Tobacco control policies and socio-economic inequalities in smoking cessation

Evaluating natural experiments

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General introduction
Chapter 1

GENERAL INTRODUCTION

Tobacco smoking is still one of the major causes of death and disease worldwide. Although governments and public health agencies have been working hard for a number of decades to combat this threat, the fight is far from over. This is the central justification for the work presented in this thesis. In this introduction, I will first discuss the emergence of scientific evidence to establish smoking as a causal factor for a large burden of morbidity and mortality. Secondly, I will present descriptive evidence on trends in the size and distribution of the smoking burden throughout Europe. Thirdly, I will discuss the history of tobacco control measures and their scientific evaluation. Finally, I will present the aims, methods and structure of this thesis.

SMOKING AND HEALTH

History
The first hypothesis of a link between cigarette smoking and lung cancer was made as far back as 1898. This was followed by statistical evidence in 1930, experimental animal studies in 1931, and several case control studies in the 1930s. However, none of these were widely publicized or accepted as mainstream scientific consensus. It was only in the early 1950s, that the landmark cohort studies by Doll and Hill in the UK, and by Hammond and Horn in the US, got the proverbial ball rolling. These, combined with more refined experimental studies by Wynder and Graham, showed conclusively that smoking was a cause of lung cancer. Following these studies, a large number of official statements and ‘white papers’ were published by public health institutions around the world, confirming the scientific consensus about the link between smoking and lung cancer. The most influential of these was the US Surgeon General’s report of 1964.

Amidst the rise in scientific evidence and media attention for the harmful effects of smoking, in December 1953, CEO’s of all the major tobacco manufacturers came together to discuss a common strategy. One of the decisions was that the companies would not use health claims in their advertising, e.g. claiming that their own brand was healthier or safer. A second result was their decision to collectively employ a public relations firm. This firm helped them launch a massive advertisement campaign in more than 400 newspapers, conveying “A Frank Statement to Cigarette Smokers”. This statement was a full-page ad that
downplayed any links between smoking and lung cancer, by emphasizing statements such as ‘no agreement’ and ‘no proof’. Furthermore it stated that: “We believe the products we make are not injurious to health”, and that more research was needed. Moreover, the joint tobacco industry itself would take the initiative by establishing a new research committee. This research committee spent millions of dollars on research that never directly tested the health effects of smoking, but only served as a public relations tool, and to create more controversy. The tobacco industry publicly maintained for decades that cigarette smoking was not a proven cause of lung cancer, but rather a possible risk. One executive even testified to these claims in court as late as 1998.

In the 1990s, 46 (out of 50) US states held court cases against the ‘big four’ tobacco companies, arguing that those companies were responsible for tobacco-related health care costs, and therefore should be made to pay for these. As the tobacco companies feared the prospect of so many lawsuits, a settlement was proposed: the Master Settlement Agreement (MSA). Under this settlement, the tobacco companies would pay over 200 billion (!) dollars over the next decades to the 46 states, and annual payments after that. Another result of the MSA was the mandatory public release of millions of internal industry documents, concerning strategy, advertising, marketing and research. These have been archived in the Truth Tobacco Industry Documents (TTID), which is freely accessible and searchable. Many tobacco control researchers have used this rich source to study what the tobacco industry privately knew about the dangers of smoking, without admitting publicly. This is especially interesting because it destroyed the industry’s main defence in litigation. They always maintained that everyone knew smoking was harmful, which would mean smokers themselves were to blame for any harm. Yet at the same time the industry said there was no proof that smoking was harmful, which meant that the industry was not to blame. One of the key documents unearthed through the TTID was a “Survey of Cancer Research”. This is a review study from 1953 that covered all existent scientific evidence on the link between smoking and cancer. The review concluded that “Studies of clinical data tend to confirm the relationship between heavy and prolonged tobacco smoking and incidence of cancer of the lung”. It ends with the implication that “…it is recommended that management take cognisance of the problem and its implications to our industry, and that positive research action be planned and initiated without delay”. This latter call went unheeded, as the industry succeeded in keeping this document from public view, until it was brought up in the MSA court cases.
the dangers of smoking had been known to the tobacco industry for decades, and thus proof that the industry had been lying and misleading the public all this time.

