12: Costs of hospital care in Slovenia (million EUR)

<sup>&</sup>lt;sup>32</sup> The annual report on DRG realisation 2014 is available on

https://partner.zzzs.si/wps/portal/portali/aizv/zdravstvene\_storitve/plan\_in\_realizacija/podatki\_o\_planu\_in\_realizaciji \_zdrav\_storitve/lut/p/z1/jZA7DsIwEETPwgk8jh0nlCsgeAORBSgf3KBUyBIECsT5oaABgcl2K703uxrhRSf80N\_Dsb-Fy9Cfnvvem4OWC14qB3ZZqUHkGmqqnQR (Accessed: 30/06/2017).

A very good match between the cost of all hospitalisations, estimated via the bottom-up approach as described above, and the top line cost as reported by ZZZS was observed, thereby verifying the performed data systematisation and cost estimation through the applied bottom-up approach: EUR 619.32 million (bottom-up) vs. 612.8 (top line; ZZZS, 2014a).

#### Outpatient care

Outpatient care data were collected separately for primary and secondary health care levels. The number of units of outpatient care (including visits, examinations and lab tests) was obtained from NIJZ, database ZUBSTAT. The monetary value was calculated based on the price-list of unit care as defined in the General Agreement of 2014, the main document for health care provision and financing in Slovenia.

For the base reference we obtained the number of outpatient care units both preventive and curative split by gender and 5-year age groups from 0-20 and 10-year age groups from 20 onwards. In order to obtain 5-year age group profiles, the value of the 10-year age groups were split according to the cohort size of the corresponding 5-year population group. All units of care were sorted by type which was the key in applying the appropriate monetary value to each unit. There were 13.7 million visits (=units of care) provided by the outpatient physicians in Slovenia in 2014, 65% of them or 8.9 million visits were to the general practitioners and 35% or 4.8 million. This estimation is EUR 30 million or 22% below the expenditure for primary health care visits reported by National Health Insurance Institute/ZZZS in the Annual report 2014. The difference however seems to be acceptable as ZZZS report includes additional health care provisions (e.g. anticoagulation services, application of hospital drugs and infusions etc.) that are not captured in ZUBSTAT statistics. The average cost of unit care at primary level is estimated to be EUR 13.4.

Bottom-up costing of visits on secondary level yielded much bigger difference of estimated costs in comparison with the data reported by ZZZS, EUR 75 million vs. EUR 166 million. The main reason for such a big discrepancy was that our bottom-up costing method included only the value of visits without medical examinations and tests performed by the specialists. To minimise this difference and to capture the missing costs of medical examinations we applied top-down costing method by splitting the total value of care at the secondary level equally between all the visits. This approach gave us an estimation of outpatient care at secondary level to be EUR 164 million with average unit care cost of EUR 34.26.

Services of the outpatient care are classified by ICD-10 only when the first care (=visit) in a calendar year takes place. The first visit includes the on-set of an acute condition, the on-set of a chronic condition and an acute exacerbation of the earlier diagnosed chronic condition. For J44 and J45-46 we therefore obtained only the numbers of so-called 1st visits in the year. Given that first visits include both newly diagnosed patients and patients with already

confirmed diagnoses but with exacerbations, we assumed that at least 90% of patients would visit their physician again in the same calendar year. This is a very conservative estimation, but due to the lack of any reliable source of data we decided to be more pessimistic rather than overestimate the costs. The split of follow-up visits between primary and secondary levels, gender and age was maintained. Costing of visits was done in a bottom-up manner by considering the type of visit (1st or follow-up, curative or preventive, by primary or secondary level physician). To be consistent with the reference base, we added the cost of medical examinations to the visits performed by the specialists which is the average cost of 1 functional breathing test of EUR 64.03.

We estimate that there were 45,000 and 32,000 of visits attributed to asthma to primary and secondary outpatient physicians in 2014, respectively. The total cost was EUR 2.3 million (0.8% of base reference) split by EUR 0.5 million and EUR 1.8 million between primary and secondary levels respectively.

The estimated number of visits attributed to COPD was 28,000 and 17,000 to primary and secondary outpatient physicians in 2014, respectively. The total cost was EUR 1.3 million (0.5% of base reference) split by EUR 0.3 million and EUR 1.0 million between primary and secondary levels respectively.

Table 13: Number	of visits to outpatie	nt physicians in Slo	venia in thousand	s, 2014
	Poforonco baso	Asthma	COPD	

	Reference base	Asthma	COPD
Primary level	8,865	44.6	28.2
Secondary level	4,780	31.9	16.9
Total	13,640	76.5	45.1
TOLAI	13,040	76.5	43.

Source: National Institute of Public Health Slovenia (2016), illustrated by VI vis (2017)

	Reference base	Asthma	COPD
Primary level	121.4	0.5	0.3
Secondary level	163.7	1.8	1.0
Total	285.0	2.3	1.3

Table 14: Cost of outpatient care in Slovenia in million EUR, 2014

Note: the monetary value was calculated based on the price-list of unit care as defined in the General Agreement of 2014.

Source: National Institute of Public Health Slovenia (2016), illustrated by VI vis (2017)

#### Rehabilitation in rehabilitation centres

In this study, costs related to rehabilitation in rehabilitation centres are included, but not those related to outpatient rehabilitation. This is valid for reference base as well as for asthma and COPD. At rehabilitation centres, patients can stay either in the inpatient or outpatient part of the centre. We collected bottom-up data from NIJZ on both types of patient stay; for asthma, COPD, and all diseases. According to the systematisation used by NIJZ,

the data we were provided on hospitalisations and inpatient parts included categories hospitalisations with overnight, daily care, and long-term daily care. Number of patients and number of rehabilitation days were provided for the inpatient part, while number of patients for the outpatient part, respectively. For the lacking number of days, an average number of days per patient in outpatient care rehabilitation programs of 2.25 days was estimated based on ZZZS Annual report 2014 (ZZZS, 2014a), and was imputed accordingly.

Costing was done based on the General Agreement (ZZZS, 2014b), taking into account the value of a non-medical care day of EUR 40.05, of a medical care day of EUR 50.93, and of the 1st medical care day for a patient in inpatient care of EUR 90.93, respectively.<sup>33</sup> The total cost of rehabilitation in rehabilitation centres for all diseases (base reference) in 2014 was EUR 42.85 million, while the respective costs for asthma (EUR 0.34 million) and COPD (EUR 0.01 million) together represented 0.8% of the base reference. For the base reference, ZZZS Annual report gives EUR 27.8 million (ZZZS, 2014a). The difference is due to the different number of days of hospitalisations reported by NIJZ (413,190 days) and ZZZS (285,034). One of the explanations is that NIJZ figure includes days paid out-of-pocket, whereas ZZZS data does not. The estimated cost of EUR 42.85 million seems to be acceptable. The detailed age split of rehabilitation costs is presented in Figure 55 and Figure 56 in the Appendix.

#### Prescribed medicines

For the cost factor prescribed medicines, we followed the bottom-up approach. We were provided following data on drugs by the National Institute for Public Health (NIJZ): number of defined daily doses (DDDs), number of prescriptions and value of prescribed drugs in Slovenia in 2014, by age and gender. The value of prescribed medicines included the price of drugs, the value of the pharmacist's service, and VAT. All these drugs are covered by public insurance/additional insurance/co-payment to full price out of pocket, where applicable. We collected data on drugs for asthma and COPD – these were all individual drugs from ATC group R03, level 5, as well as data on drugs for base reference – these were all drugs from all ATC groups.

In Slovenia, no data on diagnoses for the prescribed drugs are available. We therefore estimated the split between drugs used for asthma and those used for COPD, which is shown in Figure 28. The estimation was based upon a) approved labels of individual drugs, b) treatment guidelines such as GOLD (2016) and GINA (2016), and c) findings from an

sjlKsaF14JF9ZiVr7oIM7CG8UdG9AodOGUJhaWo1Uqm1ZlfMZogCekscf0jgtnwE4X98Bf0\_UTVgi7RfGNRtb4E58gN zFfyO3S9v2mOgJK (Accessed: 30/06/2017).

<sup>&</sup>lt;sup>33</sup> Price list of unit care to the General Agreement of 2014 is available on <u>https://partner.zzzs.si/wps/portal/portali/aizv/sifranti/!ut/p/z1/jY\_BCsIwEEQ\_aTc2TesxqDUbDUGlabsXyUkCWj2I36-IFw\_Gzm3gzQwDDD3wGB\_pFO\_pOsbzyw-</u> sjlKsaF14JF9ZiVr7oIM7CG8UdG9AodOGUJhaWo1Ugm1ZlfMZogCekscf0jgtnwE4X98Bf0\_UTVgi7RfGNRtb4E58gN

Austrian statistical evaluation of data on drugs (Filzmoser and Mert, 2012). Value and volume split of R03 drugs, used for COPD and asthma, are shown in Table 15.



Figure 28: ATC R03 drugs in Slovenia split between COPD and asthma

Table 15: Value and	volume split of R03	drugs used for	COPD and	asthma in Slovenia
---------------------	---------------------	----------------	----------	--------------------

50.3%	49.7%
51.3%	48.7%
	50.3% 51.3%

Source: VI vis (2017)

The total value of all drugs from all ATC groups prescribed in Slovenia in 2014 amounts to EUR 432.29 million, while drugs from the R03 group amount to EUR 21.33 million, presenting 4.9% of the base reference. The consumption of all prescription medicines as well as medicines for asthma and COPD in Slovenia in 2014 by age and gender is given graphically in the Appendix (Figure 57, Figure 58, Figure 59).

#### Medical devices

The assumptions were done that for asthma, no medical devices are used, while for COPD, some patients use oxygen, in the home-setting mainly. Based on our data request, ZZZS provided us with the number of patients using oxygen in 2014: 584 "old" + 355 "new" patients. The total value of oxygen treatment reported by ZZZS was EUR 668,286.13.

For the base reference, we used top-line data that are available from ZZZS (2014a). They include the expenditures of the obligatory health insurer for all medical devices, and they amount to EUR 58.50 million. A split by gender and age is not available.

#### 7.3.3. Direct non-medical costs

#### Absence from work: sick-leaves and nursing

In Slovenia, absence from work is divided into sick-leaves and nursing, e.g. taking care of a sick child or another family member needing care. Sick-leave is compensated by the employer for a period of up to 35 calendar days; thereafter it is paid by the Health insurance (ZZZS). Nursing, however, is covered by the Health insurance from 1st day on.

