Changes in Social Inequality in Smoking-Attributable Adult Male Mortality between 1986 and 2001 in Four Developed Countries

By

Sonica Singhal

A thesis submitted in conformity with the requirements for the degree of Master of Science
Institute of Medical Sciences
University of Toronto

© copyright by Sonica Singhal 2011
ABSTRACT

Changes in social inequality in smoking-attributable adult male mortality between 1986 and 2001 in four developed countries

By Sonica Singhal
Master of Science
Institute of Medical Sciences
University of Toronto
2011

Social inequalities exist in smoking-attributable mortality rates of males. Change in these social inequalities in the past two decades in developed countries remains uncertain. This study was conducted in Canada, France, Poland, and Switzerland to quantify differences in smoking-attributable mortality rates, at ages 35-69 years, among different social strata in recent years and to examine the changes in social inequalities in these rates between 1986 and 2001.

Analyses included 377,878 deaths from a total population of 13,482,210 males of these four countries. Smoking-attributable mortality rates reduced in all strata over the comparative time periods, in all countries, except France. This work specifically focuses to fill the gap in knowledge about whether tobacco control has reached the poor or lower social strata in developed countries. This study will enable follow up research including quantification of effects of the specific tobacco control policies in each country.
ACKNOWLEDGEMENT

First and foremost I would like to thank Dr. Prabhat Jha for being my supervisor, without whose constant support, it would have been difficult to produce this work. Despite his own busy schedule he was always available to provide his invaluable assistance throughout this endeavor.

I am deeply indebted to my supervisory committee: Dr. Joanna Cohen and Dr. Susan Bondy, for their support, encouragement, valuable comments and a friendly gesture which was very comforting.

I would like to thank Ms. Chinthanie Ramasundarhettige for her statistical support, Ms. Desiree Bernard for her administrative support and the whole staff of Centre for Global Health Research at St. Michael’s Hospital, who helped me now and then with their computational skills.

I am very thankful to the graduate coordinators and administrative staff of Institute of Medical Sciences, for their constant support.

I am thankful to Ontario Tobacco Research Unit for Ashley studentship to assist in this work.

Last but not the least; I thank my husband Anuj for his constant support and encouragement and son Daksh for his unconditional love and sharing his time.
# TABLE OF CONTENTS

Abstract.........................................................................................................................ii
Acknowledgement..........................................................................................................iii
List of Tables....................................................................................................................vii
List of Figures..................................................................................................................viii
Appendices......................................................................................................................ix

## 1 Introduction

1.1 Background..................................................................................................................1
1.2 Research objectives......................................................................................................3
1.3 Methods used................................................................................................................4
1.4 Organization of the thesis...........................................................................................6

## 2 Literature review

2.1 Socioeconomic status (SES) and health inequality......................................................7
   2.1.1 Measures of SES....................................................................................................7
   2.1.2 Relationship of SES and health inequality...........................................................8
   2.1.3 Measure of assessing health inequality.................................................................8
   2.1.4 Different parameters of SES in assessing health inequality...............................9

2.2 Smoking and SES.......................................................................................................13
   2.2.1 Prevalence of smoking by SES............................................................................13
   2.2.2 Trends in smoking prevalence by SES.................................................................14
   2.2.3 Reliability of smoking prevalence data...............................................................15
   2.2.4 Smoking-attributable mortality............................................................................16
   2.2.5 Social inequalities in smoking-attributable mortality.........................................17

2.3 Methods used to assess smoking-attributable mortality............................................19
   2.3.1 Prevalence methods.............................................................................................19
   2.3.2 Peto et al method.................................................................................................20
   2.3.3 Excess mortality methods...................................................................................21
   2.3.4 Prevent simulation model...................................................................................22
   2.3.5 Other methods....................................................................................................22
**LIST OF TABLES**

Table 1: Association of lung cancer risk to different parameters of SES in a Canadian study…………..10
Table 2: Tertiles were constructed by regrouping various social strata………………………………31
Table 3: Socially stratified number of male deaths of four countries………………………………..32
Table 4: Socially stratified male population counts of four countries………………………………..32
Table 5: Male relative risk of causes of deaths attributable to smoking (from CPSII)…………………..47
Table 6: Trends in male mortality attributed to tobacco in various social strata of four countries……51
Table 7: Annual death rates per 1000 men, attributed to smoking or not, in Canada…………………….54
Table 8: Percentage reduction in mortality rates, from 1986 to 2001, in Canada………………………..55
Table 9: Annual death rates per 1000 men, attributed to smoking or not, in France……………………56
Table 10: Percentage reduction in mortality rates, from 1990-96 to 1997- 99, in France……………..57
Table 11: Annual death rates per 1000 men, attributed to smoking or not, in Poland…………………58
Table 12: Percentage reduction in mortality rates, from 1995 to 2002, in Poland……………………..59
Table 13: Annual death rates per 1000 men, attributed to smoking or not, in Switzerland………………60
Table 14: Percentage reduction in mortality rates, from 1991-94 to 1998-00, in Switzerland………..61
Table 15: Proportion of all-cause mortality attributed to smoking in various social strata of Canada……63
Table 16: Proportion of all-cause mortality attributed to smoking in various social strata of France…..64
Table 17: Proportion of all-cause mortality attributed to smoking in various social strata of Poland……65
Table 18: Proportion of all-cause mortality attributed to smoking in various social strata of Switzerland66
Table 19: Rate ratio and rate difference between the lowest and the highest social strata for all cause, smoking-attributable, and nonsmoking-attributable mortality rates, in Canada……………………………..68
Table 20: Rate ratio and rate difference between the lowest and the highest social strata for all cause, smoking-attributable and nonsmoking-attributable mortality rates, in France……………………………..70
Table 21: Rate ratio and rate difference between the lowest and the highest social strata for all cause and smoking-attributable mortality rates, in Poland……………………………………………………………………………………………………………………………………………………………………….72
Table 22: Rate ratio and rate difference between the lowest and the highest social strata for all cause and smoking-attributable mortality rates, in Switzerland………………………………………..74
LIST OF FIGURES

Figure 1: Trends in smoking-attributable male mortality rates in the lowest and the highest social strata of four countries…………………………………………………………………………………..52

Figure 2: Trends in smoking-attributable mortality rates in three social strata of Canada…………………...55

Figure 3: Trends in smoking-attributable mortality rates in three social strata of France…………………..57

Figure 4: Trends in smoking-attributable mortality rates in three social strata of Poland………………….59

Figure 5: Trends in smoking-attributable mortality rates in three social strata of Switzerland……………..61

Figure 6: Trends in proportion of all-cause mortality attributed to smoking in low, middle and high social strata, by neighborhood income quintile, in Canada………………………………………..63

Figure 7: Trends in proportion of all-cause mortality attributed to smoking in low, middle and high social strata, by education, France………………………………………………………………………..64

Figure 8: Trends in proportion of all-cause mortality attributed to smoking in low, middle and high social strata, by education, in Poland………………………………………………………………………..65

Figure 9: Trends in proportion of all-cause mortality attributed to smoking in low, middle and high social strata, by education, in Switzerland……………………………………………………………..66

Figure 10: Rate ratio and rate difference between the lowest and the highest social strata for smoking-attributable mortality rates, in Canada……………………………………………………………..69

Figure 11: Rate ratio and rate difference between the lowest and the highest social strata for smoking-attributable mortality rates, in France………………………………………………………………69

Figure 12: Rate ratio and rate difference between the lowest and the highest social strata for smoking-attributable mortality rates, in Poland……………………………………………………………..73

Figure 13: Rate ratio and rate difference between the lowest and the highest social strata for smoking-attributable mortality rates, in Switzerland……………………………………………………………..75

Figure 14: Trends in risk of death, at ages 35-69 years, attributed to smoking or any cause in various social strata of Canada………………………………………………………………………..77

Figure 15: Trends in risk of death, at ages 35-69 years, attributed to smoking or any cause in various social strata of France………………………………………………………………………..78

Figure 16: Trends in risk of death, at ages 35-69 years, attributed to smoking or any cause in various social strata of Poland………………………………………………………………………..80

Figure 17: Trends in risk of death, at ages 35-69 years, attributed to smoking or any cause in various social strata of Switzerland………………………………………………………………………..82
APPENDICES

Appendix I: Template for mortality data and population count.........................................................103
Appendix II: SAS Program for analysis of smoking-attributable mortality........................................107
1 INTRODUCTION

1.1 Background

Tobacco use is the single largest preventable cause of death in the world today and is estimated to kill more than 5 million people each year worldwide (1). Smoking-attributed health problems are disproportionately borne by poorer social strata, making tobacco use a substantial contributor to overall health disparities between the rich and the poor (2). Inequalities in health among groups of different social strata constitute one of the main challenges for public health (3).