**Morbidity and mortality**

Although lung cancer is the most widely publicized and recognized disease caused by smoking, it is far from the only one. There is a wealth of epidemiological evidence that firmly establishes the role of cigarette smoking in the development of numerous diseases. This role can be categorized according to the strength of the evidence for the causality of the association, and whether smoking is the lone major risk factor, or just one of many.\(^ {17}\) The most common disease to be associated with smoking is cancer, obviously lung cancer, but also cancer of the larynx, pharynx, oesophagus, bladder, and cervix.\(^ {17}\) Moreover, smoking greatly increases the risk for other diseases such as chronic obstructive pulmonary disease (COPD), peripheral vascular disease, stroke, coronary heart disease, and aortic aneurysms.\(^ {17}\)

A more concrete and quantitative way to show the impact of smoking on health is to study life expectancy and excess mortality in relation to smoking. An essential study in establishing the smoking-cancer link in the 1950s was a British cohort of doctors. This cohort has been continued until 2001, and the 50-year follow-up data again yielded strong evidence. Smokers’ life expectancy is on average 10 years shorter than that of non-smokers, and while life expectancy for non-smokers has rapidly increased over the past half century, it has remained essentially the same for smokers.\(^ {18}\) Moreover, the health benefits of smoking cessation were quantified: quitting at age 30 would result in a life expectancy similar to that of a non-smoker. Quitting at age 50 would reduce the loss in life expectancy from 10 to 5 years.\(^ {18}\) These results were corroborated by later studies, such as a US-based linkage study of health surveys and mortality register data.\(^ {19}\) This study showed that all-cause mortality among smokers between 25 and 79 years of age is three times higher than among non-smokers.\(^ {19}\) Similar results were also found in a prospective UK study of over one million women, which added that even for light smokers (<10 cigarettes per day) 12-year mortality was twice as high as in non-smokers.\(^ {20}\) The benefit of smoking cessation on life expectancy was similar to the other two studies, but even when smoking cessation occurred between ages 25 and 44, lung cancer mortality remained twice or thrice that of non-smokers.\(^ {20}\) The World Health Organisation (WHO) estimates that 25% of all deaths among men in Europe are attributable to smoking, which is higher than for any other WHO region; while among women it is 7%.\(^ {21}\)
For the Netherlands in 1999, the impact of smoking was estimated based on national death records and established models of smoking-attributable mortality. The estimates were that 32% of male, and 18% of female premature mortality was attributable to tobacco smoking, around 25% of total premature mortality. Over the period of 1950 to 2015, smoking was calculated to be responsible for 1.2 million deaths in the Netherlands. For the period 2011 to 2030, morbidity associated with smoking is expected to keep rising (lung cancer, COPD, and stroke) or remain stable (coronary heart disease).

SMOKING IN EUROPE

The cigarette epidemic model
The fact that smoking causes, or contributes to, so much disease and premature death is reflected in the terms with which smoking is described. For instance, Robert Proctor, in his historical depiction of the rise and fall of cigarettes, chose the title ‘Golden Holocaust’ for his book. Golden refers to the colour of tobacco leaves after curing, and the Holocaust to the “…calamity of epic proportions, with too many willing to turn a blind eye, too many willing to let the horror unfold without intervention”. A more commonly used term however, is the cigarette epidemic, after the influential model developed by Alan Lopez (sometimes also referred to as the smoking epidemic. This model describes the uptake and spread of cigarette smoking, and smoking-attributable deaths throughout Western society in four stages (see Figure 1). In stage I, the prevalence of smoking is low, less than 15%, among men and even less among women. During stage II, the prevalence of smoking increases sharply within a couple of decades, to between 50% and 80% for men. Female smoking rates at this stage will lag behind male smoking by around two decades. Around the end of stage II, smoking will already be responsible for around 10% of male mortality.