We collected age- and gender-specific data on absence from work from NIJZ, in terms of number of cases and number of calendar days constituting these cases. We were provided data on absences from work due to COPD, due to asthma, and due to all diseases (base reference). We received data on absences that were paid by employers, and those paid by ZZZS. For the purpose of our study, as direct non-medical cost category only those paid by ZZZS were taken into account. They included both sick leave days as well as nursing days.

A check of the bottom-up approach was performed for the number of all days of absence from work for the base reference. A good match (96.1%) was found between the number of days provided by NIJZ, and those reported as top line data in the ZZZS Annual report (ZZZS, 2014a).

In order to assign a value to the days of absence, average daily allowance was calculated from top line data that are available from the ZZZS Annual report (ZZZS, 2014a). An average daily allowance of EUR 30.76 was calculated based on the total allowance amount paid by ZZZS, and the total number of sick-leave and nursing days. The costs were calculated as number of days multiplied by average daily allowance. The total direct cost of all absences from work (base reference) in 2014 was EUR 225.55 million, while the respective costs for asthma (EUR 0.44 million) and COPD (EUR 0.21 million) together represented 0.3% of the base reference. The detailed age split of allowances related to absence from work that were covered by ZZZS is presented in Figure 60 and Figure 61 in the Appendix.

#### **Disability pensions**

Base reference data including the number of full-year and new-entry beneficiaries as well as average monthly pensions split by gender and age groups, were provided by ZPIZ. <sup>34</sup> The overview is presented in the table below. Records of ZPIZ however do not track diseases. Therefore asthma- and COPD-related data are not available.

<sup>&</sup>lt;sup>34</sup> Data are available on file at the Study Sponsor.

Table 16: Number of disability	pension beneficiaries	and pay-outs	in million EUR in
Slovenia, 2014			

	No of beneficiaries	Av. monthly pension, EUR	Total disability pension pay-outs, million EUR
Full-year beneficiaries	86,696	473.79	492.9
New entries	1,818	435.69	9.5

Source: Pension and Disability Insurance Institute of Slovenia /ZPIZ (2016), illustrated by VI vis (2017)

According to the data from the University Clinic Golnik (the main centre for pulmonary and allergic disease in Slovenia) there are very few patients in Slovenia who retire prematurely because of asthma and COPD. The specialised disability commission is in the University Clinic Golnik, it approves 3-4 new cases/year for both conditions. New beneficiaries of disability pension due to asthma are on average around 50 years old and due to COPD 63 years old. Distribution of new beneficiaries between genders and diseases is equal.

Since the numbers of new and full-year beneficiaries caused by COPD or asthma are very small compared with the estimated total number of patients with these diseases (approx. 180,000), it is very likely that the effect from disability pensions is negligible. We therefore decided not to include this cost categorisation in the analysis.

#### Old-age pensions

Base reference data including the number of full-year and new-entry beneficiaries as well as average monthly pensions split by gender and age groups were provided by ZPIZ.<sup>35</sup> The overview is presented in the table below. Records of ZPIZ do not track diseases. Therefore asthma- and COPD-related data are not available. Disease-specific costs still emerge from the life-cycle model because old-age pension effects are driven by mortality improvements which are disease-specific (see explanations in chapter 6.2).

# Table 17: Number of old-age pension beneficiaries and pay-outs in million EUR in Slovenia, 2014

	No of beneficiaries	Av. monthly pension, EUR	Total disability pension pay-outs, million EUR
Full-year beneficiaries	431,158	613.79	3,175.2
New entries	14,463	563.62	97.8

Source: Pension and Disability Insurance Institute of Slovenia /ZPIZ (2016), illustrated by VI vis (2017)

<sup>&</sup>lt;sup>35</sup> Data are available on file at the Study Sponsor.

#### Widow/family pensions

Base reference data including the number of full-year beneficiaries and average monthly pensions split by gender and age groups were provided by ZPIZ.<sup>36</sup> Only aggregated data on new entries are available. The overview is presented in the table below.

# Table 18: Number of widow/family beneficiaries and pay-outs in million EUR in Slovenia, 2014

	No of beneficiaries	Av. monthly pension, EUR	Total disability pension pay-outs, million EUR
Full-year beneficiaries	94,552	386.54	439.0
New entries	8,373	239.18	24.0

Source: Pension and Disability Insurance Institute of Slovenia /ZPIZ (2016), illustrated by VI vis (2017)

Because widow/widower pension effects are connected with the old-age pension effects (see chapter 6.3.2), dropping this cost item will lead to a massive overestimation of the old-age pension effects. Therefore, we used the Austrian data for the age- and gender-specific transition probabilities into widow/widower pensions, rigorously assuming identical structures between Austria and Slovenia. Nevertheless, we rate this as a minor misspecification.

Age-specific costs still emerge from the life-cycle model because widow/widower pension effects are driven by mortality improvements which are disease-specific.

#### Disability benefits and assistance allowances

Base reference data including the number of full-year and new-entry beneficiaries as well as average monthly pensions split by gender and age groups were provided by ZPIZ.<sup>37</sup> The overview is presented in the table below. Records of ZPIZ however do not track diseases. Therefore asthma- and COPD-related data are not available. Though according to the data from the University Clinic Golnik disability and assistance allowances benefits due to CRD are so rarely suggested for the approval of the disability commission that they can be discarded for the purpose of this study.

# Table 19: Number of disability and assistance allowances beneficiaries and pay-outs in million EUR in Slovenia, 2014

	No of beneficiaries	Av. monthly pension, EUR	Total disability pension pay-outs, million EUR
Full-year beneficiaries	74,503	232.02	212.2
New entries	3,875	177.4	8.3

Source: Pension and Disability Insurance Institute of Slovenia /ZPIZ (2016), illustrated by VI vis (2017)

<sup>&</sup>lt;sup>36</sup> Data are available on file at the Study Sponsor.

<sup>&</sup>lt;sup>37</sup> Data are available on file at the Study Sponsor.

## 7.3.4. Indirect costs

The main source of data for the estimation of indirect or economic costs was the Slovenian Statistical office (SURS). Age- and gender-specific profiles of the labour force participation rate were provided by SURS. The overall labour force participation rate for 2014 is shown in Table 20. Active population of working age comprise employed and unemployed persons who are actively seeking for work.

# Table 20: Active population of working age in Slovenia

	Men	Women	Total
No of people	503,178	422,740	925,918
Share of population aged >15	58.1%	47.3%	52.6%

Source: Statistical Office of Republic of Slovenia (2016), illustrated by VI vis (2017)

Data on average monthly labour cost for employed and self-employed workers (wages in cash and in kind, social security contributions and other work-related costs) were provided by SURS. Monthly employer social contribution (compulsory and voluntary social contributions together with payments during the absence form work due to sickness, accidents, etc.) was estimated taking into account: the average mark-up of employer social contribution over gross salary of 16.1%, and the minimum value of monthly social contribution for self-employed workers. The monthly gross income and the employer social insurance contribution add up to the gross<sub>2</sub>-earnings or total labour cost (Table 21).

## Table 21: Estimated total labour costs in Slovenia

	Men	Women	Total
Monthly gross income	1,636.64	1,561.10	1,604.36
Employer monthly social insurance contribution	261.57	251.40	257.22

Source: Statistical Office of Republic of Slovenia (2016), illustrated by VI vis (2017)

Because the average gross<sub>2</sub>-earnings are given by wide age groups, we interpolated by cubic splines in order to estimate gender-specific 5-year age groups.

The average attendance rate profiles are derived from sick leave data (see the subchapter above "absence from work"). We were provided data on absences from work due to COPD, due to asthma, and due to all diseases (base reference). We received data on absences that were paid by employers, and those paid by ZZZS.

The calculation of the age- and gender-specific attendance rates follow on the same lines as described in chapter 7.2.4. The average sick leave days per employee are related not to 365 but to 345 days, because the holiday entitlements in Slovenia usually encompasses 20 working days and are prioritised over sick leave days. The data provided are categorised by COPD and asthma.

The following chapter presents the results of the burden of CRD in Austria and Slovenia.

# 8. Results

As described in the previous data chapter 7, the Austrian and Slovenian data sources needed for conducting the burden of disease analysis differ with respect to the completeness of diagnosis coding and availability of particular cost items. For Austria, we conducted the calculations for the whole CRD group (J40-J47) and did not split into COPD (J44) and asthma (J45-J46). In contrast, the Slovenian data allowed for the analysis of COPD and asthma separately. On the other hand, the level of detail of the Slovenian data was insufficient for directly calculating the disease effects of the non-medical cost items invalidity pension, care allowances and widow/widower pensions. Thus, the former are left out in the analysis. Because widow/widower and old-age pensions are intertwined, the Slovenian widow/widower pension effects were estimated from Austrian proportions.

These data differences between the two countries are responsible for the following depiction of the results of Austria and Slovenia which do not coincide with respect to diagnosis classes and cost items.

Further, direct medical costs of Austria were categorized according to SHA. The gap between the provided data and the published SHA category was closed by extrapolating to the reference base of the SHA category including all sources of funding (i.e. public and private financing schemes, HF.1), whenever the extrapolation error has been judged as reasonable. Otherwise, the reference base of the closest SHA subcategory was chosen. In contrast, the provided Slovenian data were not categorised according to SHA but according to the system of health data collection established by the National Institute of Public Health in Slovenia and included only those cost categories which were recorded with ICD split. Both asthma- and COPD-specific as well as the base values were estimated from the perspective of obligatory and additional (i.e. private) health insurances, and out-of-pocket payments where applicable. The reference base was therefore lower than the total health expenditures reported in Slovenia that besides health care insurances expenditures includes government, household and non-profit institutions serving household (NPSIH) expenditures.

We calculate the effects with two models – one-period and a life-cycle incidence model – by comparing the costs of the status quo in 2014 with the counter-factual conditions of a population in 2014 without being afflicted with CRD (see chapter 6.2). The output of the life-cycle model is the discounted sum of cost flows of each age group represented by the present value. The discount rate is fixed at 3%. In the next chapter we will relax this assumption (see sensitivity analysis of chapter 9). For a better comparison with annual base values, we transform the present values of each cost item into annuity due factors (discount rate 3%). These annuities are the main results of our analysis. The results of the one-period model are given for reasons of comparability with usual BoD studies.

The data chapter 7 gives the sources of the data and the base values for each cost item used for the models.