The prevalence of smoking in adults has decreased by over 50% in the past few decades in Canada, France, the United States, the United Kingdom, and other high-income countries (4) but most of these countries have observed greater declines in higher social strata (5-8). Concern has been raised if declines in smoking prevalence in the past few decades have similar or different effect on smoking-attributable adult mortality rates of different social strata (5).

Studies done in the past give enough evidence that smoking contributes significantly to social inequalities in mortality rates; however, most of these studies were conducted either for smaller cohorts, or for only specific causes (not including all the diseases, which have proved their association with smoking) (9, 10). Only one study by Jha et al (11) quantified smoking-attributable mortality rates, in males for ages 35-69 years, of different social strata, in four countries (Canada, England and Wales, Poland, and the United States (US)) using large population data for the year 1996. The study concluded that smoking-attributed mortality accounted for more than half of the absolute differences in the total male mortality rates between the highest and the lowest social strata, at ages
35-69 years. No study is known, which has assessed social inequalities in smoking-attributable male mortality rates across countries, in recent time periods, and looked at time trends of such social inequalities. This prompts the need of estimating male smoking-attributable mortality rates of various social strata for more recent years and to analyze the trends of social inequalities in these mortality rates. This analysis will directly answer whether social inequalities in smoking-attributable adult male mortality rates, aged 35-69 years, have reduced or widened in recent years in the context of declines in smoking prevalence in these countries.
1.2 Research Objectives

The aim of this study was to quantify all-cause and smoking-attributable adult male mortality rates for different social strata, in each country, for various time points between 1986 and 2001, to meet the following objectives:

1) Analyze the trends in smoking-attributable mortality rates for different social strata in each country.

2) Assess the proportion of all-cause mortality attributable to smoking for different social strata and analyze their trends.

3) Quantify the absolute (rate difference) and relative (rate ratio) differences between social strata in different years to assess change in social inequalities in smoking-attributable mortality rates over the comparative time periods.

4) Quantify the risk of dying, of a 35 year old male, of different social strata, at ages 35-69 years, due to smoking and to analyze the trends in risk of dying due to smoking.
1.3 Methods used

The contribution of smoking to adult mortality in each population was estimated indirectly by a method which was conceptualized by Peto and his colleagues (12). This method uses lung cancer mortality as an indicator of the accumulated damage from smoking in a population (in this case, categorized by different social strata), and can therefore be used to determine the proportions of smoking-attributable mortalities from other smoking-related diseases in that population (13). To apply this method, we needed to know the age and sex specific lung cancer mortality rates and deaths due to diseases causally related to tobacco in the target population. Lung cancer mortality rates of smokers and never-smokers, and the relative risks for the diseases causally related to tobacco were needed from a reference population (a prospective cohort study of one million Americans called the Cancer Prevention Study II (CPS II)) (14).

The hazards of smoking depend not only on current but on previous smoking patterns (15) and on several other co-factors (16) like age, marital status, education, consumption of fruits and vegetable and others (17); therefore, risk estimates of CPS-II study cannot be extrapolated to populations which are very different from the US (12). This analysis included populations from North America and Europe, which are similar to US; therefore, CPS II study could be used as a reference population.

This study was conducted for males of four developed countries of North America and Europe namely: Canada, France, Poland, and Switzerland using age and sex specific, socially stratified deaths and population counts from national death registries and national censuses of these countries, for different time points between 1986 and 2001.
Socioeconomic status was predefined by each country’s statistical office: by neighborhood income quintile in Canada (18) and by completed years of education in remaining three countries (19-22). All-cause and smoking-attributable mortality rates were assessed for different social strata and absolute and relative differences in these rates were observed among various social strata. Risk of dying from smoking or any cause, at ages 35 – 69 years, was calculated. Changes in social inequalities in smoking-attributable mortality rates and risk of dying were then assessed between different time periods of respective countries. Statistical Analysis Software (SAS 9.0) was used for data analyses.

In developed countries, male smoking rates have already peaked (23) and are on the decline while the female smoking rates have not yet reached the peak (24, 25). Female smoking prevalence at the time of CPS II study was still variable and has rather increased since then; therefore, using relative risk estimates from that reference population might not present the actual burden of smoking in females by giving conservative estimates of smoking-attributable mortality rates.
1.4 Organization of thesis

This thesis is organized as follows: Chapter 2 reviews the existing literature on social stratification, inequalities in health and adult mortality, prevalence of smoking and methods used in the past to assess burden of smoking. Chapter 3, details methodology to assess smoking-attributable mortality rates including study design, data sourcing, database management, and analysis. Findings of the analysis are presented in the fourth chapter, and then discussion is presented, followed by future directions.
2 LITERATURE REVIEW

In this section, past scientific literature has been reviewed to understand the relationship of socioeconomic status with health inequality and prevalence of smoking. Different methods, which exist to assess the mortality burden of smoking, have been described briefly and the usage and limitations of death certificates, which are the key component of doing this analysis, have been noted in the end.

2.1 Socioeconomic status (SES) and health inequality

Health inequality term is sometimes used to describe the fact that health varies between individuals; however, it is more usually used to refer to the systematic differences in the health of groups having unequal positions in society (26). According to Marmot report of 2007, macro-environmental factors like socioeconomic factors and the physical and social environment are the principal determinants of inequalities in health (27). Inequalities in health are a major public concern which needs attention (28). The following is a description of various indicators of SES and their relationship with health inequality.

2.1.1 Measures of SES

According to researchers, SES is a complex phenomenon, which is predicted by multiple variables like education attainment, occupation, social status and financial position (29, 30). These measures have different characteristics; for example financial condition or income reflects spending power, access to health care and living conditions like housing or diet (31) but can alter throughout adult life (32). Occupation reflects prestige, work
exposure, environmental effects and physical activity (31) while education indicates skills requisite for acquiring positive psychological, social and economic resources (31) but is less likely to change after a certain level of adulthood (32).

### 2.1.2 Relationship of SES and health inequality

Social position is commonly recognized as the cause rather than the result of health status (33, 34). Link and Phelan (1995) have written extensively on robust association between social conditions such as SES and health. In what they term “the fundamental cause perspective”, they theorize that SES provides flexible resources of power, prestige, and beneficial social connections that create gradients in health (35). Social position is considered the fundamental cause of health disparities as it systematizes access to a variety of resources that can be used to avoid or minimize risks and to protect health (36).

SES has been consistently associated with different health outcomes across various countries. Low SES has been associated with decrease in life expectancy (37), higher morbidity and mortality rates due to various diseases (9, 38, 39) and self reported poor health status (9, 40).

### 2.1.3 Measures of assessing health inequality

Valid measures are critical in the evaluation of health inequalities within countries or in the assessment of trends over time (41). Wagstaff et al provided a critical review of the various measures of health inequality (42). They identified six measures of inequality: the range (rate ratio and rate difference), the Gini coefficient (and the associated Lorenz
curve), a pseudo-Gini coefficient (and an associated pseudo-Lorenz curve), the index of
dissimilarity, the slope (SII) and relative index of inequality (RII), and the concentration
index and curve. The reviewers concluded that Gini coefficient, Lorenz curve, and index
of dissimilarity (ID) do not reflect the socioeconomic dimension to inequalities in health.
Measure of range compares the experiences of the top and bottom socioeconomic strata
and overlooks the intermediate strata and is not sensitive to changes in the distribution of
the population across socioeconomic groups (42). According to the authors the slope
index of inequality and the concentration index met the “minimum requirements” of an
inequality measure (42). Mackenback and Kunst, in 1997, presented a framework for
measuring the magnitude of socio-economic inequalities in health (43). They agreed with
most of the remarks of Wagstaff et al but held different views regarding measures like
range and the ID. According to them, simple and straightforward measures like range and
ID, if used judiciously, are more useful in informing policy makers (who are particularly
aimed for studies of socio-economic inequalities). RII, SII, and concentration index on
the other hand have a complex interpretation and can easily lead to misunderstandings
(43).

2.1.4 Different parameters of SES in assessing health inequality

Although SES is one of the strongest and most consistent predictors of a person's
morbidity and mortality (36, 38), which parameter of SES may be the most reliable and
valid measure remains unanswered. Some investigators tried to answer this question by
analyzing different parameters of SES with respect to mortality within the same database
(44-47).
A study by Mao et al (44), evaluated socio-economic inequality in lung cancer risk in Canada. Family-income-adequacy, education and occupational class were considered as markers of SES. For all the three parameters, males of lower SES were at higher lung cancer risk as compared to males of higher SES. The adjusted odds ratio of 1.7 was reported for low vs higher income males, 1.67 for low (1-8 years) vs higher educated (≥14 years) males, and 1.9 for unskilled vs professional males (Table 1). A US study looking at all-cause mortality found similar discriminative power of education, occupation and economic indicators of SES (45).

