

COMPARATIVE RISK ASSESSMENT OF TOBACCO USE IN BELGIUM

PAST AND PRESENT

Word count: 12.981

Leen Van Doorslaer

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Copromoter: Prof. dr. Delphine De Smedt

Master's dissertation submitted in order to obtain the academic degree of Master Management and Policy in Healthcare

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Abstract

Background

Non-communicable diseases are a major threat to population health. In Belgium, tobacco use is one of the most important causes of the development of these diseases. A routine quantification of the health impact of tobacco use, based on local data, is currently however lacking.

Objectives

To quantify the disease burden of tobacco use in Belgium from 2001 to 2013 in terms of smoking attributable mortality.

Methods

We performed a comparative risk assessment of tobacco use in Belgium based on locally available data. Population attributable fractions for different health outcomes associated with tobacco use were calculated according to relative risks and prevalence data for current smokers, former smokers and never smokers. Smoking attributable mortality was calculated using disease specific mortality rates for Belgium.

Results

In general, the number of smoking attributable deaths is declining over time. Nonetheless, the results remain high with 14 834 smoking attributable deaths in 2013 (13.6% of all deaths). In both sexes, cancer causes the highest amount of fatal cases, followed by cardiovascular and respiratory diseases.

Conclusion

Although some interventions to reduce tobacco use have been made in the past, more governmental support is needed to improve the population health. It is important to systematically keep records of the smoking prevalence over the years, since it still has a major influence on health and disease burden in Belgium.

Samenvatting

Achtergrond

Niet-overdraagbare ziekten vormen een nieuwe bedreiging voor de gezondheid van de samenleving. Een van de belangrijkste oorzaken van de ontwikkeling van deze ziekten is het gebruik van tabak. Vooral in België is tabak een van de belangrijkste risicofactoren die ziektelast veroorzaakt.

Doelstellingen

Het uitvoeren van een vergelijkende risicobeoordeling voor het gebruik van tabak in België, van 2001 tot 2013. Om de ziektelast van het gebruik van tabak in België te bepalen, berekent deze thesis de tabaksgerelateerde sterfte.

Methoden

Er is gekozen voor een prevalentie-gebaseerde methode. Daarom werd de populatie-toerekenbare fractie berekend op basis van relatieve risico's en prevalentiegegevens voor huidige rokers, ex-rokers en nooit-rokers. Uiteindelijk werd de tabaksgerelateerde sterfte berekend met behulp van ziekte-specifieke sterftcijfers voor België.

Resultaten

Er is een daling van de algemene tabaksgerelateerde sterfte doorheen de jaren. Toch kent 2013 een hoog absoluut aantal sterftes van 14 834 (13.6% van alle stergevallen). Bij beide geslachten veroorzaakt kanker het grootste aantal dodelijke gevallen, gevolgd door hart- en vaatziekten en ademhalingsaandoeningen.

Conclusie

Hoewel in het verleden een aantal interventies zijn gedaan om het gebruik van tabak te verminderen, is er meer steun van de overheid nodig om de volksgezondheid te verbeteren. Het is belangrijk om systematisch gegevens bij te houden over de prevalentie van roken in de loop van de jaren, aangezien deze nog steeds een grote invloed heeft op de gezondheid en de ziektelast in België.

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List of abbreviations

AM	Attributable Mortality
BeBOD	Belgian National Burden of Disease study
CRA	Comparative Risk Assessment
CVD	Cardiovascular Disease
DALY	Disability-Adjusted Life Year
GBD	Global Burden of Disease
HIS	Health Interview Surveys
ICD	International Classification of Diseases
NCD	Non-Communicable Disease
OM	Observed Mortality
PAF	Population Attributable Fraction
PEF	Population Etiological Fraction
SAM	Smoking Attributable Mortality
SES	Socio-economic Status
SIR	Smoking Impact Ratio
TCS	Tobacco Control Scale
TMRED	Theoretical Minimum Risk Exposure Distribution
WHO	World Health Organization
YLD	Year Lived with Disability
YLL	Year of Life Lost

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Preface

As the end of my career as a student is approaching, I feel happy with all the chances that have been given to me. This thesis subject is one of things I felt passionate about from the very start. The perseverance that accompanied my passion gave me the strength to work hard, even during my Erasmus in Rome this academic year. Though I was not really experienced in writing academical English, it came to me as an opportunity to grow. Opposed to most of my student-colleagues, I enjoyed writing this thesis for several reasons. Firstly, it felt like I could back-up the knowledge gained during this master program with the knowledge I gained as a dietitian. Secondly, I knew I could rely on my promotor, from whom I could learn many things. Thirdly, tobacco use has a major health influence in Belgium and research is an important step on the way of improving this.

For the realisation of this thesis, there are some persons I would like to give a special word of thanks. First of all, I would like to thank my promoter Prof. dr. Brecht Devleesschauwer for his excellent guidance and fantastic advice. As a specialist in this area, he was able to give great tips to make the work more efficient and effective. Second, I would also like to give thanks for the support of my family. A special word goes to my brother Maarten Van Doorslaer, who I could always interrupt for advice. Thirdly, for calming my stress and believing in me at all times, I would also like to thank some of my closest friends: Steffi, Lore, Selien, Lotte and Anke. Fourthly, also a warm thank you to my copromoter Prof. dr. Delphine De Smedt and to Prof. dr. Els Clays for answering my questions during the maternity leave of my copromoter.

I sincerely hope that this thesis will prove beneficial for policy, prevention and smokers, since it is worthwhile to invest in smoking cessation, leading to better health outcomes in Belgium.

1 Introduction

1.1 Tobacco use

According to the World Health Organization (WHO), tobacco is the single most preventable cause of death in the world today. Out of the one billion people who currently smoke tobacco, five million people die from a tobacco attributed disease each year. The problem remains, since the prevalence of current smokers is still increasing in developing countries. If this trend continues, tobacco will account for more than eight million attributed deaths per year by 2030 (World Health Organization, 2008).

Tobacco use is a leading risk factor for six of the eight leading causes of death in the world (Figure 1). Attributing to the development of different diseases, the result of this unhealthy habit is preventable burden and loss of productive life years. Next to the burden of disease caused by tobacco use, the financial aspect also has an important harm to families and even countries (World Health Organization, 2008).

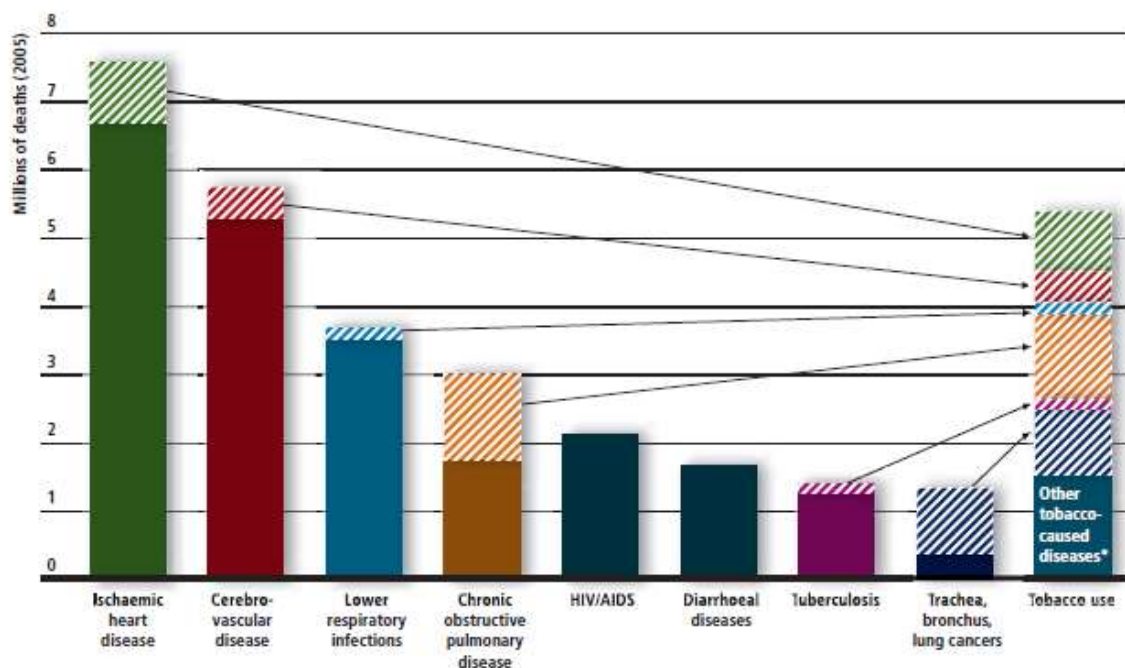


Figure 1: Tobacco use is a risk factor for six of the eight leading causes of death in the world (World Health Organization, 2008).

Although smokers are aware of, or even experiencing, the health consequences of tobacco use, many continue their unhealthy habit. Users may underestimate or minimize the health risk due to later manifestation of diseases caused by smoking. In addition, the addictive nature of smoking does not make cessation easy (Gisle &

Demarest, 2014). Incorrectly, smoking is commonly perceived to be a personal choice (World Health Organization, 2008). Instead, smoking is best regarded as a chronic disease that requires a long term management strategy, rather than a quick fix. Therefore, physicians take an important place in influencing the smoking behaviour of their patients. Due to the addictive nature of nicotine, smoking cessation causes different symptoms of withdrawal. Next to the physical consequences, also psychological factors contribute to the difficulties of smoking cessation. New coping strategies must be learned in order to break the old habits (Rigotti, 2002).

Further than the personal difficulties, a powerful global industry keen on marketing and its experts in lobbying and advertising want to maintain or even increase tobacco use (Federal Trade Commission, 2005). However strategies to reduce tobacco use have been shown effective, few countries have implemented these recognized strategies to control the tobacco epidemic. This disturbing trend has not been changed in the 50 years the dangers caused by tobacco use have been scientifically proven, nor in the past 20 years confirming the burden of second hand smoke. In developing countries, women and young adults are targeted by the tobacco industry, influencing their potential for increasing sales and profits in the tobacco industry (World Health Organization, 2007). Even more disturbing are direct or indirect interests in tobacco growing and manufacturing by governments in some countries (World Health Organization, 2008).

The potential health benefits of smoking cessation and prevention are however substantial. Decreased risks of tobacco related diseases, a slower progression of established tobacco-related diseases and an increased life expectancy are some of the benefits smoking cessation can effect. Even after the age of 65 or after the development of a tobacco related disease, these benefits are still visible in patients (Centers for Disease Control and Prevention, 1999). Improving smoking cessation in Belgium calls for government protection of public health and preventive measures. On the one hand, the attractivity of tobacco products and their availability need to be limited. On the other hand, smoking cessation programs need to be organised by prevention experts (Gisle & Demarest, 2014).

In Belgium, considerable trends in smoking behaviour can be seen. Among young people, the amount of smokers remains high and a gap can be seen between different educational levels. Tobacco is easily available, even for minors under 16 years old to

whom it is legally prohibited to sell tobacco products. The first cigarette is smoked at 16 years and 2 months in average. It is only later that smoking becomes more regular, in average at the age of 18 years and 1 month. Among adults, the proportion of smokers also remains high. As such, Belgium counted a total 23% smokers (19% daily and 4% occasional smokers) and 77% non-smokers in 2013. More worrying is that the amount of cigarettes smoked per day, with an average of 16 pieces a day, has not changed over the past ten years. The proportion of heavy smokers (smoking more than 20 cigarettes per day) is approximately one-third of the daily smokers and 6% of the population in 2013. Special attention should also be given to the increasing amount of smokers and daily smokers among young women. Over the years the strong correlation between smoking and a lower social economic status became worrying, especially during pregnancy of women (Vlaams Instituut Gezond Leven, 2019; Gisle & Demarest, 2014).

1.2 The burden of tobacco use

Since the 1990s, the Global Burden of Disease (GBD) studies have been collecting data on behavioural, metabolic and environmental risk factors. These studies have calculated the attributable burden for many different risk factors and their findings are categorised in specific countries or globally. According to the GBD 2017 study, tobacco use was the third leading behavioural risk factor for disability-adjusted life years (DALYs) and the second leading behavioural risk factor for mortality worldwide. The global burden of tobacco smoke accounted for more than 7 million deaths and more than 177 million DALYs in 2016. In Belgium, tobacco has been the leading overall risk factor for deaths and DALYs since 1990. Estimates are available until 2017, but tobacco use is likely to remain a major risk factor in the future (GBD 2016 Risk Factors Collaborators, 2017).

Overall, tobacco use is mostly associated with cardiovascular diseases (CVD), the development of neoplasms and chronic respiratory diseases. This trend is observed globally, as well as specifically in Belgium (GBD 2016 Risk Factors Collaborators, 2017). According to the Belgian health system performance assessment, these diseases also have been the leading causes of death in 2004 (Gerkens & Merkur, 2010). A more recent Belgian study highlights similar leading causes of death in 2008-2009, namely neoplasms, circular diseases and all natural causes except neoplasms

and circulatory diseases (including chronic respiratory, endocrinal, digestive and neurological deficits) (Renard et al., 2014). These studies indicate that tobacco has a large impact on mortality in Belgium.

To define the burden of disease of tobacco use, different outcomes can be calculated. In the past, mortality rates were generally measured for calculating health losses attributable to a certain risk factor (Zahra et al., 2017; GBD 2013 Risk Factors Collaborators, 2015). In order to define the smoking attributable mortality (SAM), the population attributable fraction (PAF) is calculated. This analysis consisted of including smoking related pathologies and defining the relative risk for each of these diseases. Next, the relation between smoking and these pathologies was defined with a quantitative number (Tachfouti et al., 2014).

Since the introduction of the DALY, the calculation methods of burden estimates have shifted (Zahra et al., 2017; GBD 2013 Risk Factors Collaborators, 2015). One DALY accounts for the loss of one healthy live year. Both fatal and nonfatal health loss are taken in account, giving a more complete vision on the burden of a disease or risk factor (Develeesschauwer et al., 2014).