# 8.1. Economic burden of chronic respiratory diseases in Austria

Table 22 presents the results of the burden of CRD calculation for Austria with data of 2014. CRD comprise the ICD-10 classes J40-J47. The costs are classified into **direct medical**, **direct non-medical** and **indirect costs** (see chapter 4, p.34).

Table	22:	Costs	of	chronic	respira	tory	disease	(CRD)	in	Austria	according	to	one-
		perio	od n	nodel an	d life-cy	vcle r	nodel, 20	14					

	Costs in EUR Mio.	One-perio (excl. mortal	d model ity effects)	base value	Life cycle model - annuity (r = 3%) (incl. mortality effects)		
	calculated for 2014	CRD in % of base value		2014	Present value (r=3%)	Annuity (r=3%)	in % of base value
Direct medical cos	ts (Incl. SHA-classification): 1)	431.1	1.5%	28,456	5,973.3	266.7	0.9%
HC.1 x HP.1	Inpatient, day and outpatient curative care provided by hospitals	123.0	1.0%	11,928	509.0	-4.5	0.0%
HC.2.1 x HP.1	Inpatient rehabilitative care provided by hospitals	33.2	2.7%	1,222	528.3	18.8	1.5%
HC.1.3.1 x HP.3.1.1 HC.3.1.3 x HP.3.1.3	General and specialised outpatient curative care provided by medical practices	66.6	2.2%	3,012	1,093.7	40.4	1.3%
HC.4.3 x HP.4.1	Patient transportation <sup>2</sup> )	14.2	2.4%	586	-	14.2	2.4%
HC.5.1.1	Prescribed medicines	159.2	4.9%	3,240	3,842.2	162.8	5.0%
HC.5.2	Therapeutic appliances and other medical durable goods <sup>a</sup> )	35.0	2.4%	1,459	-	35.0	2.4%
Direct non-medica	l costs:	26.0	0.05%	55,204.9	49.8	3.5	0.01%
	Care allowances	10.8	0.43%	2,525	103.6	5.1	0.20%
	Sick benefits	5.0	0.74%	674	4 <b>115.8</b> 0 <b>671.</b> 4	4.3	0.63%
	Invalidity pensions	10.2	0.26%	3,936.0			0.65%
	Old-age and widow/widower pensions <sup>3)</sup>	-	-	48,070	-840.9	-31.4	0.07%
Indirect costs (economic productivity losses) <sup>1)</sup>			0.06%	330,420	6,350	237.9	0.07%
	Balance	643.6	0.19%	330,420	12,372.7	508.1	0.15%
	per capita (in EUR)	75				59	
	per capita diseased (in EUR)	881				695	
1) base value for produ	ctivity and balance: GDP						
<ol> <li>Due to lack of data, a</li> <li>One pariedia model</li> </ol>	annuities were set equal to one-period results						
Consequently, effect	ts on old-age & widow pensions merely proceed in the life-cycle model						

Source: IHS (2018)

#### Direct medical costs

The direct medical costs are categorized according to SHA and comprise in our analysis:

- Inpatient, day and outpatient curative care provided by hospitals (HC.1 x HP.1)
- Inpatient rehabilitative care provided by hospitals (HC.2.1 x HP.1)
- General and specialised outpatient curative care provided by medical practices (HC.1.3.1 x HP.3.1.1 + HC.3.1.3 x HP.3.1.3)
- Patient transportation (HC.4.3 x HP.4.1)
- Prescribed medicines (HC.5.1.1)
- Therapeutic appliances and other medical durable goods (HC.5.2).
The public and private health costs (= base value) of the category **inpatient, day and outpatient curative care provided by hospitals** (HC.1 x HP.1) are given by EUR 11,928 million in 2014 according to the official data published by Statistics Austria (2016). We estimate the cost effects of CRD in this cost category at EUR 123.0 million (or 1.0% of the base value) in the one-period model. The life-cycle model quantifies the overall life-cycle cost effects of the Austrian population at a present value of EUR 509.0 million (discounting rate 3%). This translates into an **annuity** of EUR **-4.5 million** (or **0.04%** of the base value). As explained in chapter 6.2, the difference arises from the increased longevity effects, which are incorporated by the life-cycle model, working in opposite direction of the improved morbidity effects solely considered by the one-period model. The age- and gender-specific profiles of estimated annuities of the hospital costs attributable to CRD are given in Figure 37, p. 117.

The cost effects of CRD in the SHA category **inpatient rehabilitative care provided by hospitals** (HC.2 x HP.1) amount to EUR 33.2 million (or 2.7% of the corresponding base value) in the one-period model. The life-cycle model quantifies the overall life-cycle cost effects at a present value of EUR 528.3 million, the corresponding **annuity** at EUR **18.8 million** (or 1.5% of the base value).

The CRD costs of the **general and specialised outpatient curative care provided by medical practices** (HC.1.3.1 x HP.3.1.1 + HC.3.1.3 x HP.3.1.3)<sup>38</sup> are estimated at EUR 66.6 million (or 2.2% of the base value) in the one-period model, the **annuity** of the life-cycle model at EUR **40.4 million** (or 1.3%). Again, the improved mortality of the counter-factual population decreases the saving effects of improved morbidity. Compared with the inpatient curative costs, the costs of CRD in the outpatient curative care sector are substantially higher on a percentage basis. This is due to the fact that CRD are mainly treated and monitored in the outpatient medical practices and that only the acute exacerbations of COPD or severe asthma attacks have to be treated in hospitals.

The substantial pharmaceutical costs are associated with the mentioned observation. The largest cost factors within the direct medical costs are the **prescribed** (and invoiced) **medicines** (HC.5.1.1) with EUR 159.2 million (or 4.9% of the base value) in the one-period model and EUR **162.8 million** (or 5.0%) as **annuity** in the life-cycle model. Again, the improved mortality decreases the effects of improved morbidity in the life-cycle model but here the overall net effect exceeds the effects of the one-period model. This result mirrors the characteristics of CRD namely that especially COPD and asthma are chronic but slowly progressive diseases which can be treated in the outpatient sector for a long time.

Due to lacking ICD-specific data, the CRD-attributable costs of **patient transportation** (HC.4.3 x HP.4.1), which include emergency rescues, were estimated from German results

<sup>&</sup>lt;sup>38</sup> Without dental practices.

(DESTATIS, 2010, table 5.3) at 2.4%. With the base value amounting to EUR 585.8 million for the SHA category HC.4.3 x HP.4.1 in 2014 in Austria (Statistics Austria, 2016, p.41), we fix the ballpark estimate for the one-period and the life-cycle model at EUR **14.2 million**.

Patients suffering from CRD particularly need therapeutic appliances for ventilation (e.g. liquid oxygen, oxygen concentrators, NIV-CPAP (*non-invasive ventilation with continuous positive airway pressure*), etc.). DESTATIS (2008) estimates the CRD-attributable costs of **therapeutic appliances and other medical durable goods** (HC.5.2) at 2.4%. With the base value amounting to EUR 1,458.7 million for this SHA-category in 2014 in Austria (Statistics Austria, 2016, p.89), we fix the CRD-associated costs of HC.5.2 for the one-period and the life-cycle model at EUR **35.0 million**.

The total (public and private) current health expenditures excluding long-term care expenditures as the base value amount to EUR 28,455.9 million in 2014. Summing up the cost items mentioned above, **direct medical costs** total EUR 431.1 million (or 1.5% of the base value) in the one-period model and EUR **266.7 million** (or **0.9%** of the base value) as **annuity** in the life-cycle model. This translates into EUR 31.2 per capita or EUR 364.9 per CRD patient, assuming an overall prevalence rate of CRD of 8.6% in Austria (data from ATHIS, Statistics Austria 2014). These findings are in line with international BoD studies (see chapter 5).

#### Direct non-medical costs

The cost items of the direct non-medical costs included in the analysis with Austrian data are:

- Care allowances
- Sick benefits
- Invalidity pensions
- Old-age pensions
- Widow/widower pensions

The public expenditures for informal **care allowances** totalled EUR 2,524.6 million in Austria in 2014 (= base value, see BMASK, 2014b, p.76, table 32). The CRD-attributable costs of care allowances are estimated at EUR 10.0 million (or 0.40% of the base value) in the one-period model. For this ballpark estimation we referred to international literature (see chapter 7.2.3). Because age- and gender-specific profiles of new beneficiaries are available, we calculated the cost effects along the same lines in the life-cycle model amounting to EUR **2.2 million** (or 0.09%) as **annuity**. Here, the improved longevity of all age cohorts strongly decreases the savings' effects caused by reduced new entries of beneficiaries. One reason for this strong effect is the rigorous assumption that beneficiaries follow the same survival functions as non-beneficiaries which is owed to lacking mortality data of the care allowance

beneficiaries. Hence, the given result is a lower limit of the expected CRD-attributable costs of care allowances. The same applies to the invalidity pensions.

The official **sickness benefits** are paid to employed people being absent from work due to sickness after the employer's obligation for continued payment of remuneration is exhausted. The total expenditures for sickness benefits amounted to EUR 674.0 million in 2014 (= base value, see chapter 7.2.3). The CRD-attributable costs of sickness benefit payments are estimated at EUR 5.0 million (or 0.74% of the base value) in the one-period model and at EUR **4.3 million** (or 0.63%) as **annuity** in the life-cycle mode. The effects of sickness during the employer's obligation for continued payment of remuneration are opportunity costs and are valued in the indirect cost category.

Public expenditures for **invalidity pensions** amounted to EUR 3,936.0 million in 2014 (= base value, see BMASK, 2014a). The CRD-attributable costs of invalidity pensions are estimated at EUR 10.2 million (or 0.26% of the base value) in the one-period model and at EUR **25.5 million** (or 0.65%) as **annuity** in the life-cycle model. Figure 45, p. 120, shows the annuity profile of invalidity pension costs attributable to CRD in Austria in 2014 by age groups. The cost profile peaks at age group 50-54 at EUR 4.15 million.

The **old-age pensions** are at first sight unrelated to health effects of CRD because the condition for obtaining old-age pension is age and not health. As described in chapter 6.3.2, these costs are so-called future unrelated costs which should be included from a theoretical point of view. These costs influence public spending merely via improved longevity. This means that any health policy improving mortality inevitably leads to negative effects of the cost item old-age pensions. Usually, the old-age pensions do not perish in case of decease because the title is devolved to some extent to the surviving dependants. Thus, we calculate the widow/widower pension effects and subtract them from the old-age pension effects.