Table 1: Association of lung cancer risk to different parameters of SES in a Canadian study

<table>
<thead>
<tr>
<th>Parameter of SES</th>
<th>Adjusted odds ratio for lung cancer (lowest/highest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income adequacy</td>
<td>1.70</td>
</tr>
<tr>
<td>Education</td>
<td>1.67</td>
</tr>
<tr>
<td>Social class</td>
<td>1.90</td>
</tr>
</tbody>
</table>


However, another US study by Sorlie et al (46) found income to be the best discriminator of all-cause mortality rates, followed by education and occupation. One more US study, by Winkleby et al (47) concluded that among education, income, and occupation, the relationship between any of these SES measure and risk factors for cardiovascular diseases, education was the strongest and the most consistent indicator. A study done by Menvielle et al (20) tried to compare social inequalities in all-cause mortality, cancer mortality and mortality due to cardiovascular diseases, in France, using educational level and occupational group as socioeconomic indicators. Their results concluded that larger inequalities were observed with occupational group than with educational level.
To examine the relative ability of education, occupational class, household income and housing conditions to discriminate all-cause and cause-specific mortality risk, a study was undertaken by Naess et al in Oslo (48). They also tried to find out if this relative ability was consistent across common causes of death. The authors concluded that education, occupational class and housing conditions all seemed to discriminate all-cause mortality to a similar degree; however, the specific cause of death showed a heterogeneous pattern. The causes of death related to early life social circumstances like stomach cancer or chronic obstructive pulmonary disease, were particularly strongly related to education and the causes of death related to adult social circumstances like violence or sudden unexpected deaths were more strongly related to occupation and housing condition.

Similar results were observed by another study done by Smith et al (32) in Scotland. The only difference was in lung cancer mortality related to cigarette smoking, which was strongly related to occupation rather than education according to the Scottish study but Naess et al said that lung cancer mortality was strongly related to both education and occupation.

Relationships between health and social position are generally consistent across different social measures but the literature also suggests that the extent of health inequalities can vary with different social indicators (41). Studies done in the past suggest that although the different indicators of SES can sometime interchangeably act as a proxy measure; however, the association between health and different SES indicators may have different implications and causes (31). Therefore, social inequalities in mortality rates among
different populations, using different indicators of SES, cannot be compared to each other.
2.2 Smoking and SES

In many countries, smoking is far more common in lower than in higher social strata, whether these strata are defined by education, income, or occupation (49-51). In this section, prevalence and trends of smoking and smoking-attributable mortality in different social strata has been reviewed.

2.2.1 Prevalence of smoking by SES

There is an extensive body of literature documenting the relationship between smoking and SES (50-56). Cigarette smoking became popular in the early years of 20th century and has demonstrated a social gradient since its beginning but the interesting issue is that it started with a positive correlation (higher the social strata more the smoking prevalence) but changed to negative in second half of the century after the landmark reports of Royal College of Physicians and US Surgeon General Report in 1960 exposed the ill effects of smoking (53, 57, 58) in developed countries. Since then, fewer years of formal education, lower status occupation, lower income, living in low-socioeconomic areas have all been associated with a higher prevalence of smoking (50, 51).

In 2010 in Poland, the highest risk of smoking was observed among low educated men; the frequency of smoking was four times higher among men with the elementary level of education compared to those with the high educational attainment (50). In 2008 in the US, adults aged ≥25 years with low educational attainment had the highest prevalence of smoking (41.3% among persons with a General Educational Development certificate (GED) and 27.5% among persons with less than a high school diploma, compared with 5.7% among those with a graduate degree) and for 2009 (59), the prevalence of smoking
was 28.5% among persons with less than a high school diploma compared with 5.6% among those with a graduate degree (60). According to the Canadian Tobacco Use Monitoring Survey (CTUMS) done in 2009, 23% of people who had completed secondary education were current smokers compared to 9% of people who had completed university education (61). A study done in Switzerland to assess trends in risk factors for lifestyle related diseases from 1993-2000 concluded that smoking is more prevalent among persons with lower socioeconomic position, whether the position was assessed by occupation or education level (62).

Although a negative association of smoking prevalence and social status has not been debatable; however, is the association same quantitatively across different populations and cultural settings has not been confirmed. A recent study tried to assess whether the association of health behaviors like smoking and socioeconomic status is different across different cultural settings by using participants from the British Whitehall II study and the French GAZEL study (52). The socioeconomic gradient in smoking was different in two studies. The odds ratio was 3.68 for Whitehall II and 1.33 for GAZEL study for the lowest versus the highest occupational position (52).

### 2.2.2 Trends in smoking prevalence by SES

Number of studies are available, which have assessed trends in smoking prevalence by SES (6-8, 63, 64). Prevalence of smoking has reduced significantly in developed countries in the past few decades (4, 65) but most of the countries have observed greater declines in higher social strata with few exceptions (63). A study done to assess trends in smoking behavior, between 1985 and 2000, for nine western European countries by
education level, observed greater declines among more educated groups except Britain and Italy, where men with elementary education showed greater declines in smoking than their more educated counterparts (63). In Canada, between 1999 and 2006, smoking prevalence decreased; however, significant educational differences were observed: prevalence approximately doubled between the most and the least educated groups (6). A US study to measure state trends in educational inequalities in smoking observed that inequalities increased in 80% of the states from 1990 to 2004 (64). During 1998-2008, the proportion of U.S. adults who were current cigarette smokers declined 3.5% (from 24.1% to 20.6%); however, adults with a GED certificate had the lowest quit ratio (59). In Switzerland, from 1992 to 2007, reduction in prevalence of current and former smokers was observed with reduction from 47.2% to 46.3% in the lower education group (no education + primary), from 54.8% to 52.9% in subjects with secondary level education, and from 55.4% to 48.7% in subjects with university level education (7). In France, between 2000 and 2007, smoking prevalence decreased by 22% among executive managers and professionals and by 11% among manual workers, and did not decrease among the unemployed (8).

2.2.3 Reliability of smoking prevalence data

Studies done in developed countries have a consensus on reducing prevalence of smoking in the past few decades. The concern arises about the reliability of these estimates, which depend on survey methods used in determining true rates of smoking in communities (66) and sample selection of population (67). The estimates of cigarette smoking are self-reported and are not validated by biochemical tests in all surveys (53, 59). Some
subpopulations with high smoking rates are never included in estimates of national smoking, including prisoners, homeless, illegal immigrants, people in mental health institutions, people who do not speak the language of the country in which surveys are being conducted and poor people living in remote areas with no access to telephone (68).

2.2.4 Smoking-attributable mortality

Smoking-attributable mortality is the proportion of deaths that can be regarded as causally linked to cigarette smoking (69). It has been widely used in studies and is considered to be one of the most relevant summary statistics, due to its capacity to show harmful effects of tobacco (70). Tobacco kills approximately 5–6 million people annually worldwide, accounting for 1 in every 5 male deaths and 1 in 20 female deaths in individuals over 30 years of age (71, 72). There is strong evidence to suggest that smoking harms nearly every organ of the body and forms part of the causality chain of almost all the cancers, cardiovascular diseases, respiratory disorders, and many other medical conditions (73, 74). Smoking-attributable mortality is the result of a previous exposure to tobacco and reflects the smoking behavior of the population two to three decades earlier (75-78). Therefore, the ideal calculations of smoking-attributable mortality rates should be based on the past prevalence of smoking and current deaths but the prevalence changes over time and it is impossible to track individuals or even large cohort of smokers (79).

Study demonstrating the link and assessing the risk between cigarette smoking and mortality involve detailed smoking history (80). Two large prospective cohort studies have been conducted in the past by American Cancer Society (CPS-I and CPS-II
beginning in 1959 and 1982, respectively) including more than one million Americans and a study of British doctors beginning in 1951 (81), provided rich data about excess risks associated with cigarette smoking for number of causes of death.

While cohort studies provide evidence of the increased mortality risk related to smoking behavior, they suffer from few significant drawbacks. First, studies record the base line smoking status and assume it to remain the same throughout the study and do not reflect temporal changes in the smoking pattern of the cohort. Second, study cohorts are not true representatives of the general populations. Finally, large scale cohort studies require long periods of observation and detailed information that may be unavailable for relevant populations. Researchers have attempted to deal with such issues by using indirect methods of calculating smoking-attributable mortality using absolute number of deaths due to various diseases related to smoking without using prevalence of smokers (12).