Stage III is marked by a nascent decline in male smoking prevalence and rising smoking cessation rates, as the dangers of smoking become publicly known. Smoking rates among women reach their peak levels around 45%, and then slowly decline. But the key feature of stage III is the rapid increase in smoking-attributable male mortality, up to around 30%. In stage IV, smoking prevalence is similar among men and women, and declines slowly. Smoking-related mortality among men peaks and declines, while among women it is still rising. Stage IV also sees the implementation of many tobacco control policies, and the general turning of the
tides, as smoking is now no longer socially acceptable. As most of the developed countries are now considered to be around the end of stage IV, an update of the model was published, which concluded that the decline of smoking has been slower than predicted.\textsuperscript{25}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{cigarette_epidemic_model.png}
\caption{The cigarette epidemic model (Source: Lopez et al., 1994).\textsuperscript{24}}
\end{figure}

**Recent trends in Europe**

The development of trends in smoking behaviour (used here as a catch-all term for smoking, smoking cessation, and intensity of smoking) has been well-studied over the past decades, corresponding with stage IV of the cigarette epidemic in Northern and Western Europe. Many studies tend to focus on smoking prevalence, which is easiest to measure. European trends (over 16 year intervals) in smoking prevalence can be seen in Figure 2.

As the vast majority of smokers begins before the age of 20,\textsuperscript{27} the changes in adult smoking patterns over time are mostly determined by smoking cessation. The quit ratio (proportion of ever smokers that has quit smoking) in Europe around 2000 was highest in the Nordic countries, around 50\%, and in Western Europe, around 40\%.\textsuperscript{28} Smoking cessation was still fairly uncommon in Southern and Eastern European countries, with quit ratios between 20\% and 35\%. A more recent study
found a similar pattern, in the Nordic countries, where former smoking was more common than current smoking, followed closely by Western Europe. The Southern European countries seemed to have moved closer to Western Europe in this aspect, as with the data from 2010, the highest proportions of current smokers were found in Eastern Europe.

**Figure 2** Smoking prevalence in Europe, reproduced from Ng. et al.²⁶
In the Netherlands, the first national survey of smoking habits was performed in 1958, which showed that a staggering 89% of men, and 38% of women smoked.\(^{30,31}\) By the time that yearly surveying started in 1980, this had dropped to 52% among men, and 34% among women. The long-term trends of this period are shown in Figure 3. It was also in the early 1980s that the decline of the smoking prevalence slowed down, to about 0.5 percentage point per year. In 2014, the Dutch adult smoking prevalence was more or less similar for men and women, at around 23%.\(^{32}\) Dutch estimates predict that the overall smoking prevalence will continue to decrease slowly, to around 19% in 2030.\(^{23}\)

A recent development in the pattern of smoking-related behaviour across Europe is the rapid increase in the popularity of electronic cigarettes. These e-cigarettes (or more technically: electronic nicotine delivery systems, ENDS) are not actually cigarettes, so using them is not actually smoking. ENDS are electrical devices that do not contain tobacco, but vaporize a liquid in puffs for inhalation. This liquid usually, but not always, contains nicotine, in varying concentrations.\(^{34}\) ENDS have

**Figure 3** Trends in the smoking prevalence in the Netherlands, reproduced from STIVORO and Trimbos.\(^{30,32,33}\) Note: dotted lines represent irregular survey intervals, solid lines represent annual data, dashed lines represent projected future data.
the potential to be a safe substitute for smokers who find it hard to quit their addiction completely. However, both the health effects of ENDS and their effectiveness in aiding smoking cessation are far from being unequivocally established.\textsuperscript{35,36} So far, the introduction of ENDS does not seem to have affected patterns of use of regular tobacco; most ENDS users are current smokers, and quit rates haven’t changed since the introduction of ENDS.\textsuperscript{37}

Socio-economic inequalities

Although the overall smoking prevalence has greatly declined over the past half-century in Western Europe, that only tells part of the story. It has been known for quite some time that certain subgroups within the population are more likely to smoke and/or less likely to quit smoking, due to a number of factors.\textsuperscript{38} Consequently, the risk of premature death among some subgroups is much higher, for instance among men with a low socio-economic status (SES). Their risk of premature death is about twice as high compared to men with a high SES, and a large proportion of this difference is attributable to smoking.\textsuperscript{39,40} This shows that socio-economic inequalities in smoking are of paramount importance for general inequalities in health and life expectancy.