As different calculation methods for the effect of tobacco use show different results, their arbitrary usage could have an impact on health policy planning reporting smoking. (Tachfouti et al., 2014; Pérez-Ríos & Montes, 2008).

1.3 Tobacco control policies in Belgium

According to the law of January 24; 1977, on the protection of the health of users as regards food and other products, it is prohibited to sell tobacco products to minors under the age of 16. Therefore, it is recommended to request a proof of age (e.g. an identity card or other legal document) in case youngsters want to buy cigarettes. Another part of this obligation forbids any form of commercial and sponsoring of tobacco or its products and similar products (Federale Overheidsdienst Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu, 2016).

The use of tobacco products is regulated according to the law of December 22, 2009 and is operative since July 1, 2011. The focus of the law is protecting employees against tobacco smoke and giving a general regulation of smoke free closed places that are publicly accessible. By this law, smoking is prohibited in the catering industry,

in public spaces (for example public transport, airports, supermarkets, shopping centres etc.) and at the workplace. Therefore, smoking bans need to be placed visibly, at the entrance and in spaces itself. It is possible to install a closed smoking room according to legal conditions where smoking is allowed. Smoking is also allowed in open terraces. Even after opening hours, the smoking ban should still be taken into account (Federale Overheidsdienst Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu, 2016).

Furthermore, the royal resolution of February 5, 2016, according to the fabrication and the handling of tobacco products obliges health warnings on the packaging of the products sold in Belgium. Specifically for packages of cigarettes, a more complicated obligation is set; these packages should include a combined warning of text and image. The images are especially designed to scare smokers and are secured by the European Union (Federale Overheidsdienst Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu, 2016).

According to the federal government office of public health, European Guidelines formed on 3 April 2014, were transcript into new national measures. The Tobacco Products Directive became applicable on 20 May 2016, or specifically in Belgium on 19 May 2016. It is focused on rules governing the manufacture, presentation, and sale of tobacco and its related products. These measures concern pictorial health warnings covering 65% of the package surfaces, standardised packaging, the ban on 'characterising flavours' in cigarettes, a regulatory framework for electronic cigarettes and the set-up of a tracking and tracing system for tobacco products (Joossens & Raw, 2013; Federale Overheidsdienst Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu, 2016; European Commission, n.d.).

Within tobacco products, cigarettes, pipes, cigars, but also waterpipes and e-cigarettes are included. All these products are subject of the Belgian regulations on tobacco products and the prohibition of smoking in public places. The Belgian government performs different efforts to decline tobacco use and its harmful consequences. More specifically, the federal government office of public health is appointed tasks on controlling the compliance of the different smoking policies (Federale Overheidsdienst Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu, 2016).

New political initiatives are coming up in Belgium in order to decrease tobacco use. Although some of these initiatives are not yet translated into Federal laws, they are

worthwhile to mention. Since 2018, a new Flemish decree prohibits smoking in the car in the presence of children up to 16 years old. Hence, a penalty of maximum 1.000 euro can be assigned. This smoking ban is also applied to electronic cigarettes (Het Laatste Nieuws, 2018). Very recently, since April 2019, the Belgian Federal Government has voted on the elevation of the legal age for buying cigarettes. One of the parties proposes a new law, elevating the age limit up to 18 years. Belgium is one of the last members of the European Union where buying cigarettes at the age of 16 is still possible (De Morgen, 2019). According to the latest developments, these two bills have been approved and will be translated into measures soon (De Standaard, 2019).

In order to evaluate and compare the tobacco control policies in different countries, the tobacco control scale (TCS) was developed. The TCS aims to quantify the implementation of tobacco control policies at country level and reports on the results. A questionnaire was sent to correspondents in 30 European countries, resulting in a ranking system of the different countries. As the design allows a systematic evaluation, data was yet collected in 2010 and in 2013 (Joossens & Raw, 2006; Joossens & Raw, 2013).

Six directives were chosen in order to assess the policies in different countries. The scale evaluates the following policies: price of cigarettes and other tobacco products, smoke free work and other public places, spending on public information campaigns, comprehensive bans on advertising and promotion, large direct health warning labels and treatment to help dependent smokers stop. These six factors are scored, leading to a maximum potential score of 100. In 2013, Belgium was appointed a total score of 47 and was placed on the 13th place in the ranking. This is a shared place with the Netherlands. However in 2010, Belgium was placed three ranks higher, namely on the 10th place. Some of the highest scores of 2013 were given to respectively the United Kingdom (74), Ireland (70), Iceland (66) and Norway (61). These countries also were appointed similar scores in 2010 (Joossens & Raw, 2013).

The TCS also gives comments on individual countries, explaining the position that was appointed in the scale. In Belgium, the main issue is the low price for hand rolled tobacco, causing high sales of the product. Next to this, no progress was reported since 2006, except for the decision to ban smoking in bars in 2011 (Joossens & Raw, 2013). Since the implementation of the new guidelines in 2016, the TCS-score for Belgium may change in the future. As all European countries have implemented these

guidelines, it is still a challenge to improve the ranking position (Federale Overheidsdienst Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu, 2016). The new and more recent initiatives of 2018 are however not derived from European guidelines, which means Belgium is distinguishing itself from other countries (Het Laatste Nieuws, 2018; De Morgen, 2018; De Standaard, 2018). It is recommended to renew tobacco control policies over time, in order to maintain and even improve the decrease in prevalence numbers on smoking.

In favour of helping countries develop good tobacco control policies, WHO developed a Framework Convention on Tobacco Control in 2003 (World Health Organization, 2003). Belgium is one of the 180 parties in this framework, who are committed to protect the population health by joining the fight against the tobacco epidemic (World Health Organization, 2008; Gravely et al., 2017). The treaty has accelerated the implementation of measures, including bans, smoke-free laws and health warnings on tobacco packaging (Hiilamo & Glantz, 2017; Uang et al., 2016; Hiilamo & Glantz, 2015). To help countries meet their commitments to the treaty, WHO published a special report called 'mpower'. This focuses on giving the member countries a policy package to reverse the tobacco epidemic. The mnemonic 'mpower' stands for monitoring tobacco use and prevention policies, protecting people from tobacco smoke, offering help to quit tobacco use, warning about the dangers of tobacco, enforcing bans on tobacco advertising, promotion and sponsorship and raising taxes on tobacco (World Health Organization, 2008).

The goal of WHO is a world where no child or adult is exposed to tobacco smoke. Therefore, the policy package 'mpower' encourages policy makers, society, health-care providers and many others. To envision this idea, the package provides tools promoting a legal and socio-economic context in favour of tobacco-free living. Interventions to be implemented, are informed by systematic surveys designed to target and refine implementation. In this way, their impact can be evaluated through strict monitoring. The scope of the interventions contain a high level of coverage, because partial implementation is generally inadequate on the case of reducing tobacco use in the population (World Health Organization, 2008).

1.4 The impact of smoking attributable mortality on policy

Within developing countries, non-communicable diseases (NCDs) are a rising health issue. WHO describes this change as a risk transition, where the affecting risks for the population shift from infectious diseases to NCDs. Depending on the socio-economic development of a country, several lifestyle factors drive this risk transition. Tobacco use, being one of the most important causes of NCDs, plays an important role within this transition (World Health Organization, 2009). As a result, many low- and middle-income countries are now facing the growing burden of these modern risks, while still having to battle the traditional health risks caused by infectious diseases (Tachfouti et al., 2014; World Health Organization, 2009).

Because of the increase in life expectancies and the shift of major causes of death and disability to the chronic and noncommunicable, populations are increasingly facing modern risks. Physical inactivity, overweight and obesity, other diet-related factors and tobacco and alcohol-related risks are most common to cause the accumulation of various risk factors. Although some risk factors can be partially prevented, others lead to inevitable exposure. Luckily, public health intervention can help decrease these population risks. By the implementation of, for example, strong tobacco control policies in high-income countries, also low- and middle-income countries can learn from these interventions (World Health Organization, 2009).

A visual design of this risk transition is shown in Figure 2 (World Health Organization, 2009).

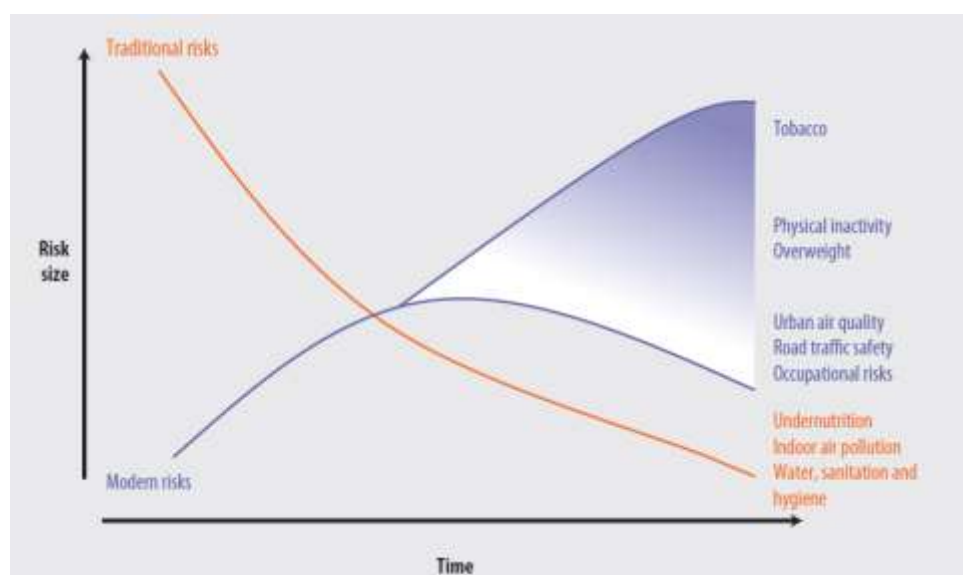


Figure 2: The risk transition (World Health Organization, 2009).

Especially in Belgium NCDs are a big challenge, 28.5% of the citizens of 15 years and older reported to have at least one chronic condition in 2013. This equals more than one-fourth of the total Belgian population. Also, the prevalence has increased over the years, in comparison to 1997 only 24.6% chronic conditions were reported (World Health Organization, 2016). This is mostly caused by ageing of the Belgian population. For example, in 2017 the average life expectancy was 83.7 for women and 79.0 for men, this has increased respectively with 0.06 and 0.15 over the past 20 years (Statbel & Belgische Federale Overheidsdiensten, 2017c). As the age increases, it is more likely that the amount of chronic conditions rises. It is seen that over the age of 65, more than one-third of the population is suffering from at least two serious chronic conditions. Although the risk factors obesity and overweight, alcohol use and sedentary lifestyle have increased over the years, the rate of current smokers is slowly decreasing (32% in 1997, 22% in 2013). This decrease is higher in men than women (World Health Organization, 2016).

The main goal of risk factor analysis is identifying emerging threats to population health. This also allows identifying opportunities for the organisation of prevention campaigns (GBD 2013 Risk Factors Collaborators, 2015). Within times of this risk transition, it is very important to realise that the diseases are caused by preventable lifestyle factors. This means that there are still opportunities to decrease incidence rates of these different diseases.

Next to using the results of comparative risk analysis (CRA) for prevention campaigns, authorities could choose to formulate new tobacco control policies. For example, it is an option to increase the taxes on tobacco products, which will add to the total price. This will help users to quit, reduce the number of new users and protect people from second-hand smoke. However, according to the economic principles of supply and demand, education by means of prevention is a better way of discouraging smokers on the long term. Some examples of interventions are bans on tobacco industry promotion and anti-tobacco advertising. This educates the users about the health risks of tobacco use and may encourage a change of mind. In other words, it would be the choice of the customer to buy less cigarettes. This opposed to an increase in price, which would decrease demand due to different motives. A certain amount of people will stop smoking or smoke less due to them being unable to afford this habit. However, as it is not their own choice, they may start smoking again given the means or look for

other ways to acquire cigarettes. Monitoring is still needed to obtain baseline information, target activities, track progress and evaluate the results of interventions (Merlevede et al., 2017; World Health Organization, 2008).

1.5 Comparative risk assessment

A CRA can be defined as a systematic evaluation of the changes in burden of disease which would result from modifying the population distribution of exposure to a theoretical minimum risk exposure distribution (TMRED). The latter implies minimum health loss, while keeping all other risk factors unchanged. The key goal of this evaluation is increasing the comparability of different risk factors (Devleesschauwer, 2017). Further, a CRA consists of a framework of risks or causes contributing to certain health outcomes. This allows quantification of risks or causes at the different levels of the framework. The attributable burden caused by the use of tobacco is only one of the risk factors included. In order to calculate the attributable disease burden of tobacco, only data regarding tobacco use can be assessed. In other words, the prevalence of illnesses and mortality rates that are related to the use of tobacco will be included in the research (GBD 2016 Risk Factors Collaborators, 2017).

A causal effect can be established through counterfactual analysis. Meaning, the specific risk factor also elevates the risk of a population outcome from other causes. In this case, the risk factor is defined as tobacco use or smoking. In order to calculate this attributable risk, current disease outcomes with current exposure are compared to disease outcomes under an alternate exposure (Devleesschauwer, 2017).

Two main outcomes on calculating the attributable burden of tobacco use can be found. The most common methodology is based on prevalence analyses. The method consists of assigning a relative risk to different selected pathologies in a relationship to smoking in order to calculate the PAF (Rockhill et al., 1998). In studies, the most common formula for calculating the PAF was proposed by Levin (Levin, 1953):

$$PAF = \frac{[P_{cur}(RR_{cur} - 1) + P_{ex}(RR_{ex} - 1)]}{1 + [P_{cur}(RR_{cur} - 1) + P_{ex}(RR_{ex} - 1)]}$$

Where P_{curr} and P_{ex} represent the prevalence of current smokers and ex-smokers, respectively. The risk, for current and ex-smokers, of dying or suffering from smoking related pathologies compared to the group of never smokers, is given by RR_{curr} and RR_{ex} , respectively. These risk rates are obtained from different data sources. As such,

a PAF can be calculated for all the diseases examined in the study (Tachfouti et al., 2014; Pérez-Ríos & Montes, 2008).