Because the one-period model merely captures morbidity effects, old-age and widow/widower pension costs are only measured by the life-cycle model and not by the one-period model. The total expenditures for old-age and widow/widower pensions in 2014 amount to EUR 42,320.1 million and 5,750.1 million (BMASK, 2014a), respectively, in total EUR 48,070.2 million (= base value). The **annuities** of the CRD-attributable costs of **old-age** and **widow/widower pension** effects are estimated at EUR -47.3 million and 16.0 million, in total negative effects of EUR **-31.4 million** (or -0.07% of the base value).

Figure 45, p. 120, shows the annuity profiles of invalidity, widow/widower, and old-age pension costs attributable to CRD in Austria in 2014 by age groups. The cost profile of the old-age pensions peaks at age group 55-59 at EUR -5.96 million. As explained in chapter 6.3.2, the CRD-attributable old-age pension effects are negative, i.e. they are counter-running against the gains of hypothetically eradicating CRD in Austria because the improved

mortality is causing costs to the pension system. The net effects of all three pension titles (invalidity, widow/widower, old-age) sum up to EUR -5.9 million annuities in 2014 (Figure 45, p. 120).

#### Indirect costs

The indirect cost category measures the **economic costs** of CRD which are so-called opportunity costs because this cost item captures productivity losses caused by work absenteeism due to sickness, invalidity or premature death of the employed (see the data section 7.2.4). The human capital approach is implemented for quantifying these costs (see chapter 6.3.3). The natural base value is the GDP (gross domestic product) amounting to EUR 330,420.0 million in Austria in 2014. The CRD-attributable economic costs are estimated at EUR 186.5 million (or 0.06% of the base value) in the one-period model and at EUR **237.9 million** (or **0.07%**) as **annuity** in the life-cycle model (see Table 22, p. 90).

Figure 46, p. 120, gives the age- and gender-specific annuity profiles of the combined effects of sick leaves, invalidity and improved mortality of the labour force. The profiles peak between the ages 45 and 54 because the wages increase with age, and secondly, the morbidity and mortality effects of CRD start up in these age groups.

#### Total cost-of-illness

Summing up over all cost categories, we fix the **burden of chronic respiratory diseases** (J40-J47) **in Austria** in 2014 at EUR 643.6 million (or 0.19% of GDP) in the one-period model and at EUR **508.1 million** (or **0.15%** of GDP) as **annuities** in the life-cycle model. This translates into EUR 59.5 per capita or EUR **695.2 per CRD-patient**, assuming an overall prevalence rate of CRD of 8.6% in Austria (data from ATHIS, Statistics Austria 2014). These findings tend to be below the results of international BoD studies (see chapter 5), even if the old-age and widow/widower pension effects are left out. However, the per-patient results strongly depend on the accuracy of the estimated prevalence rate of CRD in the Austrian population.

#### 8.2. Economic burden of COPD and asthma in Slovenia

Contrary to Austrian data, the burden of disease in Slovenia is calculated for COPD (J44) and asthma (J45-J46) separately. Table 23 presents the results of the burden of COPD and asthma calculation for Slovenia with data of 2014. Again, the costs are classified into **direct medical**, **direct non-medical** and **indirect costs** (see chapter 4, p.34). The medical costs are not classified according to SHA and only data from public financing schemes and private

health insurers were used (i.e. funding of private households, etc. is not included). For reasons of clarity the present values of the life-cycle model are not given in the table of results.

Costs in EUR Mio.	One-period model (excl. mortality effects)			hase value	Life cycle model - annuity (r = 3%) (incl. mortality effects)				
calculated for 2014		Asthma J45-J46	Sum	in % of base value	2014	COPD J44	Asthma J45-J46	Sum	in % of base value
Direct medical costs:	16.9	15.2	32.1	2.23%	1,438.0	13.6	17.1	30.6	2.13%
Hospitalisations:	4.02	2.13	6.15	0.99%	619.32	1.36	1.89	3.24	0.52%
acute hospitalisations	3.71	1.86	5.57	0.91%	611.87	1.06	1.57	2.62	0.43%
non-acute hospitalisations	0.31	0.27	0.58	7.72%	7.46	0.30	0.32	0.62	8.30%
Rehabilitation care in rehabilitation centres	0.01	0.34	0.34	0.80%	42.85	-0.25	0.19	-0.06	-0.14%
Out-patient medical practices	1.25	2.36	3.61	1.27%	284.99	0.35	1.45	1.80	0.63%
primary/general practitioners' level	0.28	0.52	0.80	0.66%	121.36	-0.09	0.41	0.32	0.26%
secondary/specialists' level	0.97	1.84	2.81	1.72%	163.62	0.44	1.04	1.48	0.90%
Prescribed medicines	10.95	10.39	21.33	4.93%	432.29	11.44	13.53	24.98	5.78%
Medical devices (oxygen)	0.67		0.67	1.14%	58.50	0.67	0.00	0.67	1.14%
Direct non-medical costs:	0.21	0.44	0.65	0.02%	3,840.2	-1.29	0.25	-1.05	-0.03%
Sick benefits	0.21	0.44	0.65	0.29%	225.55	0.16	0.37	0.53	0.23%
Old-age pensions ²)	-	-	-	-	3,175.66	-2.84	-0.12	-2.96	-0.09%
Family/widow/widower pensions <sup>2</sup> )	-	-	-	-	439.03	1.39	0.0025	1.39	0.32%
Indirect costs (economic productivity losses) <sup>1)</sup>	0.92	2.01	2.93	0.008%	37,332	2.95	1.70	4.65	0.012%
Balance	18.0	17.7	35.7	0.10%	37,332	15.2	19.0	34.2	0.09%
per capita (in EUR)	9	9	17		,	7.4	9.2	16.6	
per capita diseased (in EUR)	212	171	189			179	184	182	

#### Table 23: Costs of COPD and asthma in Slovenia according to one-period model and life-cycle model, 2014

Consequently, effects on old-age & widow pensions merely proceed in the life-cycle model

Source: IHS (2018)

#### Direct medical costs

Contrary to the Austrian analysis, the particular cost items of the direct medical costs are not categorised according to the SHA definitions (see the remarks in the data chapter 7.3) but follows the categories of the provided data sources in Slovenia:

- Hospitalisations: •
  - Acute hospitalisations (DRGs incl. overnight, daily, long-term, palliative, etc.)
  - o Non-acute hospitalisations (long-term medical & palliative care incl. overnight, daily, long-term, etc.)
- Rehabilitation care in rehabilitation centres (inpatient and outpatient)
- Outpatient medical practices (curative and preventive visits)
  - Primary/general practitioners' level
  - Secondary/specialists' level 0
- Prescribed medicines

Medical devices (oxygen)

The public **acute** and **non-acute hospitalisation costs** total EUR 619.32 million (= base value) in Slovenia in 2014 according to the official data published by the Statistical Office of Republic of Slovenia (see chapter 7.3.2). We estimate the acute and non-acute hospitalisation cost effects of COPD and asthma in the one-period model at EUR 4.02 million and 2.13 million, respectively, totalling EUR 6.15 million (or 1.0% of the base value). The corresponding **annuities** of the life-cycle model for **COPD** and **asthma** amount to EUR 1.36 million and 1.89 million, respectively; in total EUR **3.24 million** (or **0.52%**). As described in the previous chapter, the lower values of the annuities stem from the increased longevity effects working in opposite directions of morbidity gains. Because the COPD mortality is higher than for asthma, the longevity effects of COPD are more pronounced leading to lower annuities compared to asthma.

The cost effects in the one-period model of the category **rehabilitation care in rehabilitation centres (inpatient and outpatient)** amount to EUR 0.01 million for COPD and EUR 0.34 million for asthma, in total EUR 0.34 million (rounded) or 0.8% of the corresponding base value. The life-cycle model quantifies the effects of COPD at EUR -0.25 million and of asthma at EUR 0.19 million. The sum amounts to EUR -0.06 million (or -0.14% of base value) and is dominated by the negative effects of COPD. The morbidity effects of COPD rehabilitation are apparently negligible whereas the longevity effects of COPD overcompensate the other effects.

The public costs of outpatient medical practices (curative and preventive visits) total EUR 285.0 million (= base value). These costs consist of the primary level amounting to EUR 121.36 million and of the secondary level amounting to EUR 163.62 million in Slovenia in 2014. The one-period model costs of COPD/asthma are estimated at EUR 0.28/0.52 million, in total EUR 0.80 million (or 0.66% of base value) at primary level, and EUR 0.97/01.84 million, in total EUR 2.81 million (or 1.72%) at secondary level. Thus, the costs of the medical specialists are more than 3 times higher than those of general practitioners. The outpatient costs for asthma exceed those for COPD, in contrast to the hospitalisation costs (see above), whereas the pharmaceutical costs are nearly balanced (see below). In the lifecycle model, the annuities of COPD/asthma are quantified at EUR -0.09/0.41 million, in total EUR 0.32 million (or 0.26% of base value) at primary level, and EUR 0.44/1.04 million, in total EUR 1.48 million (or 0.90%) at secondary level. Again, the longevity gains in case of COPD dominate the morbidity gains at the primary level such that the net effect is negative. Asthma is slightly impacted due to low mortality levels in each age-group. Summing up primary and secondary level, the annuities of COPD/asthma are estimated at EUR 0.35/1.45 million, in total EUR 1.80 million (or 0.63% of base value). Compared to Austria, the Slovenian results of the medical practices are lower approximately by half in relative terms.

The costs of all **prescribed** (and invoiced) **medicines** in Slovenia total EUR 432.29 million (= base value) in 2014. The costs for COPD and asthma in the one-period model are estimated by VI-vis d.o.o Slovenia from official data and international literature trying to separate COPD from asthma prescriptions (see discussion in chapter 7.3): COPD EUR 10.95 million and asthma EUR 10.39 million, in total EUR 21.33 million (or 4.93% of base value). This is the largest cost factor of COPD/asthma within the direct medical cost category by far. In the life-cycle model, we estimate the **annuities** of **COPD** effects at EUR 11.44 million and of **asthma** at EUR 13.53 million, in total EUR **24.98 million** (or **5.78%**). In the case of prescribed medicines, the morbidity effects overly dominate the longevity gains such that the results of the life-cycle model exceed those of the one-period model.