Cross-sectional data from around 1990 showed that in most Western European countries, smoking was more common among the low educated.\textsuperscript{41} Similarly, smoking cessation rates were significantly higher for high educated men and women in nearly every European county.\textsuperscript{28} These inequalities were strongest in Northern European countries (Scandinavia and the UK), followed by Western Europe. In Southern European countries, this gradient (distribution of smoking according to SES) was positive in some cases, indicating a higher smoking prevalence with a higher SES.\textsuperscript{41} A comparable analysis in 1998 showed generally similar results.\textsuperscript{42} Developments in these patterns were studied in a repeated cross-sectional analysis covering the period of 1985 to 2000.\textsuperscript{43} This analysis showed that in most countries, smoking decreased more strongly among the high educated than among the low educated, leading to greater inequalities.\textsuperscript{43} The only exceptions were the UK and Italy, where decreases in smoking among the low educated were stronger, possibly as a result of successful policies targeted specifically at the low SES groups.

In the Netherlands in 1958, the smoking prevalence among men was equal among high and low educational levels, while the smoking prevalence among women was highest among the high educated.\textsuperscript{44} These patterns changed gradually as smoking among the low SES groups increased and smoking among the high SES groups
Chapter 1

decreased. In the mid-1990s, there was a clear gradient with a low SES smoking prevalence of 44% and a high SES prevalence of 30%. Moreover, the quit ratio among the lowest SES group was 33%, compared to 59% among the highest SES group. Inequalities in prevalence, cessation and initiation remained stable among men between 2001 and 2008, but inequalities in smoking intensity (the number of cigarettes smoked per day) increased. Among women, inequalities in both cessation and initiation (and therefore also in prevalence) widened significantly during this period.

Where national and international studies and reports on smoking prevalence are common, comparable data on both socio-economic inequalities and smoking cessation are much harder to find. Especially for inequalities in cessation, there have only been a few studies, mostly dating from around 2000. This evidence is in need of updating, as we have seen that the patterns in smoking prevalence have changed over the past decades. Therefore, new studies that examine trends in socio-economic inequalities in smoking with recent data are needed. Some of the studies included in this thesis (Part II) aim to address this need for new evidence.

TOBACCO CONTROL POLICIES

Brief history
Although many countries have imposed taxes on tobacco as early as the 17th century, this was in no way intended to be a tobacco control measure. These taxes had the sole purpose of generating revenue for governments. In 1880, approximately one third of the entire income of the US Government was gained from tobacco taxes. Only after the US Surgeon General’s report of 1964 did governments implement tobacco control policies for the sake of improving public health. In most countries, the early policies included some public anti-smoking campaigns, restrictions on tobacco advertising on television, radio and print media, and further tax increases. In the 1970s and 1980s smoke-free areas were introduced (e.g. in restaurants or public transport), however these were often partial, and not properly enforced. Policies like these have often been proposed by the tobacco industry as voluntary regulations. The industry was willing to put forward these regulations because they were weak and ineffective, and as a show of good will, to prevent governments from introducing stronger legislation.
In the Netherlands, the US Surgeon General’s report of 1964 led to some minor efforts to control tobacco use, primarily education in schools on the harms of smoking. Up to the late 1980s, most efforts to increase tobacco control met with a lack of political will and strong tobacco industry lobbying. As a result, it was only in 1988 that a Tobacco Act was realised. This law introduced smoke-free areas in public places. More recent developments include a major amendment of the Tobacco Act in 2002, which contains a full ban on smoking in workplaces and public transport in 2004, a ban (with exemptions) on smoking in bars and restaurants in 2008, and the reimbursement of smoking cessation medication in 2011. Since then, the exemptions of the smoking ban have been removed, the reimbursement was cancelled in 2012, and reintroduced in 2013.

In all, most tobacco control policies to this date have been characterized as being targeted at the general population. For the early policies, this was probably justified, as smoking was still common throughout the population. However, smoking is increasingly becoming clustered within specific subgroups of the population, e.g. lower educated, unemployed, those with mental illnesses etc. Therefore now some governments do target their policies specifically at these high-risk groups. Some countries have targeted low SES groups with mass medial information campaigns. However, the only targeted policy with proven effects is in the UK, where following the White Paper ‘Smoking kills’, smoking cessation services were introduced through the National Health Service (NHS). What makes these services special, is that they are focused in disadvantaged neighbourhoods, in order to achieve a high reach among those who need it most.