A similar procedure can be found, comparing only smokers and non-smokers. The relative risk (RR) and the proportion of deaths among the smoking population (P) are represented in the following formula (Tachfouti et al., 2014; Pérez-Ríos & Montes, 2008):

$$PAF = P \times \left(1 - \frac{1}{RR}\right)$$

The second methodology calculating the SAM is formulated by Peto and calculates the smoking impact ratio (SIR). The calculation is based on the amount of never smokers in a population and takes the effect of previous tobacco exposure in consideration. In the SIR formula, lung cancer mortality is used as an indirect indicator for burden estimates of tobacco use (GBD 2013 Risk Factors Collaborators, 2015; GBD 2010 Risk Factors Collaborators, 2012; Ezzati & Lopez, 2003). The SIR is defined as population lung cancer mortality, in excess of that of never smokers, relative to excess lung cancer mortality for a known reference group of smokers (Ezzati & Lopez, 2003). This method can estimate the SAM independently from the prevalence of smoking in the study population. To use this method, many factors need to be known, such as: lung cancer mortality (age and sex specific) in the target country population (C_{LC}) and in never smokers in that population (N_{LC}), the relative risks for all included diseases related to tobacco use (except lung cancer), and the lung cancer mortality rates for smokers (S_{LC}^*) and never smokers (N_{LC}^*) found in a reference population (Tachfouti et al., 2014; Pérez-Ríos & Montes, 2008; Ezzati & Lopez, 2003):

$$SIR = \frac{C_{LC} - N_{LC}}{S_{LC}^* - N_{LC}^*}$$

Afterwards, the population etiological fraction (PEF) can be calculated by age group and sex, according to the following formula (Tachfouti et al., 2014; Pérez-Ríos & Montes, 2008):

$$PEF = \frac{SIR (RR - 1)}{1 + (SIR (RR - 1))}$$

For all of the methodologies, the attributable mortality (AM) is then calculated for each cause of death using the following formula:

$$AM = OM \times PAF \text{ or } AM = OM \times PEF$$

To calculate the SAM, smoking is used as the specific risk factor and the observed mortality (OM) is related to smoking (Tachfouti et al., 2014; Pérez-Ríos et al., 2008).

After mortality rates, one of the most frequently used burden estimates is the DALY, which also takes into account the nonfatal health losses. One DALY means healthy life is shortened by one year. DALYs are calculated by adding year of life lost (YLL) and year lived with disability (YLD):

$$DALY = YLL + YLD$$

YLDs are calculated by multiplying the number of cases, the duration till remission or death and the disability weight. The disability weight is a measure rated from zero to one, representing respectively a perfect health state or the worst health state possible. While YLDs represent the morbidity component of the DALY, YLLs represent the mortality component. YLLs are calculated by multiplying the number of deaths and the life expectancy at the age of death (Devleesschauwer et al., 2014).

Most commonly used are the calculations based on prevalence of tobacco use. Also, in a minor amount of studies, the SIR is calculated individually or in combination with the prevalence based method. Since prevalence numbers of tobacco use in Belgium were collected over the years, the associated methodology was used. The prevalence numbers include never smokers, former smokers and current smokers, so the tripartite formula could be applied.

1.6 Public health impact of tobacco use in Belgium

In 2002, Sciensano (former: Scientific Institute of Public Health) published a report on the calculation of the SAM. This calculation was according to the method described by Peto, relating heavily on lung cancer mortality rates (Peto et al., 1992). Some notes on this report can be made. Seen it was reported in 2002, the included diseases are defined by ICD-9 codes. Included within this selection are the diseases with the highest amount of expected deaths, while other included diseases are grouped (Miermans & Van Oyen, 2002).

Data on tobacco use in Belgium were gained in 1996 and are all specified by gender. In summary, within deaths by medical cause 34% male deaths and 4.7% female deaths are related to smoking. In absolute numbers, this means 15 958 male deaths and 2 299 female deaths in the year 1996 were in some way related to smoking. Among females, the total amount of deaths is a lot smaller. This can be explained by the historical lower amount of use among women. However, in the last decennia, tobacco use among women is rising. This evolution, in combination with a decline of smoking among men, will lead to more equal numbers on SAM calculations among both sexes in the future (Miermans & Van Oyen, 2002).

Lung cancer is responsible for the highest amount of absolute deaths, 5 221 male deaths or 94% of all lung cancers and 565 female deaths or 58% of all lung cancer, due to the high risk on lung cancer caused by smoking. CVD and chronic obstructive pulmonary disease are other important death causes among smokers (Miermans & Van Oyen, 2002).

Within this report, regional differences are also described. It is observed that the Walloon region has a higher percentage of medical deaths among men (Wallonia 35%, Flanders 33% and Brussels 30%). In this case, medical deaths are defined as deaths caused by acute or chronic illness or disorder. Non-medical deaths are thus described as traffic accidents, suicide, accidental death, violent death etc. Among females, this ranking is different, and the highest amount of deaths is seen in Brussels (Brussels 7%, Wallonia 6% and Flanders 4%) (Miermans & Van Oyen, 2002).

Another source that can be consulted on the burden of smoking, are the GBD studies. A dynamic internet tool can be consulted on health risks and causes accompanied by their specific burden estimate (deaths, YLD and DALYs). The different systematic studies show global results and results of one country in specific (Institute for Health Metrics and Evaluation, 2017).

In Belgium, neoplasms cause the highest amount of smoking related deaths with an amount of 82.8 deaths per 100 000 population in the latest year of research (2017). In absolute numbers this equals 9 372 deaths. The second highest burden is caused by CVD with 37.8 deaths per 100 000 population or 4 279 absolute deaths. In third place, chronic respiratory diseases with 28.8 deaths per 100 000 population or 3 258 absolute deaths. The other mentioned diseases are respiratory infections and tuberculosis, neurological disorders, digestive diseases, diabetes and kidney diseases and

unintentional injuries. Together this adds up to the total amount of 177 deaths per 100 000 population or 20 061 absolute deaths related to smoking. In comparison, the worldwide SAM was 92.6 deaths per 100 000, which is significantly lower (Institute for Health Metrics and Evaluation, 2017).

It can be interesting to mention the results of 2013 in Belgium, also reported in the internet tool. This because 2013 is the latest year data was gained for this research. In this year, the GBD observed 10 087 absolute deaths or 90.9 deaths per 100 000 caused by neoplasms and related to smoking. In second place, CVD resulted in 4 855 smoking attributable deaths or 43.8 deaths per 100 000. Chronic respiratory diseases caused 3 469 deaths or 31.3 deaths per 100 000 and therefore took third place. Meaning, a similar top three in Belgium was found over these two years. The complete total of smoking attributable deaths was estimated at 23 670 deaths. This equals a SAM of 196.5 per 100 000 population in Belgium. For 2013, the global results can also be consulted, 91.2 deaths per 100 000 were estimated. This confirms the decline of SAM in Belgium over the years, however globally the SAM is still rising (Institute for Health Metrics and Evaluation, 2017).

Since the GBD studies include a global scope and analyse many data (GBD 2016 Risk Factors Collaborators, 2017), research focused on Belgian data could give more precise information on the matter. The research performed by Miermans and Van Oyen (2002), is already outdated, and needs renewing. This thesis could be seen as a more detailed renewal of the information gained in 1996 for the case of tobacco. In this thesis, recent prevalence data was used, retrieved from the Health Interview Surveys (HIS) and therefore based on habits expressed by the Belgian population. Further, different disease groups and specified diseases were included in the analysis.

1.7 Study aim

The aim of this study is to perform a CRA of tobacco use in Belgium. Moreover, the SAM will be calculated for the Belgian population. These calculations are based on the prevalence of tobacco use gathered by the Belgian HIS organised from 1997 to 2013 by Sciensano. Overall and specific mortality data are gained by consulting the Statbel-database, collecting and publishing yearly analyses. It is expected that the follow-up on these figures will be executed systematically. Since there has been executed a new HIS in 2018, new prevalence figures will be available soon.

It is possible that the results of this CRA have an influence on the Belgian health policy. As seen in the TCS (Joossens & Raw, 2013), Belgium should be doing better on tobacco control policies and is still making progress on this subject. Although the SAM in Belgium is expected to decline over the years, the burden of disease should still be an important resource for policies today.

2 Materials and methods

2.1 *Comparative risk assessment*

A CRA aims at mapping the systematic evolution of the changes in burden of disease. This results from modifying the population distribution of exposure to a TMRED. The contribution of a risk factor to disease burden can be estimated by comparing the burden due to the observed exposure distribution in a population with that which would arise from a hypothetical exposure distribution, defined according to established epidemiological findings about the disease-exposure relationship for that risk factor (Devleesschauwer, 2017).

Data on disease or injury outcomes alone are more focused on palliative or curative services. However, key for preventing disease and injury is a reliable and comparable analysis of risks to health. A CRA focuses on quantification of causes of mortality and the burden of diseases. Therefore, it allows the assessment of risk factors in a unified framework while acknowledging risk factor specific characteristics (Ezzati et al., 2004; Murray & Lopez, 1997; Murray and Lopez, 1999).

The aim is mapping alternative population health scenarios to changes in distribution of exposure of risk factors over time, irrespective of whether exposure change is achievable using existing intervention (Ezzati et al., 2004; Murray & Lopez, 1997; Murray and Lopez, 1999).

2.2 *Statistical analysis*

As mentioned before, different methods can be assessed in calculating the SAM. For this research, a prevalence based analysis was opted, because extensive smoking prevalence data was already available in order to calculate PAF values. This method allows comparing risks for current, former and never smokers. The consulted method was also used in the analyses of Public Health England and The Scottish Public Health Observatory (Barkat et al., 2016; Lifestyle Statistics & Health and Social Care Information Centre, 2013). After consulting the prevalence data, a relative risk was assigned to the included pathologies (Rockhill et al., 1998).

Using these figures, the PAF can be calculated according to Levin's formula (Levin, 1953; Barkat et al., 2016).

$$PAF = \frac{[P_{cur}(RR_{cur} - 1) + P_{ex}(RR_{ex} - 1)]}{1 + [P_{cur}(RR_{cur} - 1) + P_{ex}(RR_{ex} - 1)]}$$

Here P_{curr} and P_{ex} stand for respectively the prevalence of current smokers and former smokers. The risk of dying or suffering from smoking related pathologies compared to the group of never smokers, is represented as RR_{curr} and RR_{ex} . As such, the PAF calculated for all the diseases examined in the study will indicate the fraction of deaths probably related to smoking (Tachfouti et al., 2014; Pérez-Ríos & Montes, 2008; Barkat et al., 2016). Implicitly, never smokers are also included in the formula, used as a reference for the other prevalence numbers.

Afterwards, the SAM is then calculated for each cause of death using the following formula:

$$SAM = M * PAF$$

In this specific formula, smoking is used as the specific risk factor and the observed mortality is related to smoking (Tachfouti et al., 2014; Pérez-Ríos et al., 2008).

An additional analysis consisted of calculating the relative smoking attributable death rates. Relative numbers are required to allow comparison with different studies. Therefore, figures are internationally expressed in a similar measuring unit. For burden of disease, the relative mortality is mostly expressed per standard population size, often 100 000 inhabitants, or in a percentage.

In order to calculate the relative SAM or SAM%, the regular SAM and the all-cause mortality was required. The all-cause mortality was retrieved from Statbel and was obtained for each year used in the previous analysis (2001-2013) (Statbel & Belgische Federale Overheidsdiensten, 2017a). The SAM% is calculated as the amount of deaths attributable to tobacco per year compared to total deaths per year and expressed as a percentage (Oliveira et al., 2008).

This leads to the following formula:

$$SAM\% = \frac{SAM}{All\ cause\ mortality}$$

All data needed in order to calculate the PAF was compiled in an Excel spreadsheet. Different sheets were used in order to maintain a clear view of all data. The statistical analyses were executed in R 3.5.1 (R Core Team, 2018).

2.3 Smoking prevalence

Since 1997, Sciensano has been systematically collecting data on different health parameters by means of the Belgian HIS. The goal of these surveys is to evaluate the health of the Belgian population and to identify the main health issues and lifestyle habits. The support of different federal and regional agencies causes the data to contribute to a proactive health policy that is in line with the needs of the population. In order to improve the process or to determine new issues, it is important to organise these surveys regularly (approximately every five years). The results of these surveys are published on the online website of Sciensano and are publicly available (Sciensano, 2018).

The sample of the HIS consists of approximately 10 000 participants, who are chosen based on a stratified multi-stage, clustered sampling method. Regional differences are also taken into account, by dividing each region proportionally. Representative samples were taken of 3 500 Flemish participants, 3 000 Walloon participants and 3 000 participants from Brussels. Furthermore, 300 interviews took place in the German Community as a part of the Walloon sample. This method is chosen to represent the population composition in the best way. During one complete year, interviews are conducted in the representative households. The interview is announced by an introduction letter sent to the participants in advance, which briefly explains the complete working procedure and the objective of the HIS. Data is gained by a trained interviewer in an oral manner and participation is on voluntary basis (Sciensano, 2018).

Data on the smoking prevalence were obtained for the years 1997, 2001, 2004, 2008 and 2013. As smoking status was the indicator, results for daily, occasional, former and never smokers were gathered. In order to obtain data for current smokers in this research, the figures for daily and occasional smokers were added. Furthermore, gender and age were included in the analyses as parameters (Sciensano, 2018). The results of the analysis can be consulted in appendix 7.1: Specifications on smoking prevalence.