2.2.5 Social inequalities in smoking-attributable mortality

Smoking is an individual health behavior with the single largest impact on health inequalities (82). Smoking also contributes to social inequalities in adult male mortality; a study compared data of Canada, England and Wales, Poland and the United States, for the year 1996, found that smoking accounted for over half of the social inequalities in male risk of deaths (11). A cohort study for men, aged 40-69 years, was conducted in Melbourne, Australia from 1990 to 1994, which concluded that smoking contributes substantially to socioeconomic differentials in mortality (83). A study in US concluded that lung cancer and chronic obstructive pulmonary disease (attributed to tobacco use), accounted for 21% of educational inequalities in mortality rates, in 1990 and 2000.
Mackenbach et al conducted a study for 22 European countries for 1990s and early 2000s and concluded that smoking related conditions account for 22% of the inequalities in the rates of death from any cause among men and 6% of those among women (9). Studies done in the past give enough evidence that smoking contributes significantly to social inequalities in mortality rates (2, 9, 10, 14, 84); however, most of these studies are based on smaller cohorts, for only specific causes (not including all the diseases which have proved their association with smoking) (9, 10) or for earlier time periods. No study has assessed such inequalities across countries, in recent time periods, and looked at time trends of such social inequalities. Concern has been raised if declines in smoking prevalence in the past few decades have reduced (or widened) social inequalities in smoking-attributable adult mortality (63), which prompts the need of estimating smoking-attributable mortality rates of different social strata for more recent years and to observe the trends of changing social inequalities of these mortality rates.
2.3 Methods used to assess smoking-attributable mortality

The association of smoking and mortality is not debatable, but different methods which have been used in assessing the proportion of deaths due to smoking have always been scrutinized. The task of attributing number of deaths due to smoking continues to be a controversial process and has been questioned from different quarters including tobacco industry (85, 86). The task of quantifying smoking-attributable mortality has been performed mainly through indirect methods (13). Pérez-Ríos and Montes (13) provided a useful systematic review of these methods, which can be classified under four categories: Prevalence-based analysis (87-89), Peto and colleagues' method (12), methodologies based on the calculation of excess mortality using Garfinkel's and Roger's method (90, 91) and predictive models (Prevent) (92). The methods differ in terms of calculation processes, information requirement, data sources and assumptions required for their application (13).

2.3.1. Prevalence methods

These methods use total number of deaths causally related to tobacco, prevalence of smoking (non-smokers, current smokers, past smokers) from surveys and relative risks of different diseases related to smoking (extracted mainly from the CPS II) (17, 93). The Centers for Disease Control and Prevention (CDC) introduced SAMMEC (Smoking-Attributable Mortality, Morbidity, and Economic Cost, version II) in 1980’s (69, 94), a computer software application to study the burden of smoking using prevalence method. SAMMEC needs the number of deaths by 5-years age groups from ages 35 or older for each smoking-related diagnosis, prevalence of tobacco consumption, and relative risks of
different diseases in smokers (from CPSII) to compute population-attributable fraction of deaths that can be causally linked to tobacco (69, 95, 96). CDC acknowledges the limitations of SAMMEC model as; deaths attributable to cigar smoking, pipe smoking, and smokeless tobacco use are excluded, relative risks of CPS II study, based on deaths during 1982-1988, could have changed over time for current smokers due to changes in age of initiation or duration of smoking before quitting, and the estimates do not account for the sampling variability in smoking prevalence estimates (97).

2.3.2 Peto et al method

Richard Peto and his colleagues recognized the limitation of availability of nationally representative prospective studies in different developed countries for a direct estimation of mortality burden of smoking and therefore established a method for estimating tobacco-attributable mortality in which data requirement is less demanding, as the smoking prevalence of the population is not needed (12). This methodology assumes that lung cancer mortality is an indicator of the maturity of the smoking epidemic in a population, and thus, tobacco-attributable mortality of a specific population can be estimated by its lung cancer mortality (13). This assumption has been justified by the evidence suggesting that the changes in lung cancer rates are primarily affected by the history of smoking behavior (75, 76). Absolute lung cancer rate in a particular population is used to indicate proportions of the deaths from various other diseases, which can be attributable to smoking (12). To apply this method, age and sex specific lung cancer mortality rates, and deaths due to smoking-attributable diseases in the target population need to be known. Lung cancer mortality rates of smokers and never-smokers, and the
relative risks for smoking-attributable diseases are needed from a reference population (CPSII). This method has been widely used in the estimation of smoking-attributable mortality (12, 23, 92, 98-100). The method has been validated by the US surgeon general report, which gave approximately similar smoking-attributable deaths in the United States for the year 1985 using a different method in which prevalence of smokers were taken into account (12). Other methods have validated their results by using results of Peto method for different populations (92, 101). The calculation procedure of estimating smoking-attributable mortality rate using this method has been explained in detail in the methodology chapter.

2.3.3 Excess mortality methods

a) Garfinkel’s method:

This method uses observed and expected counts of cancer deaths in a population to achieve the tobacco-attributable fractions of cancer deaths. Age and sex specific cancer deaths of the population are considered as observed counts where as expected counts are those that would have occurred if everyone was a nonsmoker in the entire population. Expected deaths are computed using relative risk of dying due to these cancers in nonsmokers of CPS I study (followed for 12 years) (90). Attributable fractions of cancer deaths are then calculated. This method has been applied to estimate excess cancer deaths in a population due to smoking (102).

b) Roger’s method:

This method has been used only once in the US. The researchers divided smokers in seven groups (heavy, moderate, and light current smoker; heavy, moderate, and light
Then using National Health Interview Survey (NHIS) smoking prevalence data for the year 2000 and relative mortality risks for seven smoker groups by sex (from 1990 NHIS supplement data linked to mortality follow-up), estimated the numbers of deaths attributed to smoking. This attempt avoided usage of risks derived from other populations and adjustments of confounding factors (91) and offered relatively robust assessments of smoking-attributable mortality rates. However, current smoking prevalence may not be an effective measure of exposure to smoking-related mortality as mortality rates of present reflect past exposures and secondly such extensive data on smoking status and mortality are unavailable for most populations (80).

2.3.4 Prevent simulation model

It is a type of predictive model developed in 1988 in the Netherlands (103) to estimate the health effects of any interventions in a specific population. Its underlying dynamic population model allows for cohort specific approach in a real population age structure. Calculations are made with the computer simulation model. First, the effect of an intervention on the prevalence of a risk factor has to be assessed and then the model calculates the resulting changes in mortality, by using both epidemiological and demographical data (104). It has been used basically to predict mortality due to various causes, including tobacco (105).

2.3.5 Other methods

In 2010, Preston, Glei, and Wilmoth (101) developed an alternative to the Peto-Lopez method for estimating the number or fraction of smoking-attributable deaths in high-
income countries. Like Peto et al, they also used lung cancer mortality as an indirect measure of smoking history, but they did not use relative risks from CPS-II study rather, estimated the relative effect of excess lung cancer mortality due to smoking on overall mortality by age for national populations using a regression-based method. The results from their method were consistent with results produced by the Peto-Lopez method, and concluded that this consistency tended to validate both methods.
2.4 Death certificate

Mortality data continues to be a key database for epidemiologic, demographic, and historic research. According to Rosenberg (106), no other health data source exists that is as universal in coverage, as standardized, as uniform, and as timely as mortality data from the vital statistics system. However mortality data has its own limitations related to different methods of collection and estimation of data on deaths and population (107). A cause of death is a disease, abnormality, injury or poisoning that contributes directly or indirectly to death. A death often results from the combined effects of two or more conditions. These conditions may be completely unrelated, arising independently of each other; or casually related to each other (108).

Death certificates are the main source of mortality data. The information on a death certificate is provided ideally by an experienced medical practitioner that is well informed about the medical history of the dead person, and has carefully carried out a post mortem examination. In some jurisdictions, another official (who may not be medically trained) is responsible for the completion of the medical certificate of cause of death (109). The format for completion of the standard international death certificate recommended by the WHO is as follows: First to assess the immediate cause of death, antecedent cause and underlying cause of death, and then to look for any other significant disease or condition that contributed to death (109).

2.4.1 Assessment of cause of death

Deaths are classified using a standard coding system called the ICD (International Classification of Deaths), which has been organized and published by the World Health
Organization since 1946. The ICD is revised periodically (approximately every ten years) to reflect changes in medical and epidemiological knowledge and in the light of diseases that are either new or of growing importance (110).

2.4.2 Usage of death certificate

Death certificates are source of mortality statistics, which play an important role in medical research (111). The data on cause of death contained in the certificates help in assessing the effectiveness of public health programs, providing a feedback for future policy and implementation, better health planning and management, and deciding priorities of health and medical research programs (112).

2.4.3 Limitations of death certificate

ICD is a very important tool in assessing the cause of death but its usage has its own limitations.

1) As the diagnostic skills and the type of training of the certifying medical practitioners are different across countries, accuracy of the diagnosis recorded on the death certificate is affected, making cross country comparisons inappropriate (113).