International developments
Throughout the 20th century, tobacco control policy has been an issue of national or even subnational regulation and legislation. The experiences of the UK, US and other early adopters of tobacco control have always served as an example for many other countries. Through the first World Conference on Tobacco or Health (WCToH) in 1967 and other collaborative efforts promoted by the WHO, Tobacco Control was put on the agenda across the globe. The most notable achievement of the WHO’s involvement in the fight against tobacco came in 2003, with the adoption of the Framework Convention on Tobacco Control (FCTC). This public health treaty entered into force in 2005, and it is currently signed by 168 countries, demonstrating the global commitment to fighting tobacco in the 21st century. The FCTC provides countries with objectives, guiding principles, and general obligations. These cover a broad range of tobacco control related topics, such as implementing higher
excise taxes on tobacco, combating illicit trade, and protecting tobacco control and other public health policies from the influence of the tobacco industry. However, the potential impact of the legally binding nature of the treaty is limited, as the treaty lacks the ability to sanction countries that fail to follow the obligations.

In Europe however, there is another source of international agreements that helps shape tobacco control policy, namely the European Commission (EC). The EC has issued a number of Resolutions and Directives. Notable Directives have led to the implementation of health warning labels on cigarette packaging in 1989 and 2001, restrictions on advertising in 1989, 1997 and 2003, and harmonisation of tobacco excise tax structures since 2010. The most recent EU Directive has come into force in 2016, containing rules such as a ban on ‘characterising’ flavours in tobacco products, mandatory pictorial health warning labels, and rules for E-cigarettes. EU Directives are binding but they must first be transposed into national law, whereas Regulations are binding and immediately enter into force of law. So far, most of the European legislation has been in the form of Directives. The process of drafting and consultation for these Directives is often lengthy and complicated, because of the many parties involved. Both tobacco control advocates and tobacco industry lobbyists have tried to influence the Directive proposals to their respective benefits.

Policy evaluation

With the increased attention for developing tobacco control policies, there has also been an increase in studies that evaluate the effectiveness of these policies. These evaluation studies now cover a broad range of topics, from studies of one policy in one country, multi-country comparisons, to review-of-reviews of different types of policies. Despite this range, still only 8% study of papers that study tobacco focus on environmental influences (policies). In this section, I will review the current state of knowledge by discussing a few of these policy evaluations in more detail.

The International Tobacco Control (ITC) Policy Evaluation Project has studied the effects of a large number of tobacco control policies around the world. The ITC project has used longitudinal cohorts of smokers since 2002 in over 20 countries, including low and middle income countries. It measures behavioural outcomes related to policy changes, but also psychosocial intermediary factors. It has generated hundreds of scientific papers, which have made a major contribution to cementing the evidence for effectiveness of tobacco control policies. A few highlights of their results include: that pictorial health warnings on cigarette packs are more effective
than text-only warnings; comprehensive smoke-free laws stimulate smoking cessation, while partial bans do not; and using tax-avoidance strategies lowers the odds of smoking cessation, regardless of SES.

Beyond the established effectiveness of tobacco control policies in general terms, it is important to look at these policies in terms of inequalities. Wow does a policy influence socio-economic inequalities? This is called the equity impact: a positive equity impact is when a policy is more effective among lower SES groups, thereby decreasing inequalities. Positive in this sense implies that it is a desirable outcome, rather than a positive statistical association, or like mentioned earlier, a positive gradient. Conversely, a negative equity impact is when inequalities are increased, and a neutral equity impact is when both groups benefit to the same extent.

A surprisingly low number of studies has assessed the equity impact of population-level tobacco control policies. Reviews by Thomas et al. in 2008 and Hiscock et al. in 2012 found support for a positive equity impact of raising tobacco prices, and highly targeted mass media campaigns and smoking cessation services, but unclear or unconvincing evidence for all other types of tobacco control policy. These results are in line with a review of reviews to assess which tobacco control policies had the potential to decrease inequalities in smoking. Apart from a positive equity impact of raising tobacco prices, their main finding was that most reviews did not differentiate between socio-economic groups, again showing that the evidence on the equity impact of tobacco control policies is quite limited.