2.4 *Relative risks*

As published by Public Health England, the given relative risks of smoking related pathologies were also used to calculate the PAF in this thesis. The selected pathologies are defined by means of the tenth revision of the International Classification of Diseases (ICD) (Barkat et al., 2016; Lifestyle Statistics & Health and Social Care Information Centre, 2013). As found in the GBD studies, tobacco use is highly associated with CVD, the development of neoplasms and chronic respiratory diseases (GBD 2016 Risk Factors Collaborators, 2017). Since their strong relationship to smoking, different kinds of cancer, cardiovascular diseases and respiratory diseases are essential in the analysis of the SAM. Besides, digestive diseases were included in the analysis. (Barkat et al., 2016; Lifestyle Statistics & Health and Social Care Information Centre, 2013).

Table 1 gives an overview of the included diseases, sorted by group and given the ICD-10 codes per specific disease (Barkat et al., 2016; Lifestyle Statistics & Health and Social Care Information Centre, 2013). Each disease is linked to an age and gender specific risk. This risk represents the risk of a smoker or former smoker, dying from that disease compared to the risk of a never smoker. These are only applicable to people aged 35 and over, wherefore deaths have been used in the calculations (Lifestyle Statistics & Health and Social Care Information Centre, 2013). A more detailed overview of the relative risks and the included pathologies can be found in appendix 7.2: Specifications on relative risks.

Table 1: Diseases that can be caused by smoking by group and ICD-10 codes (Barkat et al., 2016; Lifestyle Statistics & Health and Social Care Information Centre, 2013).

Group	Diseases	ICD-10 codes
Cancer	Lip, Oral Cavity, Pharynx	C00-C14
	Oesophagus	C15
	Stomach	C16
	Pancreas	C25
	Larynx	C32
	Trachea, Lung, Bronchus	C33-C34
	Cervix Uteri	C53
	Kidney and Renal Pelvis	C64-C65, C68
	Urinary Bladder	C67
	Malignant neoplasm without specification of site	C80
	Myeloid Leukemia	C93
Cardiovascular	Ischemic Heart Disease	I20-I25
	Other Heart Disease	I00-I09, I26-I51
	Cerebrovascular Disease	I60-I69
	Atherosclerosis	I70
	Aortic Aneurysm	I71
	Other Arterial Diseases	I72-I78
Respiratory	Pneumonia, Influenza	J10-J18
	Bronchitis, Emphysema	J40-J42, J43
	Chronic Airway Obstruction	J44
Digestive	Stomach ulcer, Duodenal ulcer	K25-K27

2.5 Mortality

Data on age-specific and sex-specific mortality by cause of death were consulted from the website of the Statistics Belgium (Statbel). Every year, this database has been collecting different population rates. The data on mortality specifically has been collected since 1998 (Statbel & Belgische federale overheidsdiensten, 2017a).

As a Belgian statistical office, Statbel collects, produces and publishes reliable numbers about the Belgian economy, the society and the territory. Collection of the data is based on administrative data sources and interview surveys (Statbel & Belgische federale overheidsdiensten, 2017b).

The statistics on the causes of death are compiled by means of the death certificates. These are filled in by a doctor attesting to each death occurring in Belgium and then completed by the municipality of the place of death. Afterwards, the forms are forwarded to the communities, which check, code and enter the information to compile their own statistics. The databases are then sent to the statistical agency, which is then merged to compile the statistics at the federal level. The causes of death have been coded in accordance with the ICD-10 codes and associated Health Issues of the WHO. All tables of the statistics break down the deaths according to different groups of causes, whereby a distinction is also made according to age group and gender (Statbel & Belgische federale overheidsdiensten, 2017a).

It is important to note that only mortality data for those aged 35 and over is included in the analysis, as the likelihood of younger individuals dying from smoking is low (Barkat et al., 2016). The Statbel statistics have been assembled since 1998, which means that no information could be found on the year 1997. Therefore, the analysis could only be performed from the year 2001 on. This is shown in the mortality data in appendix 7.3: Specifications on mortality data.

3 Results

3.1 Smoking prevalence

Smoking prevalence by age and sex is shown in Figure 3. The total sample counted 5 000 participants, equally divided by men and women. Almost half of the population, namely 47.3%, were never smokers throughout all years. The former smokers were represented by 29.8% of the participants. It is comforting that the amount of current smokers (22.8%) is the lowest proportion among the participants.

Among the female participants, never smokers take up the largest part, accounting for 61.7%. The former and current female smokers respectively take up 20.4% and 17.9%. Differences are observed between the age categories, as the fraction of never smokers increases with age. In absolute numbers the lowest age group counts 252 never smokers (10.1% of the female participants) and the highest age group counts 409 (16.4% of the female participants). This means that the largest proportions of current and former smokers are located in the youngest age groups. Among the male participants, significant smaller proportions of never smokers are observed. In proportions, the amount of never, current and former smokers account for respectively 32.8%, 39.4% and 27.7% of the male population. The two youngest age groups contain the highest amount of current smokers, while the older age groups contain a high amount of former smokers.

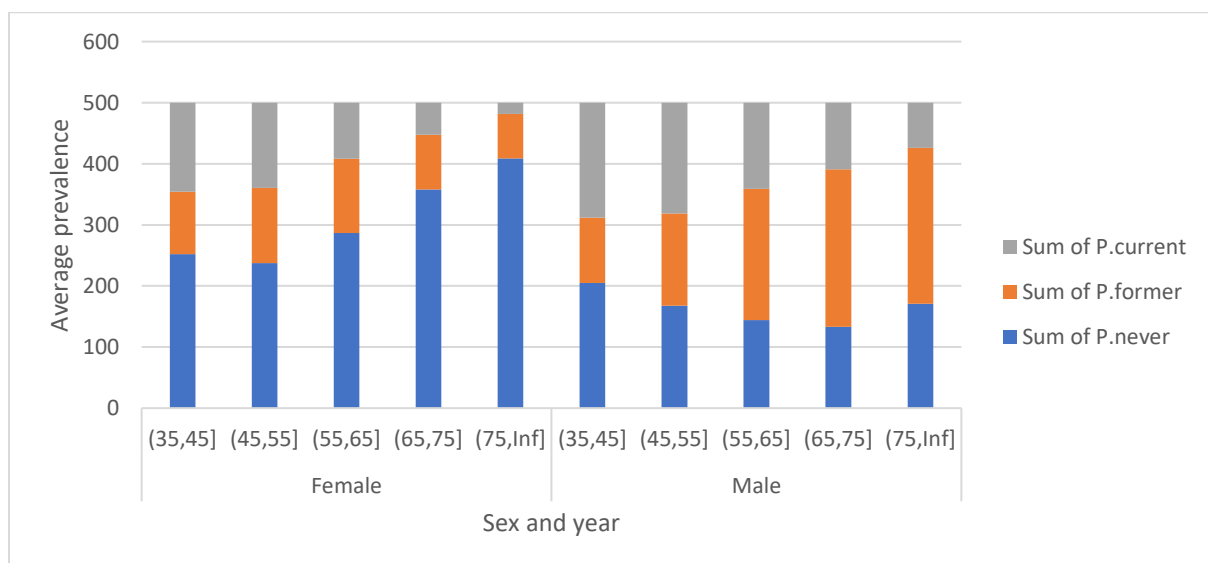


Figure 3: Smoking prevalence by sex and age, sum of never, current and former smokers from 1997-2013 (Sciensano, 2018).

Sciensano also reported a substantial difference in smoking prevalence among men and women. The smoking prevalence is higher among men, which is observed throughout all age categories. The differences between the sexes is most remarkable in the youngest age categories. The highest proportion of smokers is found in the age category from 35 to 45 years for both sexes, with 29% of the men and 24% of the women being smokers (Gisle & Demarest, 2014).

Smoking prevalence by sex and year is shown in Figure 4. While in 1997 the total amount of never smokers was 43.2%, it rose up to 53.1% in 2013. This increase in never smokers is expected to continue and can be considered a positive trend from a health perspective. The amount of former smokers declines over the years, from 31.7% in 1997 to 26.1% in 2013. Logically, the amount of current smokers also decreases over the years, which is also observed in the data (25.1% in 1997 and 20.8% in 2013).

Another difference between the sexes can be observed, while the outcomes are quite constant for women over the examined time period, more variations are observed in the male results. Averagely 61.8% never, 17.8% current and 20.2% former female smokers are observed each year. In absolute numbers this is represented by respectively 309, 89 and 101 persons out of the 500 participating females. The exception can be found in 2001, with a decrease in never smokers (257) and an increase in former smokers (152). An important observation from this data is that the smoking behaviour of women has not changed much over the years, although literature often predicts otherwise (Miermans & Van Oyen, 2002; Gisle & Demarest, 2014). The average of male never smokers accounts for 32.8% or 164 participants in absolute numbers, this is noticeably lower than the female never smokers. Consequently, a higher amount of current smokers and former smokers is to be expected. This is confirmed by the data, as they account for respectively 27.8% (139) and 35.8% (139) of the male participants. An increase of male never smokers over the years is observed, namely from 23.2% in 1997 to 41.6% in 2013. Naturally, this also results in a decline of the proportion former and current smokers for men, respectively from 43.5% to 35% and from 33.2% to 23.5% for the years 1997 and 2013.

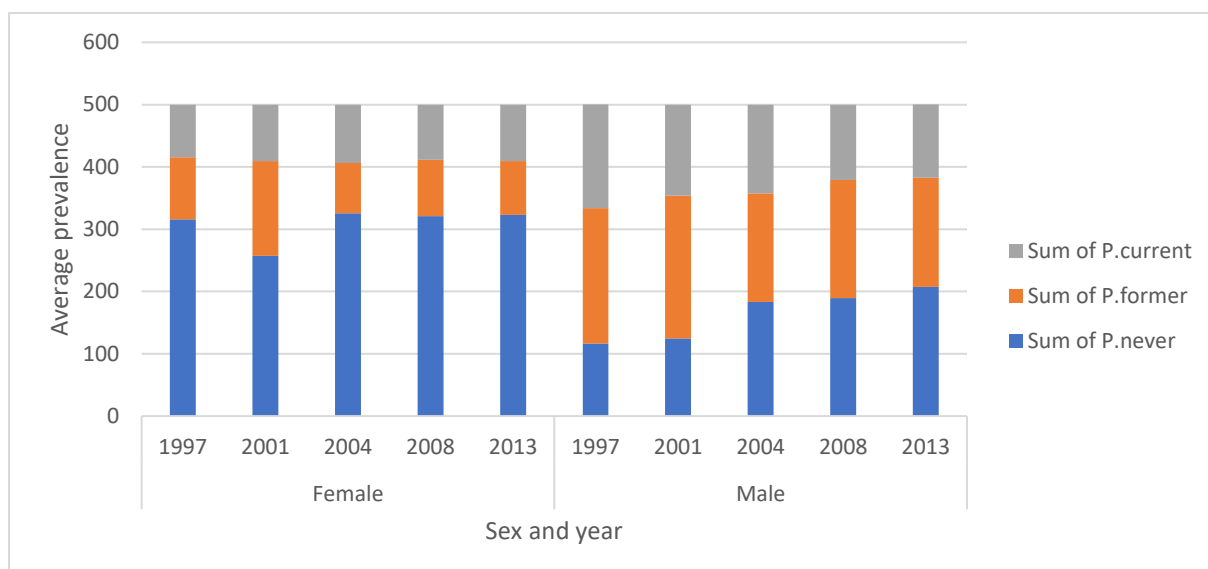


Figure 4: Smoking prevalence by sex and year, sum of never, former and current smokers over all age categories (Sciensano, 2018).

In the evolution over time, Sciensano indicates a constant reduction of smokers (daily and occasional) from 30% in 1997 to 23% in 2013 (Gisle & Demarest, 2014). Still progress should be made in the future.

Specifications on this data can be found in appendix 7.1. Here detailed data for the examined time period is available, based on age group and sex (Sciensano, 2018).

3.2 Population attributable fraction

The highest PAF is observed in reference to bronchitis, emphysema. The results remain high over all years, however small improvements are made. For men in the youngest age category, the PAF is 0.90 in 2013 and for women it is 0.81. A better improvement for women over time can be seen in comparison to men, where the change is very little (respectively 0.87 and 0.91 in 2001).

Similar results are seen for trachea, lung and bronchus cancer in the young age category. In 2013 the PAF was 0.77 for women and 0.90 for men, in 2001 it was respectively 0.83 and 0.92. A better evolution over time and over the age categories is seen, though the difference remains very small. In 2013 the oldest age category reported values of 0.39 and 0.84 respectively. A better manifested evolution is observed for women than for men.

Chronic airway obstruction reports a PAF of 0.85 in 2001 for men and women in the youngest age category. This is one of the exceptions showing similar results among

the both sexes. By 2013, this value has decreased to 0.79 for women and 0.82 for men. This indicates a small improvement over time. In the oldest age group, the PAF is 0.47 for women and 0.77 for men in 2013. A larger decrease over the age group is made among women in comparison to men.

For both sexes, the PAF for cancer of the larynx is considerably high. Starting at 0.84 for women and 0.88 for men in 2001 in the youngest age categories. Small improvements are made over the years, leading to a PAF of 0.78 for women and 0.85 men in 2013. The largest progress can be seen in women in the oldest age category, going from 0.62 in 2001 to 0.42 in 2013.

For men, lip, oral cavity and pharynx cancer also leads to high PAF results. Here the value is 0.79 in 2013 in the youngest age category, while for women the PAF is 0.54 in the same year. An improvement over the years can be seen, lowering the value for both sexes. More specifically, in 2001 the PAF was 0.63 for women and 0.83 for men. Again the trend of a lower PAF in the higher age categories is observed, reporting a value of 0.19 for women and 0.67 for men in 2013.

Oesophagus cancer reports a PAF of 0.73 for women and 0.77 for men of the youngest age category in 2001. By 2013, these values have decreased up to respectively 0.66 and 0.73, so little progress is made. This is also seen in the oldest age category for women, where the evolution is more clear (0.43 in 2001, 0.26 in 2013).