The cost item **medical devices** totalled EUR 58.5 million in 2014 (= base value). EUR **0.67 million** (or **1.14%** of base value) are attributable to COPD, mainly for oxygen treatment (see chapter 7.3.2). Data were not available for asthma, and neither were age profiles of COPD costs. Thus, we fixed the one-period costs for the annuity of the life-cycle model.

Summing up over all cost items mentioned above, **direct medical costs** of **COPD/asthma** total EUR 16.9/15.2 million, in total EUR 32.1 million (or **2.23**% of the sum of the subcategories' base values) in the one-period model, and EUR **13.6/17.1** million, in total EUR **30.6** million (or **2.13%** of the sum of the subcategories' base values) as **annuities** in the life-cycle model. This translates into costs for COPD and asthma together of EUR 14.9 per capita or EUR 159.7 per COPD patient and EUR 164.9 per asthma patient, assuming a prevalence rate of COPD of 4.1% and of asthma of 5.0% in Slovenia.<sup>39</sup>

In contrast to Austria, the Slovenian outcomes of the life-cycle and the one-period model do not differ much in the case of the medical costs. The overall morbidity gains are more or less compensated by the mortality gains in the Slovenian life-cycle model. One reason for this is the lower relative mortality of COPD/asthma in 2014: approx. 2% of all deaths in Slovenia compared to 3.4% CRD-attributable deaths in Austria. The share of non-COPD/asthma deceases in the CRD group (J40-J47) cannot explain the mortality rate differences between Austria and Slovenia, because the share amounts only to approx. 20% in Austria. On the other hand, the Slovenian overall prevalence rate of 9.1% is comparable to the Austrian rate of 8.6%, and the share of CRD costs of prescribed medicines is nearly identical in the one-period model.

#### Direct non-medical costs

The cost items of the **direct non-medical costs** included in the analysis of the Slovenian part are:

<sup>&</sup>lt;sup>39</sup> Source: European Health Interview Survey, wave 2/2014: the data were provided by the National Institute of Public Health of Slovenia.

- Sick benefits
- Old-age pensions
- Family/widow/widower pensions

The total expenditures for **sickness benefits** amounted to EUR 225.6 million in 2014 (= base value, see chapter 7.3.3). The COPD/asthma-attributable costs of sickness benefit payments are given by EUR 0.21/0.44 million, in total EUR 0.65 million (or 0.74% of the base value) in the one-period model. We estimated the **annuities** of **COPD/asthma** in the life-cycle model at EUR **0.16/0.37 million** (or 0.63%), in total EUR **0.53 million** (or **0.23%** of the base value).

The **old-age pensions** are at first sight unrelated to health effects of a particular disease because the condition for obtaining old-age pension is age and not health. As described in chapter 6.3.2, these costs are so-called future unrelated costs which should be included from a theoretical point of view. These costs influence public spending merely via improved longevity. This means that any health policy improving mortality inevitably leads to negative effects of the cost item old-age pensions.

The old-age pensions do not perish in case of decease because the title is devolved to some extent to the surviving dependants. These pension claims substantially reduce the negative effects of old-age pensions. Thus, family/widow/widower pensions are an important cost factor. Slovenian data of new entries into family/widow/widower pension were not available. Therefore, we applied the transition probabilities of Austria to the Slovenian data (see chapter 6.3.2). Admittedly, this is a strong assumption of equal transition probabilities into family/widow/widower pensions in Slovenia would have been substantially overestimated.

Because the one-period model merely captures morbidity effects, old-age and family/widow/widower pension costs are only measured by the life-cycle model and not by the one-period model. The total expenditures for old-age and family/widow/widower pensions in 2014 amount to EUR 3,175.66 million and 439.03 million, respectively, in total EUR 3,614,69 million (= base value). The **annuities** of the **COPD/asthma**-attributable costs of **old-age pensions** are estimated at EUR -2.84/-0.12 million and of **family/widow/widower pensions** at EUR 1.39/0.003 million. Thus, the net effects are negative at EUR **-1.45/-0.12** million. The net effects of COPD and asthma together total EUR **-1.57** million (or **0.04%** of the base value).

#### Indirect costs

The indirect cost category measures the **economic costs** of COPD and asthma. These costs are opportunity costs because they measure productivity losses caused by work

absenteeism due to sickness, invalidity or premature death of the employed (see the data section 7.3.4). The human capital approach is implemented for quantifying these costs (see chapter 6.3.3). Disease-specific invalidity data were not available in Slovenia. The corresponding Austrian data do not differ between COPD and asthma. Thus, we excluded the invalidity pensions as an input for the model and - contrary to the Austrian part of the analysis - calculated only the economic costs caused by absenteeism due to sickness in the one-period model and caused by absenteeism due to sickness and premature death of the employed in the life-cycle model.

The natural base value for the indirect cost category is the Slovenian GDP (gross domestic product) which amounts to EUR 37,332.0 million in 2014. The one-period economic costs attributable to COPD/asthma are estimated at EUR 0.92/2.01 million, in total EUR 2.93 million (or 0.008% of GDP). In the life-cycle model, the **annuities** of the **COPD/asthma**-attributable economic costs are estimated at EUR **2.95/1.70 million**, in total EUR **4.65 million** (or **0.012%** of GDP).

#### Total cost-of-illness

Summing up over all cost categories we fix the **burden of disease** of COPD at EUR 18.0 million and of asthma at EUR 17.7 million, in total EUR 35.7 (or 0.10% of GDP) in **Slovenia** in 2014 in the one-period model. The life-cycle model quantifies the corresponding **annuities** at EUR 15.2 million for **COPD** and at EUR 19.0 million for **asthma**, in total EUR **34.2 million** (or **0.09%** of GDP). This translates into annual per capita costs of EUR 17 for both diseases. The annual total per patient costs of COPD is estimated at EUR **179** and that for asthma at EUR **184**, assuming an overall prevalence rate of 4.1% and 5.0%, respectively.<sup>40</sup> As in the case of Austria, these findings tend to be below the results of international BoD studies with patients' record data (see chapter 5). However, the per-patient results strongly depend on the accuracy of the estimated prevalence rates in the Slovenian population.

<sup>&</sup>lt;sup>40</sup> Source: European Health Interview Survey, wave 2/2014, the data were provided by the National Institute of Public Health of Slovenia.

### 9. Sensitivity analysis

Before we applied our variant of a life-cycle model, we had to make assumptions concerning the key parameters of the model. One key parameter is represented by the discounting rate, which we fixed at 3% for the main scenario; another is the reference population structure, for which we took the actual age pyramid of the year 2014.

In the following sensitivity analysis, we change some of these key parameters in order to evaluate to which extent the results are changed in consequence. If, for instance, a parameter change of 10% (compared to the basic model) alters the money value of the results by more than 10%, we can attest a high reactivity of the model to this specific parameter, and vice versa. Due to the long time horizon, the life-cycle model is especially affected by parameter changes. Therefore, the results of the conducted sensitivity analysis will be presented merely for the multi-period life-cycle model.

We will test the following parameters: discounting rate, mortality rates, additional secondary diagnosis DRG points for CRD, alternative productivity measure, alternative population structure and excluding unrelated future costs, i.e. old-age and widow/widower pensions.

The intention of this non-probabilistic sensitivity analysis is to give a picture of the sensitivity of the model output with respect to the model input parameters. The pattern of progress of the diseases COPD and asthma, which are the key cost factors of CRD, is similar in Austria and Slovenia. These patterns determine the observed age- and gender-specific distributions of cost factors and largely influence the outcomes of the life-cycle models. Table 24 gives the results of the sensitivity analysis of the Austrian model. We report only the results of the sensitivity analysis of the Austrian model.

Sensitivity Analysis		direct medical costs		direct non- medical costs		indirect costs		total	
		annuities in Mio. Euro	changes in % of basic model						
basic model:	discounting rate 3% population and age pyramid of 2014 mortality rates of 2014 productivity measure: average gross2 wages	266.7		3.5		237.9		508.1	
discounting rate	1%	222.7	-16%	-19.5	-659%	215.4	-9%	418.7	-18%
mortality rates of CRD	-10% +10%	297.2 295.4 237.9	11% 11% -11%	7.3	111% -278%	231.8 244.0	-3% 3%	534.6 475.7	5% -6%
side diagnosis of hospital DRG	increase of DRG points by 29%	319.8	20%	3.5		237.9		561.2	10%
productivity measure	GDP per capita employed	266.7	-	3.5	-	363.8	53%	633.9	25%
	uniformly distributed (no age pyramid)	291.7	9%	21.8	527%	195.9	-18%	509.5	0%
nonulation structure	population of 2014 at age 0	98.5	-63%	3.4	-1%	126.0	-47%	227.9	-18% 11% 5% -6% 10% 25% 0% -55% 0% 41%
population structure	population of 2014 at age group 20-24	251.9	-6%	7.6	118%	250.2	5%	509.7	0%
	population of 2014 at age group 40-44	340.5	28%	5.7	63%	370.5	56%	716.7	41%
old-age and widows/widowers pensions (representing unrelated future costs)	excluded	266.7	-	34.8	901%	237.9	-	539.4	6%

#### Table 24: Results of the sensitivity analysis of the Austrian life-cycle model

Source: IHS (2018)

#### Discounting

By changing the **discount rate** of 3% of the basic scenario to 1% and 5% (= -/+ 66.6%), the total costs decrease by 18% and increase by 11%, respectively. The difference in the outcome is caused by the nonlinear behaviour of the life-cycle model. At first glance, the model seems to be very inelastic with respect to the discount rate. This is surprising because the discount rate non-linearly and increasingly penalises future cash flows the longer the time horizon of younger age cohorts becomes. However, the complete discounting term is (1+r), such that the percentage de- and increase of the discounting term (of 1.01 and 1.05) is actually -/+1.9%. Thus, we conclude that our model is indeed very sensitive to changes of the discount rate.

The model works in the opposite direction of the discount rate which is a feature of discounting: The higher the discount rate, the higher the penalty of future cash flows being discounted to the present value. In our model, the sum of present values is transformed into annuities due (see chapter 6.2) to relate the results to annual reference bases. By calculating annuities, the age- and gender-specific present values are distributed back – figuratively speaking – into future (but constant) cash flows. These annuities due are presented in Table 24. This operation moderates the discounting effect and sometimes reverses the qualitative outcomes compared to the sum of present values, depending on the magnitude of the cost effects of older age groups (as in the case of direct non-medical costs with r=5%, not presented).