This goes to show that there is a clear need for more research into the equity effects of tobacco control policies. Moreover, of the studies that did evaluate the equity impact, some were controlled studies, localized studies, or small-sample studies. Although these studies certainly have their merits, they might not be readily generalizable to a national-level setting. Therefore, this field of research would greatly benefit from evaluations of policies that have already been implemented in real life, i.e. evaluations of natural policy experiments. This type of evidence can be very valuable to policymakers, as these studies incorporate the fact that any policy is imbedded in and affected by the complex and dynamic social structures of today’s society and legislation. The studies included in Parts III and IV of this thesis are examples of such a natural experiment evaluation approach.
THIS THESIS

Brief description of EC FP-7 projects
The majority of the work presented in this thesis was performed as part of research conducted within the European Commission’s Seventh Framework Programme for Research (FP7). Chapters 2–5, 8, and 9 were carried out as part of one of these FP7 projects: the SILNE project. SILNE stands for ‘tackling socioeconomic inequalities in smoking: learning from natural experiments by time trend analyses and cross-national comparisons’. The main aim of SILNE was to analyse natural experiments in tobacco control in Europe, to obtain new scientific evidence that can inform future policies to reduce socio-economic inequalities in smoking.

The review study presented in chapter 10 was performed as part of another FP7 project, the SOPHIE project. The full title of SOPHIE was: ‘Evaluating the impact of structural policies on health inequalities and their social determinants and fostering change’. The general aim of SOPHIE was to generate new evidence on impact that structural policies (e.g. unemployment, welfare, housing) can have on health inequalities and their upstream determinants. A secondary aim was to develop and apply innovative methodological approaches to study these policies. This resulted in the study presented in Chapter 10, where the ‘realist approach’, is applied to study the effects of fiscal policies on inequalities in smoking cessation.

Aims of this thesis
The general objective is to assess, through the evaluation of natural experiments, which tobacco control policies have increased smoking cessation rates in general, and in particular those of lower socio-economic status groups. These evaluations are made by performing cross-country comparisons of European countries, and by performing time-series analyses with repeated cross-sectional survey data. With the results of these evaluations, we hope to contribute to the literature on which policies work to reduce socio-economic inequalities in smoking.

This general objective can be broken up into a number of more specific research objectives:
• To describe recent developments in tobacco control policies in Europe and underlying patterns [Part I].
• To describe recent trends in socio-economic inequalities in smoking cessation and cessation-related behaviour across Europe [Part II].
General introduction

- To evaluate associations between specific tobacco control policy measures and precursors of smoking cessation [Part III].
- To evaluate associations between a comprehensive set of tobacco control policies and socio-economic inequalities in smoking cessation [Part IV].
- To describe in more detail the causal mechanisms through which a specific tobacco control policy, i.e. an increase in taxes, can affect smoking cessation [Part V].

Data sources

One of the main data sources of this thesis is the tobacco control scale (TCS). The TCS was developed by Joossens and Raw in 2005, to provide countries with an easy to interpret scorecard of their ranking on tobacco control. The TCS uses national tobacco control experts to rate their own countries’ performance on a number of indicators across six domains, shown in Table 1. Score allocation is based on the experts’ rating of the effectiveness of each measure. Updates of the TCS were published in 2007, 2010, and 2013, albeit with a slightly modified scoring system. The new scoring allows for inclusion of more recent forms of tobacco control policy, such as bans on display of tobacco products at point of sale, and standardized packaging. We have recalculated some of the older scores, using the 2013 scoring system, to make them directly comparable. For the studies that precede 2005, we have used alternative data sources to calculate our own TCS scores.

For the Dutch analyses, presented in chapter 8, we used data from the Dutch Continuous Survey of Smoking Habits, DCSSH. This is a repeated cross-sectional survey, representative of the Dutch population, dating back to 1988, which provides us with a large population to study trends over a long period of time.

For chapters 4, 5, and 9, we have used data from the Eurobarometer surveys. This is a series of cross-sectional surveys, performed for the European Commission, in order to monitor a broad range of topics, including health, in the member states’ populations. The main benefit of using the Eurobarometer data to study smoking behaviour is the uniform methods (sampling strategy, questionnaire etc.) used across all member states, to ensure maximum comparability. The countries included in the survey follows the expansion of the EU through the years, so those countries that have been member states for longer could be studied more extensively than those that only recently joined the EU.
Table 1 The 2013 version of the Tobacco Control Scale and its constituent policies.  