Overall small progress is seen over the years of the analysis. The PAF is decreasing from 2001 to 2013, which can be derived from a reduction in the smoking prevalence. The relative risk is stable over the years, this is the reason why it can not affect the PAF in this evolution. Another note that can be made is the decrease of the PAF over the years, leaving older age categories with lower PAF values. This can be associated with both the smoking prevalence and the relative risks.

More detailed information on these results can be found in appendix 7.4.

3.3 Smoking attributable mortality

The amount of smoking attributable deaths has declined over time, from 17 662 attributable deaths in 2001 to 14 834 attributable deaths in 2013. Compared to the total amounts of deaths in 2001 and 2013, which are respectively 102 991 and 109 295 deaths, the proportion of smoking related deaths decreased from 17.1% to 13.6% over this time period. Similar trends are found in the four selected disease groups, namely cancer, cardiovascular, respiratory and digestive diseases. Based on this trend, it is predicted that the SAM will decrease even further in the future.

The highest mortality rates are found in the cancer disease group, causing 7 657 smoking attributable deaths in 2013. Meaning that 51.6% of the total SAM is caused by cancers exclusively. Especially high rates are shown for trachea, lung and bronchus cancers, resulting in a 5 206 smoking attributable deaths or 35.1% of the SAM. This indicates why lung cancer is a good predictor of the SAM, providing the SIR-method of its most important indicator (GBD 2013 Risk Factors Collaborators, 2015; GBD 2010 Risk Factors Collaborators, 2012). The second position has switched over the years, in 2001 CVD caused 5 207 attributable deaths (35.1%) and respiratory diseases caused 4 382 attributable deaths (29.5%). Remarkable figures are shown for ischemic heart disease (2 141 or 14.4%), other heart disease (1 559 or 10.5%) and cerebrovascular disease (969 or 6.5%) in this year. By 2013, respiratory diseases caused more SAM in comparison to the cardiovascular diseases, with respectively 3 818 (25.7%) and 3 298 (22.2%) attributable deaths among men and women. It is possible to declare this change because of a better prognosis for CVD. High smoking attributable death rates within the respiratory disease group are caused by chronic airway obstruction, reporting a SAM of 2 836 or in 2001 and 2 777 in 2013. Respectively, this equals a proportion of 19.1% and 18.7% of the SAM. Until 2013, smoking attributable deaths declined for ischemic heart disease (1 103 or 7.4%), other heart disease (1 170 or 7.9%) and cerebrovascular disease (643 or 4.3%). There is a remarkable gap between the previous results and those of digestive diseases, where much lower figures occur. The SAM of digestive diseases has decreased from 140 attributable deaths in 2001 to 67 in 2013. In proportional figures, this is a decline from 0.9% to 0.4% of the SAM over the same years.

These results are in line with the results of the GBD study, mentioning CVD, neoplasms and chronic respiratory diseases as mostly associated with tobacco use (GBD 2016 Risk Factors Collaborators, 2017). Belgian studies also indicate high mortality rates caused by the same tobacco attributed disease-groups in 2004 and 2008-2009 (Gerkens & Merkur, 2010; Renard et al., 2014). This indicates the impact of tobacco use on mortality in Belgium and opens opportunities for prevention and tobacco control policies.

Further results integrated in Table 2 concern the relative SAM or SAM%. This was applied only for each of the considered disease groups, yielding the results shown in brackets and at the bottom of the table. In order to make the analysis more clear, the all-cause mortality was also mentioned in the table. Analysis of the table shows a general reduction of the SAM%, which indicates a decrease in smoking attributable deaths. The decrease is greatest for CVD, dropping from 5.06% to 3.02%. Cancer causes the largest amount of smoking attributable deaths, it accounts for approximately 7% of the total amount of deaths in Belgium in 2013. Although a decrease can be observed over the years, smoking was still attributable for 13.6% of all deaths in Belgium in 2013. This number is still considerable and could be partially remedied by influencing lifestyle factors of the population.

A detailed overview of the complete analysis is shown in appendix 7.5.

Table 2: SAM and SAM% for groups and diseases by year.

Group and disease	2001	2004	2008	2013
Cancer (SAM%)	7933 (7.70)	7456 (7.36)	7731 (7.45)	7657 (7.01)
Cervix Uteri	19	20	18	17
Kidney and Renal Pelvis	180	153	168	171
Larynx	221	207	159	162
Lip, Oral Cavity, Pharynx	366	341	363	397
Malignant neoplasm without specification of site	419	362	323	374
Myeloid Leukemia	71	64	70	69
Oesophagus	405	439	451	499
Pancreas	287	277	292	317
Stomach	220	166	158	137
Trachea, Lung, Bronchus	5386	5107	5417	5206
Urinary Bladder	358	320	311	308
Cardiovascular (SAM%)	5207 (5.06)	4534 (4.48)	3903 (3.76)	3298 (3.02)
Aortic Aneurysm	413	405	361	289
Atherosclerosis	56	54	56	30
Cerebrovascular Disease	969	922	745	643
Ischemic Heart Disease	2141	1781	1443	1103
Other Arterial Diseases	68	65	59	63
Other Heart Disease	1559	1307	1238	1170
Digestive (SAM%)	140 (0.14)	102 (0.10)	91 (0.09)	67 (0.06)
Stomach ulcer, Duodenal ulcer	140	102	91	67
Respiratory (SAM%)	4382 (4.25)	4032 (3.98)	4082 (3.93)	3813 (3.49)
Bronchitis, Emphysema	818	626	522	482
Chronic Airway Obstruction	2836	2740	2939	2777
Pneumonia, Influenza	728	665	621	554
End total	17662	16123	15807	14834
All-cause mortality	102991	101250	103756	109295
SAM%	17.2%	15.9%	15.2%	13.6%

The SAM was analysed by sex and age in Figure 5. As shown, the sum of the SAM values are much lower for women when compared to men. This can be linked to the higher amount of never smokers among women, as is shown in the smoking prevalence data in Figure 3. For both genders, a positive correlation between the SAM and an increasing age has been found. In other words, smoking is more likely to cause death to a person when they are older. This trend is shown much stronger among men than women. A considerable increase is noted in the deaths caused by respiratory, digestive and cardiovascular diseases from the age group 65-75 to the oldest age group. This partially accounts for the substantial increase of the SAM over the two mentioned age groups. For example in 2013 the SAM increased from 14 320 to 21 541 for men and from 3 528 to 6 619 for women.

Among women, the highest amount of smoking attributable deaths (5 562) is caused by cancer in total. In comparison, respiratory diseases and CVD caused respectively 4 593 and 4 338 deaths. Only in the oldest age group, respiratory diseases cause a higher amount of deaths and CVD are second largest. In this age group, cancers take the third place, nonetheless causing a high amount of deaths. Among men, cancer causes the highest amount of smoking attributable deaths in total (25 215) and across all age groups. With a SAM of 11 715 for respiratory diseases and 12 603 for CVD, the gap between the deaths caused by cancer and by the other diseases is also larger than for women.

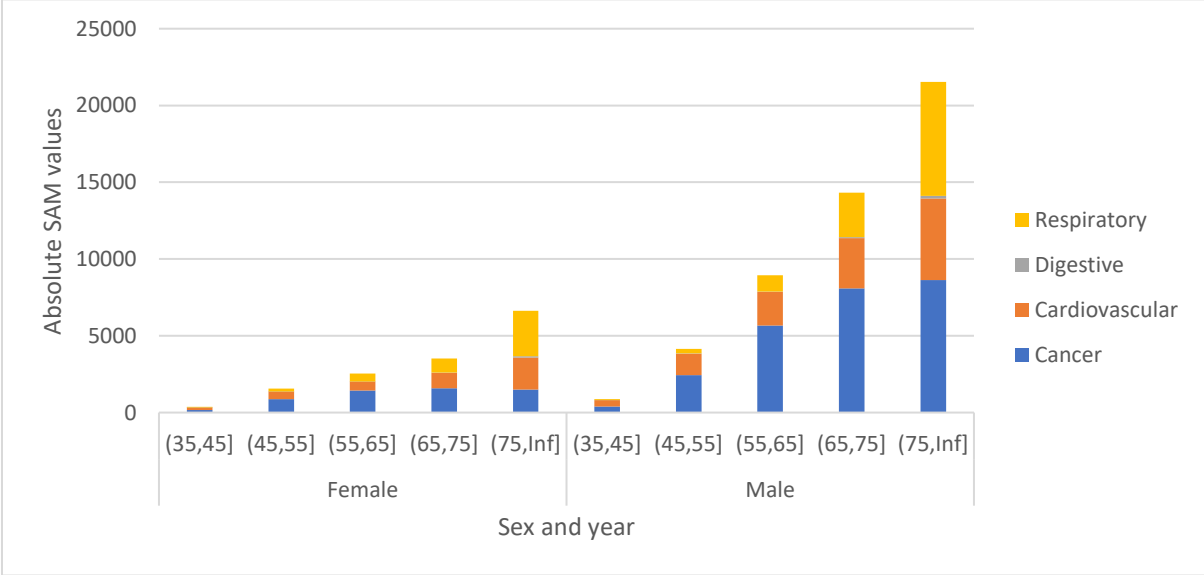


Figure 5: SAM values by sex and year for respiratory diseases, digestive diseases, cardiovascular diseases and cancer.

In Figure 6 the SAM is shown sorted by sex and year. In the entire time frame, tobacco causes a higher amount of deaths among men than women. This could, once more, be accredited to the lower amount of never smokers found in the male group. A positive observation is the decreasing SAM for men over the examined time period, as it has dropped from 13 714 to 11 232. The attributable deaths decline for all disease-groups, the strongest absolute decline is noticed for CVD. Although SAM values are much lower among women, a concerning trend can be seen. All disease groups, except for cancers, are leading to lower numbers of smoking attributable deaths over the years. Looking at the evolution of SAM caused by cancers, a decline from 2001 to 2004 can be seen, followed by an increase over the latest years. This causes an overall increase of the SAM from 1 270 in 2001 to 1 647 in 2013 specifically for cancer among women.

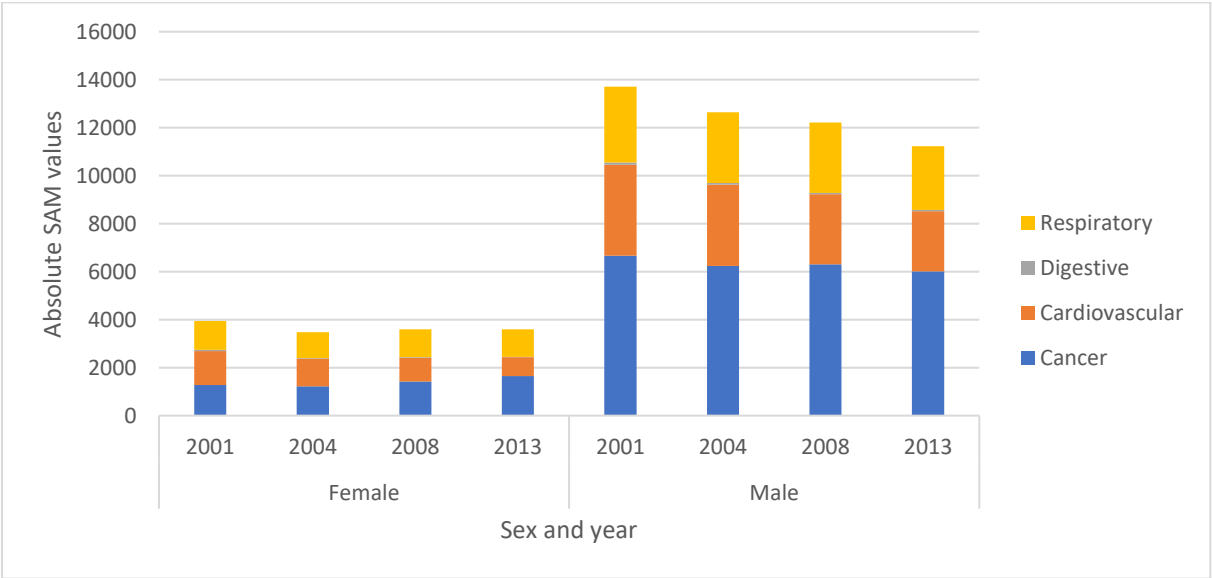


Figure 6: SAM values by sex and year for respiratory diseases, digestive diseases, cardiovascular diseases and cancer.

3.4 Summarising population attributable fraction analysis

The first results to be used, were the SAM values for the disease groups each year. This part was analysed in the previous section of the thesis, inspecting the group totals in Table 2. What is observed in these results, is a declining trend over the years throughout the different disease groups. Moreover, cancer can be determined as the leading cause of smoking attributable deaths.

The following table shows the mortality rates in Belgium for each specific disease group (Table 3). These mortality rates are not related to smoking and were used in order to obtain the SAM in the first place. In 2013 the top three is formed by CVD (30 033),

cancer (13 820) and respiratory diseases (8 477). Further, it can be noticed that the amount of deaths caused by digestive diseases (204) is much lower in comparison to the previous three (Statbel & Belgische Federale Overheidsdiensten, 2017a).

Table 3: Mortality for disease group per year (Statbel & Belgische Federale Overheidsdiensten, 2017a)

Group	2001	2004	2008	2013
Cancer	12853	12657	13372	13820
Cardiovascular	35440	33889	31815	30022
Digestive	353	251	257	204
Respiratory	8494	8362	8639	8477
End total	57140	55159	54083	52523

Table 4 shows the results of the PAF for the different disease groups sorted by year. Here a ratio-number is found, giving the figures in the form of fractions. The data indicate a slow decline in the evolution over time, from 0.31 to 0.28. Even though the decline is rather small (0.03), it can make considerable differences on population level. The PAF of the cancer-group is the highest (0.55 in 2013), this can declare why cancer tops cardiovascular diseases (0.11 in 2013) in the calculation of the SAM. It is also remarkable that the results of digestive diseases (0.33) are rather high in comparison to previous results.