2) ICD categories are based on a single cause of death. A medical examiner assigns a particular underlying cause, which seems to be most appropriate, for the death. In developed countries where age expectation is quite high, multiple causes are involved which lead to death and hence creates the possibility of error in classification (12).
3) Trend analysis can be affected by changes over time in the ICD categories themselves. An apparent increase or decrease in a cause of death may be the result of a coding/classification change only (114).
3 METHODOLOGY

In this section, demography of the four countries analyzed will be briefly addressed and then details about data sources and samples will be presented. I will explain how data were obtained, managed and analyzed, and from what all organization ethics approval was obtained for conducting this study.

3.1 Study setting

Smoking-attributable mortality rates were assessed for four developed countries of North America and Europe. Mortality data and population count were obtained, for males aged 35-69 years, of different social strata of Canada, France, Poland and Switzerland. A brief description of demography (population statistics by age and sex) and social strata classification of these countries are as follows:

Canada

The population of Canada by sex and age is estimated each year by Statistics Canada. Canada's population as of July 1, 2010 was estimated at 34,108,800 (115). Adult males, aged 35-69 years, constitute 23% of total population of Canada. Neighborhood income quintile is used as one of an indicator of social position (18). Quintiles of population are ranked from the lowest to the highest as: poorest, poorer, average, richer, and richest, respectively.

France

The population of France by sex and age is estimated by National institute for demographic studies (INED) each year (116). France’s population as of January 1, 2010
was estimated at 62,793,432. Adult males, aged 20-74, constitute 36% of the total population of France. Educational level is used as an indicator of social position. Educational level is graded from the lowest to the highest as: no diploma or primary school level, vocational or technical level, secondary school level and university level, respectively (20).

**Poland**

The population of Poland by sex and age is estimated each year by Central Statistical Office of Poland. Poland’s population as of June 30, 2010 was estimated at 38,186,860 (117). Adult males, aged 35-69 years, constitute 21% of the total population. Educational level is used as an indicator of social position. According to demography yearbook of Poland 2010 (22), education level is graded from the lowest to the highest as: primary education completed, basic vocational training, secondary and post secondary education, and higher education, respectively.

**Switzerland**

The population of Switzerland by sex and age is estimated each year by Swiss Federal Statistical Office. Permanent resident population of Switzerland as of December 31, 2009 was estimated at 7,785,800 (118). Adult males, aged 20-64, constituted 31% of the total population of Switzerland. Education level is used as an indicator of social position (19). Education level is graded in three categories from the lowest to the highest as: less than secondary: primary education or less (International Standard Classification of Education, ISCED 1-2); secondary: vocational training or high school (ISCED 3-4); and tertiary: technical colleges and upper vocational education and university education (ISCED 5-6), respectively (19).
3.2 Study design

This research work is a descriptive study, reporting all-cause and smoking-attributable mortality rates of various social strata of four countries at different time points. Using these rates, probability of a 35 yr old man dying, at ages 35 – 69 years, was calculated in different time periods. An indirect estimation of mortality rates attributable to smoking was done by obtaining mortality data, according to age, sex, cause of death, and indicators of social status, from death registries and population count from national census of Canada, France, Poland and Switzerland.

3.2.1 Variables

The variables required for the analysis were:

- For each country, death counts of various social strata for following diseases of interest: lung cancer, upper-aero digestive cancer, other cancers, all vascular diseases, chronic obstructive pulmonary disease, other respiratory diseases, and other medical diseases, for seven 5 year age groups (35-39, 40-44, 45-49, 50-54, 55-59, 60-64, and 65-69).

- For each country, corresponding population counts of various social strata for the same seven year age groups.

- Lung cancer mortality rates of never smokers and current smokers of CPS-II study for the same seven year age groups.

- Relative risk estimates for current vs. never smokers from CPS-II study for all the diseases of interest. For vascular diseases, other respiratory diseases, and other medical diseases the relative risks were age specific (different risk estimates for
age groups 35-59, 60-64, and 65-69) and for lung cancer, chronic obstructive pulmonary disease, upper-aero digestive cancers, and other cancers the relative risks were age standardized for the age group 35-69 years.

3.2.2 Analytical steps

The steps for the analyses were as follows:

- Designed a template (appendix 1) to collect absolute death counts for diseases of interest and over all deaths for seven 5-year age groups for ages 35-69 years and population count for same age groups of various social strata of different countries.
- Sorted data according to the ICD codes for diseases of concern.
- Calculated age specific lung cancer death rates of all social strata of the study population.
- Constructed a template in excel to include age, social strata, absolute number of deaths due to causes of interest, lung cancer deaths rates, cumulative lung cancer death rates for ages 35-59 years, and population counts.
- Designed a program for analyzing data using Statistical Analysis Software version 9 (appendix 2).
- Run analysis to obtain smoking-attributable mortality rates among various social strata.
- Depending on the mortality rates of different social strata, constructed tertiles of social strata by regrouping existing strata, in Canada, France, Poland and Switzerland (table 2).
- Reanalyzed data for each country
- Calculated confidence intervals of mortality rates to assess significant differences among social strata
- After calculation of smoking-attributable mortality rates, calculated risk of dying due to smoking or any cause using a cumulative risk formula
- Prepared table and graphs from the results obtained

**Student’s contribution:** All of the above mentioned steps of analyses were performed by the student

<table>
<thead>
<tr>
<th>Social stratum</th>
<th>Low</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Canada (by neighborhood income quintile)</strong></td>
<td>Poorest</td>
<td>Poorer + Middle + Richer</td>
<td>Richest</td>
</tr>
<tr>
<td><strong>France (by education)</strong></td>
<td>No diploma or primary education</td>
<td>Vocational or technical + secondary school</td>
<td>University education</td>
</tr>
<tr>
<td><strong>Poland (by education)</strong></td>
<td>Primary education + vocational training</td>
<td>Secondary and post secondary education</td>
<td>Higher education</td>
</tr>
<tr>
<td><strong>Switzerland (by education)</strong></td>
<td>Primary education or less</td>
<td>Vocational training or High school</td>
<td>Upper vocational or University education</td>
</tr>
</tbody>
</table>
3.3 Data sources and samples

For obtaining these data, as per the requirements, a template was created in Microsoft excel. A copy of the template is attached as appendix 1. Appropriate authorities of these countries were then requested for data required. Male analyses included 377,878 deaths (Table 3) from a total population of 13,482,210 males (Table 4) of these four countries.

Table 3: Socially stratified number of male deaths of four countries

<table>
<thead>
<tr>
<th>Social stratum</th>
<th>Total deaths analyzed</th>
<th>Low</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>8,323 from 1990-999</td>
<td>5,193</td>
<td>2,659</td>
<td>471</td>
</tr>
<tr>
<td>Poland</td>
<td>194,511 from 1995 and 2002</td>
<td>154,846</td>
<td>29,720</td>
<td>9,945</td>
</tr>
<tr>
<td>Switzerland</td>
<td>89,077 from 1991-2000</td>
<td>28,649</td>
<td>44,941</td>
<td>15,487</td>
</tr>
</tbody>
</table>

Table 4: Socially stratified male population counts of four countries

<table>
<thead>
<tr>
<th>Social stratum</th>
<th>Population studied (%)</th>
<th>Low</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>4,205,285 (60%)</td>
<td>778,220</td>
<td>2,498,105</td>
<td>928,960</td>
</tr>
<tr>
<td>France</td>
<td>100,617 (1%)</td>
<td>40,656</td>
<td>46,155</td>
<td>13,806</td>
</tr>
<tr>
<td>Poland</td>
<td>7,784,872 (100%)</td>
<td>5,048,666</td>
<td>1,925,267</td>
<td>810,939</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1,391,436 (100%)</td>
<td>1,394,770</td>
<td>2,755,872</td>
<td>1,415,100</td>
</tr>
</tbody>
</table>

*Population numbers are by person years in Switzerland and by persons in other three countries*
3.3.1 Canada

Mortality data and population counts for Canada were obtained from Census Metropolitan Area of Canada (CMA) including population living in institutions. A CMA is formed “by one or more adjacent municipalities centred on a large urban area (known as the urban core) and must have a total population of at least 100,000 of which 50,000 or more must live in the urban core” (119). CMAs, which account for about 60% of Canada’s total population, were used because neighborhoods are more clearly defined and residential segregation by income is more pronounced in big cities than in small towns and rural areas (18). Death counts and population data for residents of CMAs were obtained by Statistics Canada from the Canadian Mortality Data Base and population censuses for four census years; 1986, 1991, 1996, and 2001 (18). Cause of death had been coded according to the International Classification of Diseases (ICD-9 for 1986, 1991, and 1996 and ICD-10 for 2001).

Social stratification of deaths in Canada is based on the usual place of residence reported on death certificate (18) and based on this information of the deceased, postal codes are generated. Using Postal Code Conversion Files (Automated Geographic Coding), Statistics Canada converts postal codes to the Census tract (CT) (18). CTs are socially homogeneous neighborhoods with a population of 4,000. Addresses for which postal codes cannot be found are manually assigned to CT by using street index and other reference documents. These CT’s are then assigned to quintiles (1-5 as having lowest to highest percentage of low-income residents, respectively) according to percentage of their population below the low-income cut-off. Persons are classified as having low income if their total family income in the year preceding the census is below that year’s
Statistics Canada low-income cut-off, which varies according to family size and CMA size. Each CMA is divided in such quintiles.