<table>
<thead>
<tr>
<th>Policy domain</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Policy measure</strong></td>
<td><strong>100</strong></td>
</tr>
<tr>
<td>1. Price of cigarettes</td>
<td>30</td>
</tr>
<tr>
<td>2. Smoke-free public areas</td>
<td></td>
</tr>
<tr>
<td>Workplaces</td>
<td>10</td>
</tr>
<tr>
<td>Bars and restaurants</td>
<td>8</td>
</tr>
<tr>
<td>Public transport, educational, health, government etc.</td>
<td>4</td>
</tr>
<tr>
<td>3. Tobacco control spending (public information campaigns)</td>
<td>15</td>
</tr>
<tr>
<td>4. Bans on advertising and promotion</td>
<td></td>
</tr>
<tr>
<td>On television and radio</td>
<td>2</td>
</tr>
<tr>
<td>Outdoor (billboards)</td>
<td>2</td>
</tr>
<tr>
<td>In print media</td>
<td>1.5</td>
</tr>
<tr>
<td>In cinemas</td>
<td>1</td>
</tr>
<tr>
<td>On internet</td>
<td>0.5</td>
</tr>
<tr>
<td>Indirect advertising (cigarette branded clothes etc.)</td>
<td>1</td>
</tr>
<tr>
<td>Sponsorship</td>
<td>1</td>
</tr>
<tr>
<td>Point of sale advertising</td>
<td>1</td>
</tr>
<tr>
<td>Ban on display of tobacco products at point of sale</td>
<td>2</td>
</tr>
<tr>
<td>Standardized packaging</td>
<td>1</td>
</tr>
<tr>
<td>5. Health warning labels</td>
<td></td>
</tr>
<tr>
<td>Plain packaging</td>
<td>4</td>
</tr>
<tr>
<td>Size of warnings</td>
<td>3</td>
</tr>
<tr>
<td>Pictorial warnings</td>
<td>3</td>
</tr>
<tr>
<td>6. Cessation support services</td>
<td></td>
</tr>
<tr>
<td>Recording of smoking status in medical notes</td>
<td>1</td>
</tr>
<tr>
<td>Brief advice in primary care</td>
<td>1</td>
</tr>
<tr>
<td>Quitlines</td>
<td>2</td>
</tr>
<tr>
<td>Network of cessation support and reimbursement</td>
<td>4</td>
</tr>
<tr>
<td>Reimbursement of stop-smoking medication</td>
<td>2</td>
</tr>
</tbody>
</table>

In order to study the effects of tobacco control policy on what we consider a precursor of smoking cessation, namely searching for smoking cessation information online, we have used Google Trends. This is a fairly new type of data source, that provides easy access to the volume of internet search queries for a specific search term over a given period, within a certain country. These data are
collected, for most countries, on a weekly basis, allowing for a detailed analysis of the timing of possible effects.

**Study design and statistical methods**

In this thesis, we use a variety of study designs and statistical methods, here we provide a brief description of the most used designs and methods. In general terms, we use two designs to study policy effects: comparisons between countries, and comparisons over time. Moreover in some studies, these two designs have been combined, by studying several countries over time. The benefit of comparing countries within Europe is that countries are fairly similar in terms of income level, smoking prevalence, and sociocultural aspects. In this way comparing countries with different tobacco control policies can provide clues of their effectiveness. Comparisons within countries over time has the benefit of being able to link changes in tobacco control policy to subsequent changes in smoking behaviour.

Our main statistical tool for these analyses is multilevel regression modelling. The main reason for this, is that it allows us to cluster respondents together on the basis of any variable on which we expect that their variance is not at random. In a multi-country study, we expect respondents from one country to be more similar to their compatriots than to others, and in a multi-year trend study, we expect respondents surveyed at one moment in time to be more similar to each other than to those surveyed earlier or later. Multilevel modelling allows for any number of ‘levels’ to be used; in some studies we use either country or time, and in others we use both. This clustering will also take away some of the confounding caused by shared environmental influences that are not captured by the variables in the model. In this way, we hope to control as much as possible for some important but hard to capture variables such as the stage of the cigarette epidemic, the prevailing social norm against smoking, and societal support for tobacco control.