Generally speaking, the more the incurred costs are located at older age groups, the more sensitive does the model react to changes of the discount rate. We can read off this mechanism from the results of the cost categories in Table 24. The changes to the model outcomes of the direct non-medical costs are very elastic, whereas those of the direct medical and indirect costs are (still elastic with respect to the discount rate but) more insensitive relative to the outcomes of the non-medical costs. One reason for that is the lower share of the medical and economic costs accruing in older ages, whereas the non-medical costs are dominated by the old-age pension effects accumulating in older ages. The other reason is a pure mathematical effect of the low value of the reference base of the non-medical costs.

#### Mortality

The same mechanism comes into effect when changing the official **mortality rates** by - /+10% in each age group. Table 24 shows the model outcome in the category non-medical costs. Because the number of deaths increases with age, the effects of invalidity and old-age pensions dominate and are very elastic. In contrast, the reaction of indirect costs is inelastic because the labour force is located in the middle-aged cohorts which exhibit lower mortality rates. The indirect costs dominate the total costs being insensitive, too.

Interestingly, the medical costs are relatively elastic, revealing the counter-running effects of morbidity and mortality in the life-cycle model. Usually, BoD studies hypothetically assume the extinction of a specific disease without competing risks compensating the health gains of the eliminated disease. Our variant of the life-cycle model makes this assumption as well, but simultaneously incorporates morbidity as well as mortality effects. Now, if CRD are hypothetically obliterated, the direct medical costs per capita decrease, but at the same time the higher longevity causes additional costs which could (at least partially) compensate for the morbidity gains. By lowering the mortality rates in the sensitivity analysis, the morbidity

#### LKF secondary diagnoses

The quality of the Austrian data was discussed with a scientific advisory board. One topic covered the under- and misreporting of CRD in the hospital diagnosis groups. The advisory board agreed that there is a certain degree of underreporting of CRD in the LKF data. In order to account for the potential underreporting, we extracted those cases with **secondary diagnosis of CRD** (J40-J47), see Table 25.<sup>41</sup> In a second step, we tried to link CRD to the specific main diagnosis (marked in the table) and to give a rule-of-thumb estimate of the share of hospital stays attributable to CRD. We calculated 7,267 additional stays caused by CRD, representing 29.3% of the stays with CRD as major diagnosis. Next, we accordingly increased the LKF points (but only for the age groups 40 upwards assuming that younger age groups are not affected by these secondary diagnoses) and ran the model. Table 24 shows the results.

# Table 25: Number of hospital stays with secondary diagnosis CRD (J40-J47) in 2014 inAustrian fund hospitals and rough estimation of CRD-attributable staysaffected by underreporting



Source: Austrian Ministry of Health, calculations by IHS (2018)

Because the share of the hospital costs in the direct medical costs does not exceed one third, this parameter change has an insensitive effect on the overall direct medical costs

<sup>&</sup>lt;sup>41</sup> The data have been kindly provided by the Austrian Ministry of Health.

(EUR +33.4 million or +7.8%) in the one-period model (not presented). However, the isolated increase of the annuity value of the hospital cost category (SHA: HC.1 x HP.1) reaches EUR 53.1 million or +20% of the direct medical cost category in the life-cycle model, compared to the basic scenario. The model seems to be sensitive with respect to the amount of LKF points and their monetary value. Thus, under- and misreporting of the LKF diagnosis influence the medical costs' results suggesting further research in this topic.

The reason for the observed sensitivity is again the mechanism mentioned before: The distribution of LKF points attributable to CRD is heavily asymmetric towards older age groups (see Figure 36, p. 117). In the basic scenario, the annuities due of the older age groups are negative and dominate the overall effect (see Figure 37, p. 117). This turns over to positive net effects when the secondary diagnoses are incorporated in the model. The reason for this result is that the middle age groups profit most in relative terms by augmenting the hospitals stays with secondary diagnosis of CRD. We get similar figures for the above discussed scenario of decreasing the mortality rates instead of augmenting the LKF points as a measure of morbidity, confirming our interpretation of the working mechanism of the life-cycle model.

#### Productivity measures

The marginal productivity in the basic scenario is approximated by the gross<sub>2</sub> wages (see chapter 7.2.4). Some BoD studies utilise GDP per capita. Following this concept, we calculated with **GDP per capita employed**, because the aggregate value added of an economy is mainly generated by the employed people. Not unexpectedly, this parameter change heavily increases the annuity of the indirect cost category and of the total costs by 53% and 25%, respectively. In terms of GDP, the total costs of CRD rises from 0.15% to 0.19% of GDP in 2014.

#### Population structure

Next, we examined the effect of the population structure on the model outcomes. The actual age pyramid in Austria is centred on the age groups 45-49 and 50-54. By **uniformly distributing** the population of each gender over their age groups, the absolute numbers of the middle-aged cohorts are decreased and older and younger cohorts are increased. This assumed distribution cuts the size of the labour force and consequently the annuities of the indirect costs. Because the net effects of the counter-running morbidity and mortality factors are positive in the middle-aged cohorts, the population cut decreases the gains in the direct medical cost category, too. The direct non-medical cost category, however, experiences an improvement of the overall annuity effects from EUR 3.5 million to EUR 21.8 million. This shift is caused by shortening the longevity of the beneficiaries of old-age pensions by allocating more persons into the senectitude cohorts of 70+. In sum, this scenario increases the annuity net effects only marginally.

An alternative scenario allocates the population of each gender into **one single age cohort**. We calculated the model for the age groups **0**, **20-24** and **40-44**. The **direct medical costs** of the age cohort 0 are heavily cut by -63%, the cohort 20-24 by moderate -6%, whereas the medical costs of the cohort 40-44 rise by +28%, compared to the basic scenario. The main drivers of the medical costs are the hospitals and the costs for prescribed pharmaceuticals. The age distribution of the hospital cost annuities reveals a moderate peak in the middle-aged cohorts and turns into negative values around the age 60+ (see Figure 37, p. 117). The hospital cost annuities sum up to EUR -4.5 million in the basic scenario. The distribution of the annuities of the costs of prescribed pharmaceuticals shows a distinct peak at the age cohorts 45-60 and never turns into negative effects. Their annuities sum up to EUR 162.8 million.

The characteristics of the two factors explain the outcomes: The cohort 0 faces a long time span before its members reach the costly age groups 60+. Heavily discounting reduces the negative effects of the hospital costs in the elderly as well the positive effects in the middle-aged. Because the less discounted positive effects dominate the negative effects, the sum of the hospital cost annuities increases to a positive value of EUR 7.9 million or by +276%, compared to the basic scenario. The cohorts 20-24 and 40-44 experience a more moderate discounting of the hospital costs. Their net effects rise even more, namely to EUR 24.7 million and EUR 40.6 million, respectively.

In contrast, the discounting of the age-specific pharmaceutical costs causes the sum of their annuities to decrease by EUR -150 million (-92%) for the cohort 0 and by EUR -52 million (-32%) for the cohort 20-24. Continuing this trend, the cohort 40-44 sees an enlargement of their net annuities by EUR +17.1 million (+11%), compared to the basic scenario. This is simply caused by the concentration of the whole population in the middle-aged cohorts with the highest annuities where the discounting reveals no influence.

In the category of the **direct non-medical costs**, the net effect of the basic scenario is negative, because the costs of old-age pensions dominate. This relation remains unchanged in the sensitivity analysis but is mitigated by the longer time horizon of discounting in the alternative scenarios of concentrating the whole population within the cohort 0 and 20-24. In the cohort 40-44 scenario, the discounting effects are finally lower than those effects of the basic scenario such that the old-age pension effects increase the net costs of the direct non-medical cost category by EUR -29 million (-36%). It is worth mentioning that the invalidity pensions, care and sick leave allowances increase on the same lines with decreasing discounting horizon but do not compensate the old-age pension effects.

The **indirect costs** decrease in the cohort zero relative to the basic scenario by -47%, again due to discounting over a longer time period. For the cohort 20-24 and 40-44 scenarios, the net effects increase by +5% and +56%, respectively, because the whole population is

concentrated on the productive middle-age cohorts. The net effect of the cohort 40-44 is larger than that of the cohort 20-24 due to increased average wages of older employees.

#### Old-age pensions

In our variant of the life-cycle model, we incorporated old-age and widow/widower pension effects representing a type of future costs which, at first glance, are unrelated to the disease under investigation. The increase in longevity after the hypothetical eradication of a specific disease generates non-medical costs. The inclusion of these so-called unrelated future costs is still a matter of debate in the health economics literature (see chapter 6.3.2). We decided to incorporate old-age and widow/widower pension effects in our base scenario.

In order to capture the magnitude of these pension effects, we therefore calculate one scenario **without the old-age** and **widow/widower pension** effects. The net effects of the direct non-medical costs rise now from EUR 0.6 million in the base scenario to EUR 34.8 million in this scenario. This corresponds to an enormous increase of the non-medical costs by +901%. The effects on the total costs, however, are small (+6%) in relative terms.

### References

- AMS (2015): Arbeitsmarktlage 2014 [Labour market situation 2014]. Austrian Public Employment Service. Table 1.
- Austrian LEAD Study (2016): Vergleich der Studienergebnisse mit ärztlicher COPD-Diagnose [Comparison of study results with physician diagnosed COPD]. Infographic. Retrieved from <u>https://www.leadstudy.at/download/</u> [Accessed: 12/04/2017].
- AUVA (2015): Jahresbericht 2014. Ausgabe Dezember 2015 [Annual report 2014. Edition December 2015]. Austrian Workers' Compensation Board.
- BKA (2014a): New entries in invalidity pension 2014. Austrian Federal Chancellery.
- BKA (2014b): The Austrian Federal Civil Service 2014. Facts and Figures. Vienna: Austrian Federal Chancellery.
- BMASK/Statistics Austria (2014a): ESSOSS database. Austrian Federal Ministry of Labour, Social Affairs and Consumer Protection.
- BMASK (2014b): Österreichischer Pflegevorsorgebericht 2014 [Austrian long-term care report 2014]. Austrian Federal Ministry of Labour, Social Affairs and Consumer Protection.
- BMG (2010): Das österreichische LKF-System [The Austrian LKF system]. Austrian Federal Ministry of Health.
- BMGF (2016): Krankenanstalten in Zahlen [Hospitals in numbers]. Austrian Federal Ministry of Health and Women's Affairs. Retrieved from <u>http://kaz.bmg.gv.at/startseite.html</u> [Accessed: 26/04/2017].
- Burney, P., Jithoo, A., Kato, B., Janson, C., Mannino, D., Niżankowska-Mogilnicka, E., Studnicka, M, Tan, W., Bateman, E., Koçabas, A., Vollmer, W. M., Gislason, T., Marks, G., Koul, P. A., Harrabi, I., Gnatiuc, L., Buist, S. (2014): Chronic obstructive pulmonary disease mortality and prevalence: the associations with smoking and poverty—a BOLD analysis. Thorax, 69: 465-473.
- Dal Negro, R. W., Tognella, S., Tosatto, R., Dionisi, M., Turco, P., Donner, C. F. (2008): Costs of chronic obstructive pulmonary disease (COPD) in Italy: the SIRIO study (social impact of respiratory integrated outcomes). Respiratory medicine, 102(1): 92-101.