Statistics Canada data release protocols prohibit distribution of tables showing cell sizes of death counts 1 or 2, so when that occurred, cell contents are moved into the next higher age group (until a cell size of 3 or more was obtained). Then beginning with the oldest ages, same thing is done in reverse; if cell size of 1 or 2 were encountered the contents are moved into the next lower age group (until a cell size of 3 was obtained).

### 3.3.2 France

For France, data were obtained from a permanent demographic sample currently including about one million people, corresponding to more than 1% of the population of France, randomly selected on the basis of date of birth (four days in an year) (20). Data are updated at each successive census (1968, 1975, 1982, and 1990). A person remains in the sample until death. Data were obtained for a cohort started in 1990 and followed up until 1999. The French National Institute of Statistics (INSEE) follows the subjects of this sample and collects demographic, social and educational information from census. The information on social stratum came from census data collected in 1990 at baseline. The information on cause of death was obtained from the death registry. Death registries were checked in 1999 and therefore all the deaths which occurred between 1990 and 1999 were included in the dataset. Causes of death were obtained from the national file of the French Institute of Health and Medical Research (INSERM). Causes of death were coded according to international classification of diseases (ICD-9) codes and were identified for approximately 98% of the deaths. Census data and death registry were
linked using information on death certificate which included age, sex, date of birth and death, and place of death. Linkage was achieved for about 97% of deceased subjects. The sample was restricted to people born in France mainland (excluding overseas territories and people born abroad). This applied both to alive and dead subjects. These data have been used for other studies as well in the past and the authors have rated these data to be of high quality and a representative of the national situation of France (20).

3.3.3 Poland

Mortality data were obtained from Central Statistical Office of Poland for years 1993, 1994, 1995, 2001, 2002, and 2003, which included all deaths occurred in these years. Until the end of 1996, the underlying cause of death was recorded and coded with the three-digit code of ICD-9. Since the introduction of ICD-10 in 1997, four-digit coding is being carried out. Population data for 35-69 years, by education, were available only for years 1995 and 2002 (years of national census); therefore, we analyzed mortality data for only those two years. In 2002, education status was not stated for 2% of 35-69 years old population, which were excluded from the study. Education as a marker for socioeconomic status has been coded in Poland since 1992. Before that year the social status was coded as a marker of socioeconomic status.

3.3.4 Switzerland

Data were obtained from database of Swiss National Cohort (SNC), which was established by five University Institutes of Social and Preventive Medicine (ISPMs) in
2005 (19). SNC is a national longitudinal research platform which supports projects examining extent of variations in all-cause and cause-specific mortality in different municipalities, explained by their socio-economic status.

Name of the deceased person is noted in the death certificate which is archived at the municipality of residence and replaced before forwarding to the Federal Statistical Office by an anonymous record containing sex, community of residence, date of death and hour of death, date of birth of the deceased, marital status of the deceased, date of birth of spouse, religious affiliation of the deceased and nationality of the deceased. All these variables (except date of death) were also assessed in the census records and were thus used for deterministic and probabilistic record linkage (120).

Decennial censuses, conducted at the beginning of December of every tenth year, have been done in Switzerland since 1850 but in 1990 it was for the first time that it included the exact date of birth (121). This opened the possibility of linking census and mortality data. The 1990 census was successfully linked to mortality data and 2000 census by SNC. As a consequence they do not have yearly population counts but exact person time under risk. “The linkage was automated using the Generalized Record Linkage System (GRLS) package developed by Statistics Canada ”(121). On request they split data available from 1991-2000 in three time periods as 1991-1994, 1995-1997, and 1998-2000.

Causes of death are registered on the death certificate as: underlying cause, immediate cause, and concomitant causes plus information whether an autopsy has been performed. Cause of death information is centrally coded according to the ICD classification at the Federal Statistical Office and a primary cause of death is derived. In Switzerland ICD-9 was never used for cause of death registration. ICD_8 coding was used until the end of
1994 and since 1995 ICD-10 is in use. For a small proportion of deaths (<0.1%), educational level is not known which are omitted from mortality data as well as from population count.
3.4 Database management

3.4.1 Abstraction of relevant variables from the data available

For France, Poland and Switzerland data were obtained as per the template provided to the concerned authorities. For Canada, data were obtained from Statistics Canada having information for all age groups. Data for ages 35-69 years were extracted and the template was constructed as per the requirement.

3.4.2 Data quality assessment

Nationally representative data obtained from four countries were of high quality. For Poland and Switzerland, data obtained were 100% representation of mortality and population data from national death registries and national census data, respectively. For Canada, data were obtained from CMA’s which represent 60% of the Canadian population and for France, although data were obtained from a random permanent demographic sample constituting about 1% of the total population but these data, were from census and national death registries, representing the national situation in France.
3.5 Data analyses

3.5.1 Estimation of smoking-attributable deaths

The Peto method, which is an indirect method of assessing smoking-attributable mortality, has been widely used in developed countries. It is a conservative way of determining proportions of deaths attributed to tobacco. Details of the procedure are summarized below (12):

Deaths <35 years of age - As most of the deaths from tobacco occur in the middle or old ages, any deaths before age of 35 were ignored.

Deaths due to liver cirrhosis or external causes - Although it has been observed that cirrhosis is more common in smokers but as there are other factors like alcohol which contributes significantly towards the disease, it is difficult to quantify risk of cirrhosis associated with smoking therefore deaths due to cirrhosis were ignored. Similarly deaths from suicide, fires and all other external causes were also ignored.

Lung cancer deaths at ages 35-69: compare with US non-smokers - Lung cancer deaths are uncommon among non-smokers in developed countries. To reliably assess such death rates large cohort studies are needed. Two large prospective studies involving more than million people were conducted in the US (14), one in 1960s (CPS I) and the other in 1980s (CPS II). Both of these studies showed similar lung cancer rates for non-smokers; although the studies were done at an interval of twenty years. These rates were similar to a study of British doctors as well, which was conducted in two phases, one from 1951-1971 (122) and second from 1972-2001 (81). Therefore, an assumption was considered that the US non-smokers lung cancer rates in CPS II might approximate non-smokers lung cancer rates for other developed countries (having similar demography).
**Conservative halving of excess risk of other diseases attributed to smoking** - It could not be assumed that the absolute number of deaths due to diseases other than lung cancer would be comparable between CPS II and other populations. Therefore, the absolute lung cancer death rates in a particular population were used to indicate the proportions of deaths from various other diseases to attribute to smoking. Using relative risks of diseases, attributed to smoking, from CPS II study, excess mortality ratio for different causes of deaths, for ages 35-69 years, were calculated in target populations. But, it could not be assumed that all the excess mortality among smokers in the CPS II study was all caused by tobacco; therefore, to ensure that hazards of tobacco were not exaggerated, the excess mortality in the mixed population of smokers and non-smokers was halved before estimating the population fraction attributable to tobacco. Halving the percentage is acknowledged to be crude and arbitrary by the authors but it gives a reasonable degree of protection against over estimation of the epidemic. Smoking attributable national mortality rates, for year 1985, calculated by Peto method were almost exactly the same as reported by US Surgeon General, which used a different approach of calculation by using additional data on smoking prevalence as well (12).

**Smoking exposure from past smoking, second hand smoke and from pipes and cigars** -
Absolute excess of lung cancer deaths of smokers in population of interest include any tobacco exposure that have been sufficient to cause the effect, without differentiating between active or passive exposure, current or past, or source of exposure for example cigarettes, cigars or pipes. In the reference population the absolute excess of lung cancer deaths in smokers was only related to exposure of current cigarette smoking. Therefore, ratio of the two excess mortalities in various age groups might give overestimation of
excess mortality ratios in population of interest but as the ratios are arbitrarily halved for any confounding factors, chances of overestimation reduces.

**Relative risk estimates from CPSII study**-Relative risks of different diseases causally related to smoking were used from CPS-II study, because CPS-II is one of the few studies of smoking and cause-specific mortality conducted when the full effects of the smoking epidemic were apparent, especially for men. These relative risks have been used extensively by different methodological approaches used in assessment of smoking-attributable mortality.

For women, as the consequences of smoking epidemic were still to develop in 1980’s (24, 25), relative risks from CPS-II study have a probability of giving conservative estimates of smoking-attributable mortality rates. According to Adhikari et al, in future, CDC’s SAMMEC model might estimate mortality rates attributed to smoking using updated RRs (97), particularly for females, because their adoption of smoking (and hence their duration of smoking) lagged that of males during the early to mid-1900s.