In chapters 6 and 7, we use time series analyses to study the weekly or monthly Google Trends relative search volumes (RSVs). More specifically, we employ autoregressive moving average (ARIMA) modelling. Where regression assumes independence between data points, this is often not the case. In our case, the dependence is historical, any observation is likely to be influenced by the observation(s) directly preceding it. By using autocorrelation, we can control for this dependency. Moreover, having data on regular intervals over many years, allows for seasonal decomposition, i.e. removing seasonal variance that is present and might distort the effect size of the intervention. Especially for smoking cessation this is
very important, as there is a well-known link between New Year’s resolutions and smoking cessation attempts. Lastly, this method allows the construction and inclusion of a number of intervention variables that can distinguish short-term and long-term effects.

Chapter 10 is a systematic review of the literature on the effects of tobacco tax/price increases on smoking cessation. However, rather than focusing on the often-studied, but still debated, question of how strong this association is, our aim is to elucidate how, why and under which circumstances this effect occurs. This approach is called the realist approach (therefore this is a realist review), which takes a more qualitative view of the evidence than traditional reviews. We incorporate both qualitative and quantitative evidence from a range of scientific fields including public health, economics, and social sciences.

**Structure of this thesis**

This thesis starts in Part I with two studies that examine the tobacco control policies that have been implemented in Europe in the past two decades. We aimed to identify general patterns and elucidate which factors were responsible for the large variation observed between countries in their choice for specific tobacco control policies and the timing of their implementation. In Chapter 2 we used principal components analysis to establish clusters in the development of tobacco control policies across Europe over time. By studying these clusters, we aimed to identify general patterns of policies that generally develop concurrently, and in addition we aimed to highlight policy areas where development has been lacking. In Chapter 3, we studied some aspects of why these differences in policy exist. More specifically, we examined the influence of politics on the development of tobacco control, with a focus on political ideology and the effectiveness of government agencies.

Part II of this thesis consists of two descriptive studies that focus on socio-economic inequalities in smoking cessation-related behaviour across Europe. We used the Eurobarometer surveys to study different aspects of smoking cessation-related behaviour in a large number of countries over a long period of time. In Chapter 4 we describe the trends in socio-economic inequalities in both smoking cessation and smoking intensity in 11 European countries over the past 25 years. Chapter 5 is a study of the uptake of the relatively new phenomenon of e-cigarettes. We describe the socio-demographic factors associated with the use of e-cigarettes in general and specifically as a tool to quit smoking.
In Part III of this thesis, we studied one of the earlier stages of the process of smoking cessation. In this part we use online information seeking about smoking cessation as a proxy for (pre)contemplation of smoking cessation. Through Google Trends, we obtained data on the national-level volume of searching for smoking cessation information on a weekly basis. We then proceeded to link these data to the implementation dates of certain tobacco control policies, to test whether these were associated with an increase in internet searches for smoking cessation. In Chapter 6, we assessed the effect of the Dutch smoking ban in bars and restaurants, and reimbursement of smoking cessation medication on searching for smoking cessation information. Chapter 7 includes data from six European countries, where we tested the association between the introduction of pictorial health warning labels on cigarette packaging and smoking cessation information seeking.

In Part IV, we looked at the association of the tobacco control policies studied in Part I with the socio-economic inequalities in smoking cessation described in Part II. In two empirical studies, we evaluated natural policy experiments. We tested whether increases over time in the combined set of policies were associated with increases in smoking cessation, and more specifically among the low versus the high SES groups. Moreover, we tried to establish which types of policies contributed most strongly to these possible associations. Chapter 8 is a long-term study of Dutch data, which compares the associations between policy and inequalities in cessation between the 1990’s and 2000’s. In Chapter 9, we performed a similar analysis using Eurobarometer data from 2006 to 2012, covering all 27 European Union member states.

Part V of this thesis consists of one systematic review study (Chapter 10), which uses the realist approach to assess the mechanisms of action that lead from increases in the tax and/or price of tobacco to smoking cessation. By focusing on the mechanisms behind the effect, and the context that influences it, we aimed to shed light on differences in the effect between specific populations. For instance, low income versus high income smokers, or young versus older smokers. We aimed to find out whether the differences in effect between these groups emerge because the effect is achieved through a different mechanism for each group, or perhaps because contextual factors work in a different way to mediate the effects of tax/price increases.

This thesis ends with the general discussion, where I reflect on the main findings. There, I also discuss some of the broad methodological issues that have arisen in
this thesis, and the lessons learned. I will discuss in more detail some of the overarching conclusions derived from this body of work, along with subsequent implications for policy and recommendations for future research.

REFERENCES

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