Table 4: PAF results for disease group per year.

Group	2001	2004	2008	2013
Cancer	0.62	0.59	0.58	0.55
Cardiovascular	0.15	0.13	0.12	0.11
Digestive	0.40	0.41	0.35	0.33
Respiratory	0.52	0.48	0.47	0.45
End total	0.31	0.29	0.29	0.28

4 Discussion

4.1 Summary

Before assessing a comparative risk assessment on tobacco use, the different plausible methodologies should be evaluated. In order to obtain effective calculations, the methodology should fit the study design. Before assessing this research, a systematic literature review was performed. Here, 30 international studies on the calculation of burden of tobacco use were analysed. It could be concluded that prevalence based calculations are most commonly used, although the value of calculating the SIR should not be underestimated. In some studies, both techniques are even combined as an alteration of methodologies between different diseases.

For this research, a prevalence-based method was most fitted. The reason behind this good fit is the availability of extensive prevalence data that was collected in the past. It is the objective of Sciensano to continue the HIS of lifestyle factors in Belgium. This opens the possibility to future research on the burden of tobacco use.

In the implementation of this study, other studies that have proven their scientific importance were used as an example. Many information was retrieved from the GBD studies (GBD 2010 Risk Factors Collaborators, 2012; GBD 2013 Risk Factors Collaborators, 2015; GBD 2015 Risk Factors Collaborators, 2016; GBD 2015 Tobacco Collaborators, 2017; GBD 2016 Risk Factors Collaborators, 2017; Institute for Health Metrics and Evaluation, 2017), Statistics on Smoking in England (Lifestyl Statistics, Health and Social Care Information Centre, 2013), Smoking attributable deaths in Scotland (Barkat et al., 2016) and a health report in Belgium (Miermans & Van Oyen, 2002). As the method and objectives were similar, these reports provided a good guideline for the execution of this research.

An important difference that can be indicated, is the focus on policy within this research. Literature on tobacco control policies in Belgium was consulted and the state of affairs was evaluated. Much importance is also given to the possibilities of prevention campaigns, indicating where it is most needed. Together this indicates that there is still work for Belgium in improving initiatives to decline the tobacco use all over the country.

4.2 Comparison with other studies

Comparisons can be made to different studies, first of all the report of Miermans and Van Oyen (2002) can be consulted. It is possible to make a comparison of the Belgian population over time. In brief, data gained in 1996 proved a total of 15 958 male deaths and 2 229 female deaths related to smoking. These results were calculated by the Peto-method, using lung cancer rates in order to calculate the SAM (Peto et al., 1992). As the same population was analysed through a different method (PAF-method or prevalence based), in 2001 this research found 13 714 male and 3 948 female deaths attributable to smoking. Although these results are only five years apart, large differences are indicated. In order to complete this comparison, results from 2013 are consulted. Here the results indicate that smoking caused 11 232 male and 3 602 female attributable deaths. Over the years it can be seen that the SAM is slightly rising among women, while it is declining among men.

Another remarkable result mentioned in the report, were the amount of lung cancer deaths attributable to smoking, 5 221 male deaths and 565 female deaths (Miermans & Van Oyen, 2002). In 2001, lung cancer caused 746 female and 4 640 male attributable deaths. This difference is much smaller than seen among the total results. In order to make a good comparison, it is again worthwhile to mention the figures given for 2013. Then, the SAM was 1 194 for females and 4 012 for males. A smaller difference in men can be seen, while the difference among women has increased. Within the group of cancer diseases, the overall SAM is increasing for females over time (except for the year 2004), while it is decreasing for males. Further results among females show a decrease of the SAM for CVD and digestive diseases and more or less steady results for respiratory diseases over the years. Concluding the overall increase of the SAM is mostly due to the increase of the cancer related mortality.

A second important source that can be consulted are the GBD studies. The latest study was executed in 2017 and used the PAF-method as well. According to the GBD studies, smoking was attributable for 20 061 deaths all over the country in 2017. The results for 2013, which are most comparable to this research, show a complete total of 23 670 smoking attributable deaths (Institute for Health Metrics and Evaluation, 2017). Given the results of this research, the SAM indicated 14 834 deaths in total in 2013, the most recent year that was analysed. This indicates a substantial difference over the two studies in 2013 and from 2013 to 2017. Even so, it is not expected for the SAM

to increase this far in the future, since many initiatives have been taken in order to reduce this number.

More specific results of the studies are however more in line with one another. As the top three of the SAM in Belgium is formed by neoplasms (9 372 deaths), CVD (4 279 deaths) and chronic respiratory diseases (3 258 deaths) for 2017. Again the results for 2013 can be consulted, when smoking attributable deaths were mostly caused by cancer (10 087 deaths), CVD (4 855 deaths) and respiratory diseases (3 469 deaths) (Institute for Health Metrics and Evaluation, 2017). In 2013, this analysis indicated a SAM of 7 657 for cancer, 3 298 for CVD and 3 813 for respiratory diseases. Although differences can still be noticed, the figures are getting closer together. Note that this analysis indicates a difference in the sequence of the top three, mentioning respiratory diseases in second place and CVD in third place. As mentioned in the results, these two disease groups have switched places over time.

Another interesting part of the GBD tool makes it possible to compare the results for different countries. Therefore, the SAM is expressed in deaths per 100.000 population. It seemed interesting comparing Belgium, with approximately 185 deaths per 100.000 attributable to smoking to its nearest neighbouring countries. In Germany and the Netherlands, the death rate was similar with values around respectively 180 and 190 deaths per 100.000. While in France and Luxembourg, much lower rates could be observed, with respectively 125 and 120 deaths per 100.000. Remarkable is that tobacco was the highest placed risk factor overall, except for Germany where dietary risks were ranked even higher (Institute for Health Metrics and Evaluation, 2017). This analysis proves that tobacco use is still a major problem in different Central-European countries, as found by the TCS (Joossens & Raw; 2013).

The TCS gives the possibility of comparing ranks between Belgium and its neighbouring countries. The Netherlands were placed on the same rank as Belgium. This was due to the new initiatives and support on tobacco control policies given by the current government. A relevant initiative was the reintroduction of smoke free bars in 2014. Luxembourg was placed on the 28th place, mainly due to the low taxes on tobacco products, which also attracts cross border shopping. The lack of the introduction of new tobacco control policies since 2010, was the reason why Germany ended on the 33th place. Although many of our neighbouring countries are not performing so well, France can be seen as an example. In the TCS it was ranked on

the 5th place and is improving its policies over the years. The introduction of health warnings for cigarettes and tobacco products in 2011 and 2012 expect to reduce the SAM. A further decline of the smoking attributable deaths is even expected, caused by the new cancer plan, which will lead to more tobacco control activities in the country (Joossens & Raw, 2013).

In addition, it is interesting to compare the deaths per 100 000 for a country scoring very high in the TCS. Apparently, 145 deaths per 100 000 are attributable to tobacco use in the United Kingdom. The first place in the ranking was already given to the UK since 2010. This is caused by good scoring initiatives, for example in tobacco display banning legislations (Institute for Health Metrics and Evaluation, 2017; Joossens & Raw, 2013). Although a clear difference can be seen with the death rates in Belgium, the rates for France and Luxembourg are significantly lower than in the UK. While France was ranked on the 5th place on the scale, good initiatives could declare the lower burden caused by the risk factor. Opposed to this, Luxembourg was only placed on the 28th rank, so no direct reason can be formed for the lower death rates (Joossens & Raw, 2013).

4.3 Limitations

Sciensano performed a stratified multi-stage, clustered sampling method for sampling the participants of the HIS. The interviews are executed proportionally throughout the different regions in Belgium and participation is on voluntary basis. This method is chosen to represent the population composition in the best way (Sciensano, 2018). Still a substantial difference in the results can be seen in comparison to the GBD study. Part of the reason behind these variations are the different methods in estimating smoking prevalence. Opposed to Sciensano, the GBD studies used probability density functions, a fitting method and a model selection criterion to model the distribution of any particular risk factor (GBD 2016 Risk Factors Collaborators, 2017). Further variation indicates some bias in the HIS on behalf of the participants. Since the surveys were executed by the population itself, there is a chance of social desirability. This makes it possible for someone to choose whether they want to identify themselves as a smoker or not. Especially occasional smokers will recognize this problem, for them it could be more difficult to admit their usage.

It is a limitation that data of 2018 was not ready for analysis yet. Therefore only data from 2001 up to 2013 could be analysed in this research. Recent data gives a more correct view of the current situation of the tobacco use in Belgium. It is possible that this would give more incentives to the government to form new tobacco control policies or to invest more in prevention campaigns. Nonetheless, data of past HIS have proven to be useful and hopefully this trend in analysis will be continued on a systematic basis. Data of the HIS 2018 will be published soon, giving the opportunity of executing new analyses with recent data.

Furthermore, it was unfortunate that prevalence data gained in 1997 by the HIS could not be included in this research. Since no mortality data was available for this year, it was not possible to include the prevalence data in the analysis. Given these more dated results, a better comparison of the conclusions mentioned by Miermans and Van Oyen (2002) could have been made. The lower consciousness about the negative effects of tobacco use and the looser policies could show some differences in the results of the SAM. This would make the concluding evolution, a decrease of the SAM, more visible in the analysis.

A comparison between the different regions in Belgium will improve this research. As mentioned before, the HIS sample was representatively selected throughout the three different regions (Sciensano, 2018). This makes it possible to analyse results for the regions separately. An important reason why regional differences should be included, is to know where prevention is most needed. Then, prevention campaigns could be organised in selective regions. It is expected that prevention will have a higher impact on changing unhealthy lifestyle factors by using this method.

Also, including socio-economic status (SES) within the analysis would lead to interesting results. While evidence-based tobacco control policies have been successfully implemented in European countries, health inequalities in the trend of smoking are persistent. The most worrying inequalities are indicated by SES, as the smoking prevalence among those with a low SES is highest and is declining less rapidly, compared those with a higher SES (Bosdriesz et al., 2016). Again this is an important field for prevention, organising help or education in a way that is most needed for a specific population.

4.4 Recommendations for research and policy

The use of tobacco creates problems on the long term. Most of the diseases caused by smoking only manifest after a long period of time. This means that current analyses on disease burden reflect results of a behaviour manifested in the past and possibly over many years. If smoking campaigns are undertaken at this moment, the effect on health burden will only be seen in the future. This is why systematic research on smoking behaviour and the effects of smoking is highly important. It is necessary to follow up on the evolution of the smoking behaviour in order to know the extent of its effects in the future.

Since 1997, Sciensano has been performing the Belgian HIS every five years, collecting data on different health indicators. The continuous character of the Belgian HIS calls for similar analyses in the future to keep data up-to-date (Sciensano, 2018). This can map not only the evolution of the smoking behaviour in Belgium, but also the evolution of the burden of disease of tobacco use. Sciensano is planning on taking this initiative even further, by introducing the Belgian National Burden of Disease study (BeBOD). This study aims at analysing and ranking risk factors that attribute to the total burden of disease in Belgium. The objective of the study is promoting the population health and informing policy makers, so that the necessary budgets can be spent in a more efficient way. In order to do so, the BeBOD is based on systematic data sources which will report on DALYs (Sciensano, 2016).

Although the prevalence of smoking is declining, the burden estimates for tobacco use remain considerable. In Belgium the reason for the high amount of smoking-attributable deaths and DALYs is partially due to the ageing population. According to evidence-based strategies to reduce tobacco consumption, the problem is manifested mostly on political level for tobacco control. Improvements need to be made in order to decrease the consumption of tobacco products (GBD 2015 Risk Factors Collaborators, 2016). Especially in countries with the highest numbers of smokers, more progress should be made. The toll of tobacco use expands beyond the individual to the health system, causing financial and operational burdens. In order to overcome the tobacco epidemic, a renewed and sustained focus is needed on comprehensive tobacco control policies around the world. Furthermore, present and future smoking rates need to be kept low, which requires intensive interventions of prevention campaigns (GBD 2015 Tobacco Collaborators, 2017).

According to the TSC (Joossens & Raw, 2013), Belgium has work to improve its policy and luckily some changes have already been made since. New initiatives on reducing tobacco use should be introduced, for example starting with elevating the prices of taxes on these products and limiting the possibilities of the tobacco industry to influence the public. Systematic analysis in the future should also lead to new and innovative interventions. It is important that the federal or regional governments react on leading health issues and marketing of the industry, now and in the future. On the other hand, the awareness of the smokers themselves should be improved. Therefore, prevention campaigns are the best educational method. Naturally, it is important to take into account regional and socio-economical differences in the population to maximize the impact of the campaigns. People can best be helped and the learning effects will increase, when prevention is adapted to personal needs.

5 Conclusion

Although some interventions to reduce tobacco use have been made in the past, more governmental support needs to be given in order to improve the population health. Too many people are dying from the effects of tobacco use, as it can be partially prevented. Special attention should be given to women, since the SAM is rising in the latest years, while it is already declining among men. Within this process, patience is very much needed, since health effects will only be shown in the future.

Sciensano will soon publish new data on the smoking prevalence in 2018 for the Belgian population. It is important to systematically keep records of the smoking prevalence over the years, since it still has a major influence on health and disease burden in Belgium.

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7.1 Specifications on smoking prevalence

Table 5: Prevalence of tobacco use (%) by sex and by age, by year and for current, former and never smokers (Sciensano, 2018).