Usage of these relative risks has encountered a number of criticisms. According to Sterling et al (85), CPS II was not a nationally representative population as the majority of volunteers, who participated in the study, were Whites, middle class, and more educated that general population of the US so it may be inappropriate to apply these relative risks to the whole US population and would be further inappropriate to apply for other populations outside of US. Secondly, these estimates were although adjusted for age and sex but not for other confounding factors like socio economic status, alcohol consumption, and other illnesses like hypertension or diabetes (85, 123).
Thun et al conducted a study to determine whether controlling for other risk factors like education, occupation, race, alcohol consumption, and various dietary factors, in addition to age and sex, substantially alters the relative and attributable risk estimates associated with tobacco smoking (17). Multivariate adjustments decreased the smoking-attributable deaths in the US by just 1% per year.

**Deaths >69 years of age-** As chances of misclassification increases at older ages, this analysis was restricted to ages up to 69 years (124, 125).

### 3.5.2 Risks at ages 35–69 years

Probability of dying in middle ages, 35–69 years, due to smoking or any cause was calculated using standardized death rates in this age range. Death rates for seven 5 years age groups (ages 35-69 years) were standardized by direct method. If the average annual death rate in this age range is \( R \) per 1000, then at these age-specific death rates the probability that a 35-year-old man will die within the next 35 years (ie, at age 35–69 years) can be shown to be \( 1 - \exp(-35R/1000) \) (12). For example, if the average annual death rate in this age range is three per 1000, then the cumulative risk of a 35-year-old dying at ages 35–69 years would be 0·1 (ie, 10%).
3.5.3 Statistical analysis

The steps which are considered for calculating smoking-attributable mortality rates are as follows:

1) Lung cancer death rates (per 100,000) were calculated of all social strata for seven five year age groups (35-39, 40-44, 45-49, 50-54, 55-59, 60-64, and 65-69). Death rates were then divided into three groups as 35-59, 60-64, and 65-69 years. Cumulative death rates for ages 35-59 were calculated (by adding death rates for five age groups and multiplying by 5)

2) For each age group i (where i=1 to 3, for age groups 35-59, 60-64, 65-69) Ri was defined, which is the ratio of overall and non-smoker lung cancer mortality rates in a target population.

\[ R_i = \frac{L_i}{A_i} \]

where \( L_i \) is the lung cancer mortality rate in age group i for given country X, and \( A_i \) is the smoothed nonsmoker lung cancer rate in age group i from CPS II study (the rate for age group 35-59 is also the cumulative rate) as lung cancer mortality rates of non smokers of target population were not available

Similarly, for CPS II population

\[ R_i = \frac{C_i}{A_i} \]

where \( C_i \) is the smoker lung cancer mortality rate in age group i from CPS II study, and \( A_i \) is same as above

3) The excess mortality ratio for lung cancer due to smoking in the target population is \( I_i \), in age group i

\[ I_i = R_i - 1 \]
(the risk of dying due to lung cancer would have been 1 if no one smoked)

\[ I_i = \frac{L_i}{A_i} - 1 \]

\[ I_i = \frac{L_i - A_i}{A_i} \]

4) The excess mortality ratio for lung cancer due to smoking in the CPS II population is \( S_i \) in each group \( i \)

\[ S_i = R_i - 1 \]

\[ S_i = \frac{C_i}{A_i} - 1 \]

\[ S_i = \frac{C_i - A_i}{A_i} \]

5) Smoking impact ratio (SIR) is the ratio corresponds to the absolute excess lung cancer death rate in the country of interest relative to the absolute excess among a known reference group of smokers (CPS-II) which is the effective proportion of smokers \( (F_i) \) in the target population. It was calculated as follows:

\[ F_i = \frac{I_i}{S_i} \]

\[ F_i = \frac{(L_i - A_i)/A_i}{(C_i - A_i)/A_i} \]

\[ F_i = \frac{L_i - A_i}{C_i - A_i} \]

6) If \( F_i \) is the proportion of smokers, then \( 1 - F_i \) is the proportion of non-smokers and the overall lung cancer rate will be

\[ L_i = F_i * C_i + (1 - F_i) * A_i \]

\[ L_i = C_i * (L_i - A_i)/(C_i - A_i) + A_i * (1 - (L_i - A_i)/(C_i - A_i)) \]

7) Seven group of causes of death were created, defined as \( k = 1 \) to 7 (1= lung cancer, 2= upper aero-digestive cancers, 3=other cancers, 4=COPD, 5= other respiratory diseases, 6= all vascular diseases, 7= other medical diseases)
8) Excess mortality ratio \( (E_{ik}) \) was calculated for all causes of death \( k = 1 \) to \( 7 \)

For diseases \( k=1 \) to \( 4 \)

\[
E_{ik} = F_i * M_k \quad \text{where is the ACS excess risk ratio for all ages (35-69)}
\]

\[
M_k = \text{Risk ratio of smokers (Table 5)} - 1 \quad (1 \text{ is risk of non-smokers})
\]

For diseases \( k=5, 6 \) or \( 7 \)

\[
E_{ik} = F_i * V_k \quad \text{where } V_k \text{ is the ACS excess risk ratio, in age groups 35-59, 60-64, and 65-69}
\]

\[
V_k = \text{Risk ratio of smokers} - 1 \quad (1 \text{ is risk of non-smokers})
\]

9) Population-attributable fraction \( (B_{ik}) \) to smoking was calculated as proportion of excess mortality ratio out of total mortality ratio.

For lung cancer:

\[
B_{ik} = \frac{E_{ik}}{E_{ik} + 1}
\]

(non smokers mortality ratio would have been 1)

For other diseases, the excess mortality ratio was halved to be conservative, so for deaths due to other diseases:

\[
B_{ik} = \frac{(\frac{E_{ik}}{2})}{(\frac{E_{ik}}{2}) + 1}
\]

\[
B_{ik} = \frac{(\frac{E_{ik}}{2})}{(\frac{(E_{ik} + 2)}{2})}
\]

\[
B_{ik} = \frac{E_{ik}}{E_{ik} + 2}
\]

10) Smoking attributed deaths \( D_{jk} \) for country \( X \) from cause \( k \) in age group \( j \)

(where \( j=1 \) to \( 7 \), for ages 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, and 65-69) were given by

\[
D_{jk} = B_{ik} * N_{jk}
\]
where \( N_{jk} \) was the total number of deaths from cause \( k \) in age group \( j \) for country \( X \).

NOTE that \( D_{jk} \) is calculated for seven age groups \( j \) using values of \( B_{ik} \) calculated for five age groups \( i \) as follows:

\[
\begin{align*}
\text{for age } j=1 \text{ to } 5 & \quad \text{used } B_{1k} \\
\text{for age } j=6 & \quad \text{used } B_{2k} \\
\text{for age } j=7 & \quad \text{used } B_{3k}
\end{align*}
\]

11) If total smoking attributed deaths were negative for any given age group, then values were reset to zero in this and all higher age groups.

12) Attributed number of deaths was rounded off to nearest whole number.

13) Attributable rates were calculated by dividing this number by the corresponding population and multiply by 100,000.

14) Mean of smoking-attributable mortality rates of all causes for all seven age groups of each social stratum were calculated separately.

15) Standardized smoking attributable mortality rates, for ages 35-69 years, were calculated by averaging the age-specific death rates for the seven 5-year age groups within this 35-year age range. This was achieved by multiplying mean rates by seven and dividing by 100 to obtain rates per 1000.

16) Calculation of probability of a 35-year-old man dying at ages 35–69 years

\[
\text{Risk of dying at ages } 35-69 \text{ years} = 1 - \exp(-35R/1000)
\]

\( R = \) average annual death rate per 1000, in age range of 35–69 years
Table 5: Male relative risk of causes of deaths attributable to smoking (from CPSII)

<table>
<thead>
<tr>
<th>ICD (9)</th>
<th>ICD (10)</th>
<th>Name of category</th>
<th>Relative risk for males</th>
</tr>
</thead>
<tbody>
<tr>
<td>162</td>
<td>C33, C34</td>
<td>Lung cancer</td>
<td>24.22</td>
</tr>
<tr>
<td>140-150, 161</td>
<td>C00-C15, C32</td>
<td>Upper aero-digestive cancer</td>
<td>7.87</td>
</tr>
<tr>
<td>Rest of 140-209</td>
<td>Rest of C00-C97</td>
<td>Other cancer</td>
<td>1.69</td>
</tr>
<tr>
<td>490-2, 492-6</td>
<td>J40-J47, J67</td>
<td>Chronic obstructive pulmonary disease</td>
<td>13.82</td>
</tr>
<tr>
<td>390-459, Rest of 001-799, Rest of 460-519</td>
<td>I00-I99, Rest of A00-R99, Rest of J00-J98</td>
<td>All vascular, Other medical and Other respiratory</td>
<td>3.05, 2.31, 2.09</td>
</tr>
</tbody>
</table>
3.6 Ethics approval

For conducting this research project, research ethics approval was obtained from St. Michael’s Hospital (REB # 10-186, 06/30/2010) and administrative approval was obtained from University of Toronto (ORE # 26169, 2/17/2011).