DESTATIS (2008): Cost of illness, Germany 2008.

- DESTATIS (2010): Krankheitskosten 2002, 2004, 2006 und 2008 [Cost of illness 2002, 2004, 2006 and 2008], Fachserie 12, Reihe 7.2, Wiesbaden 2010: Statistisches Bundesamt.
- DESTATIS (2016): Diagnosedaten der Patienten und Patientinnen in Vorsorge- und Rehabilitationseinrichtungen 2015 [Diagnosis data of patients in prevention and rehabilitation facilities 2015]. Wiesbaden: Statistisches Bundesamt.
- Ehteshami-Afshar, S., Fitzgerald, J. M., Doyle-Waters, M. M., Sadatsafavi, M. (2016): The global economic burden of asthma and chronic obstructive pulmonary disease. The International Journal of Tuberculosis and Lung Disease, 20(1): 11-23.
- ERS (2012): An International Comparison of COPD Care in Europe. Results of the First European COPD Audit. European Respiratory Society.
- Eurostat (2014): People reporting a chronic disease, by disease, sex, age and educational attainment level [hlth\_ehis\_st1]. Retrieved from <a href="http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=hlth\_ehis\_cd1e&lang=en">http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=hlth\_ehis\_cd1e&lang=en</a> [Accessed: 09/02/2017].
- Filzmoser, P., Mert, C. (2012): Statistische Evaluation der Medikamentendaten Cut-off Bestimmung für COPD [Statistical evaluation of pharmaceutical data – determining the cut-off for COPD]. Working paper, Department of Statistics and Probability Theory, Vienna University of Technology, Austria. Retrieved from http://www.hauptverband.at/cdscontent/load?contentid=10008.566552&version=139118 4727 [Accessed: 16/10/2017].
- Foo, J., Landis, S. H., Maskell, J., Oh, Y. M., van der Molen, T., Han, M. K., Mannino, D. M., Ichinose, M., Punekar, Y. (2016): Continuing to Confront COPD International Patient Survey: Economic Impact of COPD in 12 Countries. PloS one, 11(4): e0152618.
- Garber, A.M., Phelps, C.E. (1997): Economic foundations of cost-effectiveness analysis. Journal of Health Economics, 16(1): 1-31.
- Ghanem, R. (2014): Eine Retrospektive Datenanalyse: Österreichische Versorgungsanalyse zur Epidemiologie des schweren Asthmas [A retrospective data analysis: analysis of Austrian claims data on epidemiology of severe asthma]. Diploma thesis. Medical University Vienna.
- Ghanem, R., Reichardt, B., Wolzt, M., Doberer, D. (2015): Estimating severe asthma prevalence in Austria using nationwide prescription data. European Respiratory Journal,

46, Supplement 59. Abstracts for ERS International Congress 2015. Abstract Nr. PA4061.

Global Asthma Network (2014): The Global Asthma Report 2014. Auckland, New Zealand.

- GOLD (2016): Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease. Updated 2016. Global Initiative for Chronic Obstructive Lung Disease.
- Gothe, H. (2012): Prävalenz der Chronisch Obstruktiven Lungenerkrankung (COPD) in Österreich [Prevalence of Chronic Obstructive Pulmonary Disease (COPD) in Austria]. Project report. Hall/Tyrol: UMIT.
- Güder, G., Brenner, S., Angermann, C. E., Ertl, G., Held, M., Sachs, A. P., Lammers, J.-W., Zanen, P., Hoes, A. W., Störk, S., Rutten, F. H. (2012): GOLD or lower limit of normal definition? A comparison with expert-based diagnosis of chronic obstructive pulmonary disease in a prospective cohort-study. Respiratory research, 13(1): 13.
- Haidinger, G., Waldhör, T., Schauer, U., Jungwirth, M., Robetin, E., Vutuc, C. (2011): Prävalenz von Asthma und Allergien bei Kindern der ersten Schulstufe in Niederösterreich – eine Totalerhebung [Prevalence of asthma and allergies in firstgrade schoolchildren in Lower Austria – a full census]. Atemwegs- und Lungenkrankheiten, 37(2), 61-67.
- Hoogendoorn, E. J. I., Feenstra, T. L., Rutten-van Mölken, M. P. M. H. (2004): Inventarisatie van het gebruik en de kosten van zorg voor astma en COPD in Nederland [Resource use and costs of care for treating asthma and COPD in the Netherlands]. RIVM rapport 260604001. Rijksinstituut voor Volksgezondheid en Milieu (RIVM).
- HV (2011): Pensionsversicherung Jahresstatistik. Berichtsjahr 2011 [Annual statistics on pension insurance. Reporting year 2011]. Main Association of Austrian Social Security Institutions.
- HV (2014a): Pflegegeldinformation (PFIF) des Hauptverbandes der österreichischen Sozialversicherungsträger [Care Allowance Information of the Main Association of Austrian Social Security Institutions].
- HV (2014b): Pensionsversicherung Jahresstatistik. Berichtsjahr 2014 [Annual statistics on pension insurance. Reporting year 2014]. Main Association of Austrian Social Security Institutions.

- HV (2015a): Aufwendungen nach Alter KV insgesamt (außer SVA, VAEB). Extramurale Leistungen. Berichtsjahr 2014 [Expenditure by age – all health insurance institutions (excl. SVA, VAEB). Outpatient services. Reporting year 2014]. Main Association of Austrian Social Security Institutions.
- HV (2015b): Krankenstands-Statistik. Berichtsjahr 2014 [Statistics on sick leave. Reporting year 2014]. Main Association of Austrian Social Security Institutions.
- HV (2016): Heilmittelkosten und -verordnungen der 19 Krankenversicherungsträger Österreichs. Abrechnungsjahr 2014 [Pharmaceutical costs and prescriptions of the 19 Austrian health insurance institutions. Reporting year 2014]. Main Association of Austrian Social Security Institutions.
- Jansson, S. A., Andersson, F., Borg, S., Ericsson, A., Jonsson, E., Lundback, B. (2002): Costs of COPD in Sweden according to disease severity. Chest Journal, 122(6): 1994-2002.
- Jensen, M. B., Fenger-Gron, M., Fonager, K., Omland, O., Vinding, A. L., Hansen, J. G. (2013): Chronic obstructive pulmonary disease involves substantial health-care service and social benefit costs. Danish medical journal, 60(1): A4557.
- Johansson, L. A., Björkenstam, C., Westerling, R. (2009): Unexplained differences between hospital and mortality data indicated mistakes in death certification: an investigation of 1,094 deaths in Sweden during 1995. Journal of Clinical Epidemiology, 62(11): 1202-1209.
- Kruschwitz L. (2000). Investitionsrechnung [Investment calculation] Oldenburg Wissenschaftsverlag, München.
- Lai, C., Beasley, R., Crane, J., Foliaki, S., Shah, J., Weiland, S. (2009): Global variation in the prevalence and severity of asthma symptoms: phase three of the International Study of Asthma and Allergies in Childhood (ISAAC). Thorax.
- Landis, S. H., Muellerova, H., Mannino, D. M., Menezes, A. M., Han, M. K., van der Molden, T., Ichinose, M., Aisanov, Z., Oh, Y.-M., Davis, K. J. (2014): Continuing to Confront COPD International Patient Survey: methods, COPD prevalence, and disease burden in 2012–2013. International Journal of COPD, 9: 597-611.
- Mathers, C. D., Loncar, D. (2006): Projections of global mortality and burden of disease from 2002 to 2030. PLOS Medicine, 3(11): e442.

- Mukherjee, M., Stoddart, A., Gupta, R. P., Nwaru, B. I., Farr, A., Heaven, M., Fitzsimmons, D., Bandyopadhyay, A., Aftab, C., Simpson, C. R., Lyons, R. A., Fischbacher, C., Dibben, C., Shields, M. D., Phillips, C. J., Strachan, D. P., Davies, G. A., McKinstry, B., Sheikh, A. (2016): The epidemiology, healthcare and societal burden and costs of asthma in the UK and its member nations: analyses of standalone and linked national databases. BMC medicine, 14(1): 113.
- Nowak, D., Dietrich, E. S., Oberender, P., Überla, K., Reitberger, U., Schlegel, C., Albers, F., Ruckdäschel, S., Welsch, R. (2004): Krankheitskosten von COPD in Deutschland [Cost of illness of COPD in Germany]. Pneumologie, 58(12): 837-844.
- OECD/Eurostat/WHO (2011): A System of Health Accounts. 2011 Edition. OECD Publishing.
- OÖGKK (2016): Sick leave and sickness benefits in Upper Austria 2014. Upper Austrian Regional Health Insurance Fund.
- Pock, M., Czypionka, T., Müllbacher, S., Schnabl, A. (2008): Volkswirtschaftliche. Effekte des Rauchens. Eine ökonomische Analyse für Österreich [Economic effects of smoking. An economic analysis for Austria]. Research report. Vienna: Institute for Advanced Studies (IHS).
- Preston, S. H., Heuveline, P., Guillot, M. (2001): Demography: Measuring and modeling population processes. Blackwell Publishers, Oxford.
- Rice, D. P. (1966): Estimating the Cost of Illness. Health Economics Series No 6. Washington: U. S. Government Printing Office, PHS Pub. No. 947-6.
- Romanelli, A. M., Raciti, M., Protti, M. A., Prediletto, R., Fornai, E., Faustini, A. (2016): How Reliable Are Current Data for Assessing the Actual Prevalence of Chronic Obstructive Pulmonary Disease? PloS One, 11(2): e0149302.
- Schirnhofer, L., Lamprecht, B., Vollmer, W. M., Allison, M. J., Studnicka, M., Jensen, R. L., Buist, A. S. (2007): COPD prevalence in Salzburg, Austria: results from the Burden of Obstructive Lung Disease (BOLD) study. Chest Journal, 131(1): 29-36.