Gender & Age	1997			2001			2004			2008			2013		
	C	F	N	C	F	N	C	F	N	C	F	N	C	F	N
Female	84.4	99.4	316	90.4	152.3	257.1	93.4	80.7	325.8	88.7	90.3	321.0	90.7	86.3	322.9
(35,45]	32.8	21.8	45.3	32.8	28.4	38.8	31.3	18.3	50.4	24.5	19.0	56.5	24.4	14.4	61.2
(45,55]	25.3	27.7	47.0	28.6	33.6	37.8	29.6	22.1	48.3	30.8	21.9	47.2	25.0	18.0	57.0
(55,65]	15.1	19.4	65.5	17.5	33.1	49.3	15.2	16.9	67.8	18.7	25.2	56.1	25.3	26.7	48.0
(65,75]	7.8	18.7	73.5	7.7	29.3	62.9	11.9	13.9	74.2	11.2	11.1	77.7	13.6	16.9	69.5
(75,Inf]	3.4	11.8	84.7	3.8	27.9	68.3	5.4	9.5	85.1	3.5	13.1	83.5	2.4	10.3	87.2
Male	166.3	217.5	116.4	146.1	229.1	124.8	142.6	174.0	183.4	121.0	189.6	189.2	117.5	175.0	207.6
(35,45]	42.4	22.8	34.8	42.7	26.5	30.9	37.1	17.3	45.6	33.4	16.9	49.7	32.9	23.0	44.1
(45,55]	41.2	35.4	23.5	38.8	39.7	21.5	37.8	29.0	33.2	34.9	24.6	40.5	28.6	22.7	48.8
(55,65]	33.5	44.1	22.5	26.4	48.7	24.9	29.8	39.7	30.4	24.4	43.6	32.0	26.7	38.7	34.6
(65,75]	28.6	56.9	14.5	22.0	51.2	26.8	21.4	46.5	32.1	18.7	50.7	30.4	18.3	52.2	29.5
(75,Inf]	20.6	58.3	21.1	16.2	63.0	20.7	16.5	41.5	42.1	9.6	53.8	36.6	11.0	38.4	50.6
End total	250.7	316.9	432.4	236.5	381.4	381.9	236.0	254.7	509.2	209.7	279.9	510.2	208.2	261.3	530.5

C = Current smokers

F = Former smokers

N = Never smokers

7.2 Specifications on relative risks

Table 6: Relative risks for diseases by age for current and former smokers, by gender (Barkat et al., 2016; Lifestyle Statistics, Health and Social Care Information Centre, 2013).

Diseases	ICD-10 codes	Female RR.former	RR.current	Male RR.former	RR.current
Aortic Aneurysm	I71				
35+			2.07	7.07	3.07
Atherosclerosis	I70				
35+			1.00	1.83	1.33
Bronchitis, Emphysema	J40-J42, J43				
35+			11.77	12.04	15.64
Cerebrovascular Disease	I60-I69				
35-54			1.30	5.40	1.10
55-64			1.30	3.70	1.10
65-74			1.30	2.60	1.10
75+			1.00	1.30	1.10
Cervix Uteri	C53				
35+			1.14	1.59	1.00
Chronic Airway Obstruction	J44				
35+			6.78	13.08	6.80
Ischemic Heart Disease	I20-I25				
35-54			2.60	5.30	2.00
55-64			1.10	2.80	1.60
65-74			1.20	2.10	1.30
75+			1.20	1.40	1.10
Kidney and Renal Pelvis	C64-65, C68				
35+			1.10	1.40	1.70
Larynx	C32				
35+			5.16	13.02	6.34

Lip, Oral Cavity, Pharynx	C00-C14				
35+		2.29	5.08	3.40	10.89
Malignant neoplasm without specification of site	C80				
35+		1.30	2.20	2.50	4.40
Myeloid Leukemia	C92				
35+		1.30	1.20	1.40	1.80
Oesophagus	C15				
35+		2.79	7.75	4.46	6.76
Other Arterial Diseases	I72-I78				
35+		1.12	2.17	1.01	2.07
Other Heart Disease	I00-I09, I26-I51				
35+		1.14	1.49	1.22	1.78
Pancreas	C25				
35+		1.55	2.25	1.15	2.31
Pneumonia, Influenza	J10-J18				
35-64		1.10	4.30	1.40	2.50
65+		1.10	2.20	1.40	2.00
Stomach	C16				
35+		1.32	1.36	1.47	1.96
Stomach ulcer, Duodenal ulcer	K25-K27				
35+		1.40	5.50	1.80	5.40
Trachea, Lung, Bronchus	C33-C34				
35+		4.53	12.69	8.70	23.26
Urinary Bladder	C67				
35+		1.89	2.22	2.09	3.27

7.3 Specifications on mortality data

Table 7: Mortality data for diseases by age, by year and sex (Belgische Federale Overheidsdiensten, 2017a).

Diseases by age	2001			2004			2008			2013		
	Female	Male	Both	Female	Male	Both	Female	Male	Both	Female	Male	Both
Aortic Aneurysm	179	501	680	192	514	706	173	476	649	171	385	556
(35,45]	0	8	8	2	3	5	3	8	11	1	3	4
(45,55]	1	24	25	4	26	30	4	23	27	6	9	15
(55,65]	8	53	61	11	57	68	12	50	62	11	45	56
(65,75]	37	170	207	30	153	183	19	119	138	30	93	123
(75,Inf]	133	246	379	145	275	420	135	276	411	123	235	358
Atherosclerosis	287	149	436	225	149	374	234	186	420	126	104	230
(35,45]	0	0	0	0	1	1	0	0	0	0	0	0
(45,55]	0	1	1	0	0	0	1	2	3	1	1	2
(55,65]	3	9	12	3	11	14	2	10	12	5	9	14
(65,75]	15	21	36	14	37	51	10	37	47	7	20	27
(75,Inf]	269	118	387	208	100	308	221	137	358	113	74	187
Bronchitis, Emphysema	370	573	943	298	479	777	287	367	654	331	310	641
(35,45]	2	3	5	3	3	6	0	3	3	1	4	5
(45,55]	5	13	18	8	11	19	7	9	16	5	8	13
(55,65]	25	43	68	16	47	63	9	41	50	23	24	47
(65,75]	61	177	238	37	112	149	32	66	98	35	74	109
(75,Inf]	277	337	614	234	306	540	239	248	487	267	200	467
Cerebrovascular Disease	5151	3306	8457	4920	3106	8026	4420	3070	7490	4136	2829	6965
(35,45]	51	35	86	41	47	88	37	40	77	27	17	44
(45,55]	88	133	221	118	121	239	81	107	188	68	97	165
(55,65]	131	273	404	145	245	390	147	246	393	139	224	363
(65,75]	657	824	1481	606	724	1330	453	581	1034	374	459	833
(75,Inf]	4224	2041	6265	4010	1969	5979	3702	2096	5798	3528	2032	5560

Cervix Uteri	162	0	162	185	0	185	184	0	184	173	0	173
(35,45]	27	0	27	24	0	24	26	0	26	14	0	14
(45,55]	29	0	29	39	0	39	35	0	35	36	0	36
(55,65]	29	0	29	38	0	38	28	0	28	33	0	33
(65,75]	35	0	35	33	0	33	33	0	33	37	0	37
(75,Inf]	42	0	42	51	0	51	62	0	62	53	0	53
Chronic Airway Obstruction	1056	2499	3555	1196	2499	3695	1337	2634	3971	1442	2482	3924
(35,45]	4	12	16	5	6	11	4	3	7	3	7	10
(45,55]	35	52	87	35	55	90	35	56	91	41	55	96
(55,65]	81	214	295	90	184	274	141	263	404	170	265	435
(65,75]	239	765	1004	231	672	903	271	627	898	276	573	849
(75,Inf]	697	1456	2153	835	1582	2417	886	1685	2571	952	1582	2534
Ischemic Heart Disease	5547	6888	12435	5259	6576	11835	4301	5603	9904	3441	4773	8214
(35,45]	29	149	178	22	104	126	23	102	125	12	73	85
(45,55]	106	425	531	99	402	501	100	339	439	57	265	322
(55,65]	244	849	1093	232	808	1040	204	814	1018	186	613	799
(65,75]	954	2042	2996	755	1758	2513	557	1194	1751	377	983	1360
(75,Inf]	4214	3423	7637	4151	3504	7655	3417	3154	6571	2809	2839	5648
Kidney and Renal Pelvis	284	393	677	274	365	639	258	423	681	317	457	774
(35,45]	2	5	7	4	6	10	2	7	9	3	3	6
(45,55]	21	33	54	12	21	33	12	28	40	13	28	41
(55,65]	36	85	121	32	70	102	23	65	88	30	74	104
(65,75]	76	138	214	83	110	193	60	126	186	61	114	175
(75,Inf]	149	132	281	143	158	301	161	197	358	210	238	448
Larynx	38	225	263	37	215	252	32	164	196	36	167	203
(35,45]	1	12	13	0	6	6	0	5	5	0	0	0
(45,55]	4	49	53	10	39	49	2	27	29	6	14	20
(55,65]	14	54	68	7	62	69	14	55	69	10	51	61
(65,75]	11	65	76	7	61	68	6	43	49	10	55	65
(75,Inf]	8	45	53	13	47	60	10	34	44	10	47	57

Lip, Oral Cavity, Pharynx	123	388	511	132	367	499	126	407	533	144	448	592
(35,45]	5	29	34	5	13	18	7	7	14	3	10	13
(45,55]	22	107	129	19	106	125	19	104	123	19	68	87
(55,65]	34	113	147	33	111	144	33	158	191	38	162	200
(65,75]	29	78	107	29	88	117	22	78	100	40	129	169
(75,Inf]	33	61	94	46	49	95	45	60	105	44	79	123
Malignant neoplasm without specification of site	519	558	1077	483	527	1010	506	465	971	554	578	1132
(35,45]	9	10	19	5	12	17	8	5	13	11	7	18
(45,55]	32	52	84	28	46	74	21	32	53	19	31	50
(55,65]	58	92	150	52	88	140	63	79	142	59	118	177
(65,75]	125	150	275	86	119	205	108	126	234	110	136	246
(75,Inf]	295	254	549	312	262	574	306	223	529	355	286	641
Myeloid Leukemia	178	191	369	170	215	385	194	238	432	202	254	456
(35,45]	8	7	15	3	7	10	7	9	16	4	9	13
(45,55]	15	13	28	13	12	25	12	14	26	14	10	24
(55,65]	23	30	53	24	36	60	26	31	57	28	25	53
(65,75]	49	73	122	42	68	110	38	68	106	41	70	111
(75,Inf]	83	68	151	88	92	180	111	116	227	115	140	255
Oesophagus	150	430	580	172	485	657	167	514	681	179	589	768
(35,45]	0	16	16	1	14	15	1	8	9	0	7	7
(45,55]	12	78	90	17	76	93	12	84	96	11	63	74
(55,65]	23	104	127	43	117	160	28	137	165	37	165	202
(65,75]	50	125	175	31	161	192	46	140	186	39	181	220
(75,Inf]	65	107	172	80	117	197	80	145	225	92	173	265
Other Arterial Diseases	221	259	480	218	241	459	262	264	526	287	320	607
(35,45]	3	2	5	2	5	7	4	3	7	1	3	4
(45,55]	6	13	19	6	12	18	12	10	22	9	8	17
(55,65]	16	20	36	8	34	42	17	41	58	10	43	53
(65,75]	29	88	117	37	67	104	28	64	92	26	73	99
(75,Inf]	167	136	303	165	123	288	201	146	347	241	193	434

Other Heart Disease	8039	4913	12952	7589	4900	12489	7734	5092	12826	7905	5545	13450
(35,45]	44	94	138	37	78	115	33	71	104	38	50	88
(45,55]	92	270	362	97	237	334	132	221	353	89	190	279
(55,65]	220	383	603	200	415	615	216	456	672	215	431	646
(65,75]	885	1108	1993	701	1000	1701	590	877	1467	504	828	1332
(75,Inf]	6798	3058	9856	6554	3170	9724	6763	3467	10230	7059	4046	11105
Pancreas	630	576	1206	627	676	1303	746	767	1513	838	820	1658
(35,45]	7	14	21	9	13	22	7	14	21	8	11	19
(45,55]	40	56	96	37	68	105	37	72	109	45	55	100
(55,65]	74	111	185	72	131	203	91	166	257	123	155	278
(65,75]	187	195	382	158	217	375	173	227	400	194	282	476
(75,Inf]	322	200	522	351	247	598	438	288	726	468	317	785
Pneumonia, Influenza	2171	1825	3996	2027	1863	3890	2189	1825	4014	2040	1872	3912
(35,45]	10	13	23	7	6	13	11	14	25	14	9	23
(45,55]	12	39	51	17	40	57	21	47	68	12	33	45
(55,65]	45	77	122	38	92	130	47	98	145	58	94	152
(65,75]	184	315	499	150	313	463	155	244	399	119	261	380
(75,Inf]	1920	1381	3301	1815	1412	3227	1955	1422	3377	1837	1475	3312
Stomach	419	552	971	336	500	836	305	486	791	281	455	736
(35,45]	13	16	29	9	13	22	8	10	18	6	11	17
(45,55]	19	46	65	10	44	54	21	41	62	18	36	54
(55,65]	33	87	120	35	89	124	31	87	118	24	73	97
(65,75]	85	156	241	57	143	200	47	118	165	43	125	168
(75,Inf]	269	247	516	225	211	436	198	230	428	190	210	400
Stomach ulcer, Duodenal ulcer	194	159	353	129	122	251	134	123	257	107	97	204
(35,45]	2	5	7	0	4	4	0	5	5	0	1	1
(45,55]	2	15	17	6	10	16	4	8	12	2	5	7
(55,65]	8	16	24	8	15	23	4	14	18	4	14	18
(65,75]	25	24	49	11	31	42	14	19	33	10	15	25
(75,Inf]	157	99	256	104	62	166	112	77	189	91	62	153

Trachea, Lung, Bronchus	1084	5149	6233	1274	4822	6096	1571	5006	6577	1879	4588	6467
(35,45]	46	88	134	38	59	97	32	51	83	25	32	57
(45,55]	152	460	612	178	405	583	222	413	635	226	312	538
(55,65]	216	1111	1327	266	1005	1271	373	1114	1487	489	1036	1525
(65,75]	348	1900	2248	376	1672	2048	432	1559	1991	553	1448	2001
(75,Inf]	322	1590	1912	416	1681	2097	512	1869	2381	586	1760	2346
Urinary Bladder	219	585	804	195	600	795	229	584	813	238	623	861
(35,45]	1	5	6	0	0	0	2	3	5	1	2	3
(45,55]	4	27	31	9	18	27	10	13	23	6	22	28
(55,65]	18	87	105	12	91	103	13	76	89	23	62	85
(65,75]	56	176	232	32	190	222	38	134	172	30	143	173
(75,Inf]	140	290	430	142	301	443	166	358	524	178	394	572
End total	27021	30119	57140	25938	29221	55159	25389	28694	54083	24827	27696	52523

7.4 Specifications on PAF results

Table 8: PAF results for diseases by age, by year and sex.

Diseases by age	2001		2004		2008		2013	
	Female	Male	Female	Male	Female	Male	Female	Male
Aortic Aneurysm								
(35,45]	0.70	0.74	0.68	0.70	0.63	0.68	0.62	0.69
(45,55]	0.68	0.74	0.67	0.72	0.68	0.70	0.63	0.66
(55,65]	0.59	0.70	0.52	0.70	0.58	0.68	0.65	0.69
(65,75]	0.44	0.69	0.47	0.68	0.44	0.67	0.50	0.67
(75,Inf]	0.35	0.68	0.30	0.63	0.26	0.62	0.20	0.58
Atherosclerosis								
(35,45]	0.21	0.41	0.21	0.37	0.17	0.35	0.17	0.35
(45,55]	0.19	0.41	0.20	0.39	0.20	0.37	0.17	0.33
(55,65]	0.13	0.35	0.11	0.36	0.13	0.33	0.17	0.34
(65,75]	0.06	0.33	0.09	0.32	0.09	0.30	0.10	0.30
(75,Inf]	0.03	0.31	0.04	0.27	0.03	0.24	0.02	0.22
Bronchitis, Emphysema								
(35,45]	0.87	0.91	0.84	0.89	0.83	0.89	0.81	0.90
(45,55]	0.87	0.92	0.85	0.91	0.85	0.90	0.82	0.89
(55,65]	0.85	0.92	0.78	0.91	0.83	0.91	0.85	0.91
(65,75]	0.80	0.92	0.74	0.91	0.71	0.91	0.77	0.91
(75,Inf]	0.77	0.92	0.62	0.90	0.64	0.90	0.58	0.88
Cerebrovascular Disease								
(35,45]	0.60	0.60	0.59	0.56	0.53	0.54	0.53	0.53
(45,55]	0.58	0.58	0.58	0.57	0.59	0.55	0.54	0.50
(55,65]	0.36	0.38	0.32	0.40	0.37	0.36	0.43	0.37
(65,75]	0.17	0.24	0.19	0.23	0.18	0.21	0.21	0.21
(75,Inf]	0.01	0.14	0.02	0.12	0.01	0.10	0.01	0.09

Cervix Uteri

(35,45]	0.19	0.00	0.17	0.00	0.15	0.00	0.14	0.00
(45,55]	0.18	0.00	0.17	0.00	0.17	0.00	0.15	0.00
(55,65]	0.13	0.00	0.10	0.00	0.13	0.00	0.16	0.00
(65,75]	0.08	0.00	0.08	0.00	0.08	0.00	0.09	0.00
(75,Inf]	0.06	0.00	0.04	0.00	0.04	0.00	0.03	0.00

Chronic Airway Obstruction

(35,45]	0.85	0.85	0.83	0.82	0.80	0.81	0.79	0.82
(45,55]	0.84	0.86	0.83	0.84	0.83	0.83	0.80	0.80
(55,65]	0.80	0.84	0.74	0.84	0.79	0.83	0.82	0.83
(65,75]	0.72	0.84	0.69	0.83	0.67	0.83	0.72	0.83
(75,Inf]	0.67	0.84	0.55	0.80	0.54	0.80	0.47	0.77

Ischemic Heart Disease

(35,45]	0.65	0.62	0.62	0.58	0.58	0.55	0.56	0.56
(45,55]	0.64	0.62	0.62	0.60	0.63	0.58	0.58	0.53
(55,65]	0.26	0.41	0.22	0.41	0.27	0.39	0.33	0.39
(65,75]	0.12	0.25	0.14	0.24	0.13	0.23	0.15	0.23
(75,Inf]	0.07	0.11	0.04	0.10	0.04	0.08	0.03	0.08

Kidney and Renal Pelvis

(35,45]	0.14	0.45	0.13	0.40	0.10	0.38	0.10	0.40
(45,55]	0.13	0.46	0.12	0.44	0.13	0.41	0.11	0.37
(55,65]	0.09	0.42	0.07	0.42	0.09	0.40	0.11	0.40
(65,75]	0.06	0.41	0.06	0.39	0.05	0.39	0.07	0.39
(75,Inf]	0.04	0.41	0.03	0.35	0.03	0.34	0.02	0.30

Larynx

(35,45]	0.84	0.88	0.82	0.86	0.79	0.84	0.78	0.85
(45,55]	0.83	0.88	0.82	0.87	0.82	0.86	0.79	0.84
(55,65]	0.78	0.86	0.72	0.86	0.77	0.85	0.81	0.85
(65,75]	0.68	0.85	0.67	0.84	0.64	0.84	0.70	0.84
(75,Inf]	0.62	0.85	0.51	0.82	0.49	0.81	0.42	0.78

Lip, Oral Cavity, Pharynx

(35,45]	0.63	0.83	0.60	0.80	0.55	0.79	0.54	0.79
(45,55]	0.62	0.83	0.60	0.82	0.61	0.80	0.56	0.77
(55,65]	0.53	0.79	0.46	0.80	0.52	0.78	0.58	0.78
(65,75]	0.41	0.77	0.40	0.76	0.38	0.75	0.44	0.75
(75,Inf]	0.34	0.76	0.26	0.72	0.24	0.69	0.19	0.67

Malignant neoplasm without specification of site

(35,45]	0.32	0.65	0.30	0.60	0.26	0.58	0.25	0.59
(45,55]	0.31	0.66	0.30	0.63	0.30	0.61	0.26	0.57
(55,65]	0.24	0.62	0.19	0.62	0.23	0.60	0.28	0.60
(65,75]	0.15	0.60	0.16	0.59	0.14	0.58	0.18	0.58
(75,Inf]	0.11	0.60	0.09	0.54	0.08	0.53	0.06	0.49

Myeloid Leukemia

(35,45]	0.13	0.31	0.11	0.27	0.10	0.25	0.08	0.26
(45,55]	0.14	0.32	0.11	0.29	0.11	0.27	0.09	0.24
(55,65]	0.12	0.29	0.07	0.28	0.10	0.27	0.12	0.27
(65,75]	0.09	0.28	0.06	0.26	0.05	0.26	0.07	0.26
(75,Inf]	0.08	0.28	0.04	0.23	0.05	0.23	0.03	0.19

Oesophagus

(35,45]	0.73	0.77	0.71	0.73	0.67	0.71	0.66	0.73
(45,55]	0.72	0.78	0.71	0.76	0.71	0.74	0.67	0.71
(55,65]	0.64	0.76	0.57	0.76	0.63	0.74	0.69	0.74
(65,75]	0.51	0.75	0.51	0.74	0.49	0.74	0.55	0.74
(75,Inf]	0.43	0.76	0.35	0.70	0.32	0.71	0.26	0.66

Other Arterial Diseases

(35,45]	0.29	0.32	0.28	0.29	0.24	0.26	0.23	0.26
(45,55]	0.27	0.30	0.27	0.29	0.28	0.27	0.24	0.24
(55,65]	0.20	0.22	0.16	0.24	0.20	0.21	0.25	0.22
(65,75]	0.11	0.19	0.13	0.19	0.13	0.17	0.15	0.17
(75,Inf]	0.07	0.15	0.07	0.15	0.05	0.10	0.04	0.11

Other Heart Disease								
(35,45]	0.17	0.28	0.15	0.25	0.13	0.23	0.12	0.24
(45,55]	0.16	0.28	0.15	0.26	0.15	0.25	0.13	0.22
(55,65]	0.12	0.24	0.09	0.24	0.11	0.22	0.14	0.23
(65,75]	0.07	0.22	0.07	0.21	0.07	0.20	0.08	0.20
(75,Inf]	0.05	0.21	0.04	0.18	0.04	0.16	0.02	0.15
Pancreas								
(35,45]	0.36	0.38	0.33	0.34	0.29	0.32	0.28	0.32
(45,55]	0.35	0.36	0.33	0.35	0.34	0.33	0.29	0.29
(55,65]	0.29	0.30	0.22	0.31	0.27	0.28	0.32	0.29
(65,75]	0.20	0.27	0.18	0.26	0.17	0.24	0.21	0.24
(75,Inf]	0.17	0.23	0.11	0.22	0.10	0.17	0.08	0.17
Pneumonia, Influenza								
(35,45]	0.53	0.43	0.51	0.38	0.45	0.36	0.45	0.37
(45,55]	0.49	0.43	0.50	0.41	0.51	0.38	0.46	0.34
(55,65]	0.38	0.37	0.34	0.38	0.39	0.35	0.46	0.36
(65,75]	0.11	0.30	0.14	0.29	0.13	0.28	0.15	0.28
(75,Inf]	0.07	0.29	0.07	0.25	0.05	0.24	0.04	0.21
Stomach								
(35,45]	0.17	0.35	0.15	0.30	0.13	0.29	0.12	0.30
(45,55]	0.17	0.36	0.15	0.33	0.15	0.31	0.13	0.28
(55,65]	0.14	0.33	0.10	0.32	0.13	0.31	0.15	0.30
(65,75]	0.11	0.31	0.08	0.30	0.07	0.29	0.09	0.30
(75,Inf]	0.09	0.31	0.05	0.26	0.05	0.26	0.04	0.22
Stomach ulcer, Duodenal ulcer								
(35,45]	0.61	0.68	0.60	0.64	0.54	0.62	0.54	0.62
(45,55]	0.59	0.67	0.59	0.65	0.60	0.63	0.54	0.59
(55,65]	0.48	0.61	0.43	0.62	0.49	0.59	0.55	0.60
(65,75]	0.32	0.58	0.37	0.57	0.35	0.55	0.40	0.55
(75,Inf]	0.22	0.55	0.22	0.51	0.17	0.46	0.13	0.44

Trachea, Lung, Bronchus

(35,45]	0.83	0.92	0.81	0.91	0.78	0.90	0.77	0.90
(45,55]	0.82	0.92	0.81	0.91	0.81	0.91	0.78	0.89
(55,65]	0.76	0.91	0.70	0.91	0.75	0.90	0.80	0.90
(65,75]	0.66	0.90	0.65	0.89	0.63	0.89	0.69	0.89
(75,Inf]	0.59	0.89	0.49	0.87	0.47	0.86	0.39	0.84

Urinary Bladder

(35,45]	0.40	0.56	0.35	0.51	0.32	0.49	0.30	0.50
(45,55]	0.39	0.57	0.36	0.54	0.36	0.51	0.32	0.47
(55,65]	0.34	0.53	0.25	0.53	0.31	0.51	0.35	0.51
(65,75]	0.26	0.51	0.21	0.50	0.19	0.49	0.24	0.50
(75,Inf]	0.23	0.51	0.13	0.45	0.14	0.45	0.11	0.40

7.5 Specifications on SAM results

Table 9: Specifications on SAM calculations for diseases by group, by year and sex.

Diseases by group	2001			2004			2008			2013		
	Female	Male	Both	Female	Male	Both	Female	Male	Both	Female	Male	Both
Cancer	1270	6664	7933	1223	6233	7456	1423	6308	7731	1647	6010	7657
Cervix Uteri	19	0	19	20	0	20	18	0	18	17	0	17
Kidney and Renal Pelvis	17	163	180	13	139	153	11	157	168	13	158	171
Larynx	27	194	221	25	182	207	21	138	159	24	138	162
Lip, Oral Cavity, Pharynx	58	308	366	53	288	341	52	312	363	60	337	397
Malignant neoplasm without specification of site	79	340	419	60	303	362	62	261	323	63	311	374
Myeloid Leukemia	17	54	71	9	55	64	12	58	70	12	57	69
Oesophagus	77	328	405	81	358	439	75	376	451	78	421	499
Pancreas	130	157	287	98	179	277	114	179	292	132	186	317
Stomach	45	176	220	21	145	166	22	136	158	18	119	137
Trachea, Lung, Bronchus	746	4640	5386	812	4295	5107	998	4419	5417	1194	4012	5206
Urinary Bladder	55	304	358	32	289	320	38	272	311	37	272	308
Cardiovascular	1418	3788	5207	1145	3389	4534	990	2913	3903	784	2513	3298
Aortic Aneurysm	68	346	413	67	338	405	55	306	361	52	237	289
Atherosclerosis	9	46	56	11	43	54	8	48	56	4	26	30
Cerebrovascular Disease	291	678	969	316	605	922	243	503	745	212	432	643
Ischemic Heart Disease	548	1594	2141	392	1389	1781	336	1107	1443	238	865	1103
Other Arterial Diseases	21	47	68	20	45	65	22	37	59	18	45	63
Other Heart Disease	482	1077	1559	339	968	1307	326	912	1238	261	909	1170
Digestive	49	91	140	34	68	102	29	62	91	19	48	67
Stomach ulcer, Duodenal ulcer	49	91	140	34	68	102	29	62	91	19	48	67
Respiratory	1211	3171	4382	1080	2952	4032	1151	2931	4082	1152	2661	3813
Bronchitis, Emphysema	290	527	818	194	432	626	190	333	522	206	276	482
Chronic Airway Obstruction	741	2096	2836	715	2025	2740	804	2135	2939	821	1956	2777

Pneumonia, Influenza	180	548	728	171	495	665	158	463	621	124	429	554
End total	3948	13714	17662	3482	12641	16123	3592	12214	15807	3602	11232	14834