Statistics Austria (2014): Austrian Health Interview Survey (ATHIS) 2014.

Statistics Austria (2015a): Statistics on causes of death 2014, Vienna.

Statistics Austria (2015b): Statistik der Lohnsteuer 2014 [Wage tax statistics 2014], Vienna.

- Statistics Austria (2015c): Gebarungsübersichten 2014 [overview of public finances 2014], Vienna.
- Statistics Austria (2016): Austrian health expenditures 2014 according to SHA, Vienna.
- Stock, S., Redaelli, M., Luengen, M., Wendland, G., Civello, D., Lauterbach, K. W. (2005): Asthma: prevalence and cost of illness. European Respiratory Journal, 25(1): 47-53.
- Thomsen, R. W., Lange, P., Hellquist, B., Frausing, E., Bartels, P. D., Krog, B. R., Hansen, A.-M. S., Buck, D., Bunk, A. E. (2011): Validity and underrecording of diagnosis of COPD in the Danish National Patient Registry. Respiratory medicine, 105(7): 1063-1068.
- Thun, M. J., Carter, B. D., Feskanich, D., Freedman, N. D., Prentice, R., Lopez, A. D., Hartge, P., Gapstur, S. M. (2013): 50-year trends in smoking-related mortality in the United States. New England Journal of Medicine, 368(4): 351-364.
- To, T., Stanojevic, S., Moores, G., Gershon, A. S., Bateman, E. D., Cruz, A. A., Boulet, L. P. (2012): Global asthma prevalence in adults: findings from the cross-sectional world health survey. BMC Public Health, 12(1): 204.
- Torén, K., Palmqvist, M., Löwhagen, O., Balder, B., Tunsäter, A. (2006): Self-reported asthma was biased in relation to disease severity while reported year of asthma onset was accurate. Journal of Clinical Epidemiology, 59(1): 90-93.
- Van Baal, P., Meltzer D., Brouwer, W. (2016): Future costs, fixed healthcare budgets, and the decision rules of cost-effectiveness analysis. Health Economics, 25(2): 129-256.
- Van Boven, J. F. M., Vegter, S., Van Der Molen, T., Postma, M. J. (2013): COPD in the working age population: the economic impact on both patients and government. COPD: Journal of Chronic Obstructive Pulmonary Disease, 10(6): 629-639.
- Van den Bussche, H., Heinen, I., Koller, D., Wiese, B., Hansen, H., Schäfer, I., Scherer, M., Glaeske, G., Schön, G. (2014): Die Epidemiologie von chronischen Krankheiten und Pflegebedürftigkeit [The epidemiology of chronic diseases and care dependency]. Zeitschrift für Gerontologie und Geriatrie, 47(5): 403-409.
- Wacker, M. E., Jörres, R. A., Schulz, H., Heinrich, J., Karrasch, S., Karch, A., Koch, A., Peters, A., Leidl, R., Vogelmeier, C., Holle, R. (2016): Direct and indirect costs of COPD and its comorbidities: results from the German COSYCONET study. Respiratory medicine, 111: 39-46.

- Wegner C, Gutsch A, Hessel F, Wasem J (2005), Volkswirtschaftliche Produktivitätsverluste infolge des Rauchens eine Analyse unter Berücksichtigung der Friktionskostenmethode [Economic productivity loss due to smoking – an analysis in consideration of the friction cost approach]. Gesundheitsökonomie und Qualitätsmanagement, 10: 356-364.
- WHO (2013): Asthma. Fact sheet Nr. 307. Retrieved from <u>http://www.who.int/mediacentre/factsheets/fs307/en/</u> [Accessed: 26/01/2017].
- WHO (2016a): Global Health Estimates 2015: Deaths by Cause, Age, Sex, by Country and by Region, 2000-2015. Geneva.
- WHO (2016b): International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10). Retrieved from <u>http://apps.who.int/classifications/icd10/browse/2016/en</u> [Accessed: 07/02/2017].
- WHO (n.d.): Asthma: Definition. Retrieved from http://www.who.int/respiratory/asthma/definition/en/ [Accessed: 30/01/2017].

### **Appendix Austria**



Figure 29: Annual average population pyramid in Austria in 2014 by gender and age

Source: Statistics Austria (2015a), illustrated by IHS (2018)



Figure 30: Share and number of deaths attributable to CRD, COPD and asthma in Austria in 2014 by age

Source: Statistics Austria (2015a), illustrated by IHS (2018)





Source: Statistics Austria (2015a), illustrated by IHS (2018)

Figure 32: Absolute gains in conditional 5x5 mortality probabilities attributable to CRD in Austria in 2014 by gender and age



Figure 33: Relative gains in conditional 5x5 mortality probabilities attributable to CRD in Austria by gender and age, in %



Source: IHS (2018)

Table 26: Estimated life expectancy gains in months without CRD of the Austrianpopulation in 2014, by gender and age

age	male	female	age	male	female
0	4.3	3.0	50-54	4.5	3.0
1-4	4.4	3.0	55-59	4.4	3.0
5-9	4.4	3.0	60-64	4.4	2.9
10-14	4.4	3.0	65-69	4.2	2.7
15-19	4.4	3.0	70-74	3.6	2.2
20-24	4.4	3.0	75-79	3.0	1.8
25-29	4.4	3.0	80-84	2.5	1.4
30-34	4.4	3.0	85-89	1.9	1.0
35-39	4.4	3.0	90-94	1.1	0.5
40-44	4.4	3.0	95+	0.0	0.0
45-49	4.4	3.0			

Source: IHS (2018)



### Figure 34: Relative gains in conditional 5x5 survival probability function S(t,a) attributable to CRD for males in Austria in 2014 by age, in %

Source: IHS (2018)





Source: IHS (2018)

Figure 36: Estimated per capita costs of hospitals (HC.1xHP.1) attributable to CRD (J40-J47) in Austria in 2014 by age and gender













Source: IHS (2018)

# Figure 39: Estimated per capita costs of outpatient care provided by medical practices (HC.1.3.1xHP.3.1.1) attributable to CRD (J40-J47) in Austria in 2014 by age and gender



Figure 40: Per capita costs\* of prescribed medicines ATC-Code R03 in Austria in 2014 by age and gender



<sup>\*</sup> The cost base is the reimbursement price for pharmaceuticals excl. VAT and patient's deductible. Prescriptions being cheaper than the deductible are not included, except the patient is exempted. The data stem from the 19 Austrian social health insurance institutions (which do not include the special institutions "Krankenfürsorgeanstalten"). Source: IHS (2018)

Figure 41: Estimated new beneficiaries of care allowances attributable to CRD (J40-J47) in Austria in 2014 by age and gender



Figure 42: Estimates sick leave days attributable to CRD (J40-J47) in Austria in 2014 by age and gender



Figure 43: Estimated costs of sick leave allowances attributable to CRD (J40-J47) paid by social insurance institutions in Austria in 2014 by age and gender



Source: IHS (2018)

Figure 44: Estimated new beneficiaries of invalidity pension attributable to CRD (J40-J47) in Austria in 2014 by age and gender



Source: IHS (2018)

## Figure 45: Estimated annuities of old-age, widow/widower, and invalidity pensions attributable to CRD (J40-J47) in Austria in 2014 by age



Source: IHS (2018)

## Figure 46: Estimated annuities of indirect costs (productivity costs) attributable to CRD (J40-J47) in Austria in 2014 by age and gender



Source: IHS (2018)

### **Appendix Slovenia**

The data were provided and illustrated by VI vis d.o.o, Slovenia. Figure 47 till Figure 52, Figure 62, and re 63 were illustrated by IHS.



Figure 47: Population pyramid in Slovenia as of 01/07/2014 by gender and age

Figure 48: Share and number of deaths attributable to COPD and asthma in Slovenia in 2014 by age





## Figure 49: Number of deaths attributable to COPD in Slovenia in 2014, by gender and age

### Figure 50: Absolute gains in conditional 5x5 mortality probabilities of COPD and asthma in Slovenia in 2014 by gender and age



Absolute mortality gains as difference between of status quo and counter-factual mortality probabilities without CRD. Source: raw data SURS, calculated by IHS (2018)





Relative mortality gains in percent related to the status quo gender- and age-specific mortality probabilities. Source: raw data SURS, calculated by IHS (2018)

# Table 27: Estimated life expectancy gains in months without COPD and asthma of theSlovenian population in 2014, by gender and age

age	male	female	age	male	female
0	2.7	3.0	50-54	2.8	3.0
1-4	2.8	3.0	55-59	2.9	3.0
5-9	2.8	3.0	60-64	2.9	2.9
10-14	2.8	3.0	65-69	2.9	2.7
15-19	2.8	3.0	70-74	2.8	2.2
20-24	2.8	3.0	75-79	2.4	1.8
25-29	2.8	3.0	80-84	2.0	1.4
30-34	2.8	3.0	85-89	1.5	1.0
35-39	2.8	3.0	90-94	1.0	0.5
40-44	2.8	3.0	95+	0.0	0.0
45-49	2.8	3.0			

Source: raw data SURS, calculated by IHS (2018)





Source: raw data SURS, calculated by IHS (2018)



Figure 53: Hospital care costs in Slovenia in 2014, base reference (EUR)



Figure 54: Hospital care costs in Slovenia in 2014, asthma and COPD (EUR)

# Figure 55: Rehabilitation costs in rehabilitation centers in Slovenia in 2014, base reference (EUR)







#### Figure 57: Value of all prescribed medicines (all ATC groups) in Slovenia in 2014




Figure 58: Value of medicines prescribed for asthma and COPD in Slovenia in 2014

Figure 59: Value of medicines prescribed for asthma and COPD in Slovenia in 2014, by



gender





## Figure 61: Value of allowances paid by ZZZS for sick leaves and nursing in Slovenia in 2014, asthma and COPD (EUR)







Source: IHS (2018)





Autoren: Thomas Czypionka, Markus Pock, Miriam Reiss, Gerald Röhrling

Titel: Economic burden of chronic respiratory diseases in Austria and Slovenia: Results of a life-cycle model

Projektbericht/Research Report

© 2018 Institute for Advanced Studies (IHS), Josefstädter Straße 39, A-1080 Vienna 2 +43 1 59991-0 • Fax +43 1 59991-555 • http://www.ihs.ac.at