3.7 Confidentiality of data

This thesis involved analysis of secondary data from databases of Canada, France, Poland, and Switzerland with no personal identifiers. No individual subjects were needed for the study. Data analyzed were totally anonymized and were received electronically. Data were stored in shared H drive of St. Michael’s hospital. Laptops at the hospital are encrypted, so the confidentiality was well protected.
4 RESULTS

A total of 377,878 deaths, at ages 35-69 years, were analyzed from a total population of 13,482,210 males of Canada, France, Poland, and Switzerland. Absolute number of deaths and respective rates attributable to smoking in three social strata of four countries are presented first. Trends in these rates over the comparative time periods of these countries are presented in the second section. The third section shows changes in proportion of all-cause mortality attributable to smoking. The fourth section presents absolute and relative differences in all-cause and smoking-attributable rates between the highest and the lowest stratum and finally trends in the risk of dying of a 35 yr old man within next 35 years due to smoking or any cause are detailed.

4.1 Socially stratified smoking-attributable male mortality rates

Smoking-attributable mortality rates were calculated for three social strata each, of Canada, France, Poland, and Switzerland. Table 6, gives detailed breakdown of absolute death counts attributable to smoking (which are affected by the size of the population analyzed) as well as rates of smoking-attributable mortality (which are not), in different time periods in four countries. Confidence intervals (at 95%) of these rates were calculated to observe whether these socially stratified rates were significantly different from each other for any time period. In all countries, for any time period, lowest social stratum had significantly higher mortality rates as compared to the highest social stratum. Lowest social stratum of Poland, in particular, was observed to be the most disadvantaged as the rates were not only significantly higher than their more educated
counter parts, for both the years, but were the highest (in absolute terms) compared to lowest social strata of other countries observed, at any time period.
Table 6: Trends in male mortality attributed to tobacco in various social strata, for ages 35-69 years (Rate = rate per 1000, standardized for age). Social stratification is based on neighborhood income quintile in Canada and by education in all other countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Low*</th>
<th>Middle*</th>
<th>High*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Number</td>
<td>Rate (CI)</td>
<td>Number</td>
</tr>
<tr>
<td>Canada</td>
<td>1986</td>
<td>3269</td>
<td>6.14 (3.71-8.57)</td>
<td>5482</td>
</tr>
<tr>
<td></td>
<td>1991</td>
<td>3158</td>
<td>5.32 (3.26-7.38)</td>
<td>5530</td>
</tr>
<tr>
<td></td>
<td>1996</td>
<td>2890</td>
<td>4.25 (2.53-5.98)</td>
<td>5136</td>
</tr>
<tr>
<td></td>
<td>2001</td>
<td>2716</td>
<td>3.49 (2.04-4.93)</td>
<td>4422</td>
</tr>
<tr>
<td>France</td>
<td>1990-96</td>
<td>1164</td>
<td>3.94 (2.77-5.03)</td>
<td>837</td>
</tr>
<tr>
<td></td>
<td>1997-99</td>
<td>435</td>
<td>3.91 (2.81-5.02)</td>
<td>402</td>
</tr>
<tr>
<td>Poland</td>
<td>1995</td>
<td>45892</td>
<td>9.09 (5.57-12.61)</td>
<td>6950</td>
</tr>
<tr>
<td></td>
<td>2002</td>
<td>36325</td>
<td>7.93 (4.94-10.92)</td>
<td>6514</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1991-94</td>
<td>5244</td>
<td>3.76 (2.20-5.31)</td>
<td>7000</td>
</tr>
<tr>
<td></td>
<td>1995-97</td>
<td>2983</td>
<td>3.11 (1.97-4.25)</td>
<td>5777</td>
</tr>
<tr>
<td></td>
<td>1998-00</td>
<td>2793</td>
<td>3.08 (1.88-4.28)</td>
<td>4345</td>
</tr>
</tbody>
</table>

* Check Table 2 for country wise classification of social strata low, middle and high, 1 - significant differences between low and high, 2 - significant differences between low and middle, and 3 - significant differences between middle and high.
Figure 1: Trends in male mortality attributed to tobacco in the lowest and the highest social strata, for ages 35-69 years (Rate = rate per 1000, standardized for age). Social stratification is based on neighborhood income quintile in Canada and by education in all other countries.
4.2 Trends in socially stratified mortality rates

Trends in all-cause and smoking-attributable mortality rates were observed between the time periods for which, data were obtained. Weighted regression to observe the statistical significance of these changes was not performed. All-cause mortality rates reduced in absolute terms in all strata of the four countries analyzed. Absolute smoking-attributable mortality rates reduced in all social strata in Canada, Poland and Switzerland but not in France where rates remained almost stable. More reductions were observed in higher stratum as compared to lower ones. Tables 7-14 show, socially stratified all-cause, smoking-attributable and non-smoking-attributable mortality rates of four countries for all the time periods observed.

Canada

In Canada, data were obtained for years 1986, 1991, 1996 and 2001. Analyses included 85,967 deaths from four years, with 24,511 deaths in the lowest social stratum, 49,119 deaths in medium stratum, and 12,337 deaths in the highest social stratum. Table 7 shows all-cause, smoking-attributable and non-smoking-attributable mortality rates for four years. From 1986-2001, all-cause and smoking-attributable mortality rates dropped for all strata (Table 8); however, more reductions were observed for higher social stratum and for smoking-attributable rates.
Table 7: Annual death rates per 1000 men aged 35-69 years, attributed to smoking or not, stratified by neighborhood income quintile, in Canada

<table>
<thead>
<tr>
<th></th>
<th>Smoking-attributable mortality rate/1000</th>
<th>Non smoking-attributable mortality rate/1000</th>
<th>Total mortality rate/1000</th>
<th>All-cause deaths</th>
<th>Smoking-attributable deaths</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>6.14</td>
<td>8.19</td>
<td>14.33</td>
<td>6,534</td>
<td>2,800</td>
<td>532,395</td>
</tr>
<tr>
<td>Middle</td>
<td>3.29</td>
<td>6.19</td>
<td>9.48</td>
<td>12,297</td>
<td>4,277</td>
<td>1,666,370</td>
</tr>
<tr>
<td>High†</td>
<td>2.22</td>
<td>5.48</td>
<td>7.70</td>
<td>3,042</td>
<td>878</td>
<td>591,050</td>
</tr>
<tr>
<td>1991</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>5.32</td>
<td>7.34</td>
<td>12.66</td>
<td>6,309</td>
<td>2,651</td>
<td>593,665</td>
</tr>
<tr>
<td>Middle</td>
<td>2.84</td>
<td>5.50</td>
<td>8.34</td>
<td>12,565</td>
<td>4,289</td>
<td>1,947,145</td>
</tr>
<tr>
<td>High†</td>
<td>1.82</td>
<td>4.66</td>
<td>6.49</td>
<td>3,000</td>
<td>843</td>
<td>704,120</td>
</tr>
<tr>
<td>1996</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.25</td>
<td>7.07</td>
<td>11.32</td>
<td>6,057</td>
<td>2,274</td>
<td>679,915</td>
</tr>
<tr>
<td>Middle</td>
<td>2.35</td>
<td>5.20</td>
<td>7.55</td>
<td>12,387</td>
<td>3,861</td>
<td>2,185,735</td>
</tr>
<tr>
<td>High†</td>
<td>1.49</td>
<td>4.34</td>
<td>5.83</td>
<td>3,159</td>
<td>807</td>
<td>814,135</td>
</tr>
<tr>
<td>2001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>3.49</td>
<td>6.31</td>
<td>9.80</td>
<td>5,622</td>
<td>2,004</td>
<td>778,220</td>
</tr>
<tr>
<td>Middle</td>
<td>1.77</td>
<td>4.58</td>
<td>6.36</td>
<td>11,937</td>
<td>3,322</td>
<td>2,498,105</td>
</tr>
<tr>
<td>High†</td>
<td>1.08</td>
<td>3.83</td>
<td>4.91</td>
<td>3,160</td>
<td>703</td>
<td>928,960</td>
</tr>
</tbody>
</table>

٭ poorest income quintile, ◊ poorer + middle + richer income quintile, † richest income quintile
Figure 2: Trends in smoking-attributable mortality rates in three social strata of Canada

Table 8: Percentage reduction in mortality rates, from 1986 to 2001, in Canada

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-cause mortality</td>
<td>32%</td>
<td>33%</td>
<td>36%</td>
</tr>
<tr>
<td>Smoking-attributable</td>
<td>43%</td>
<td>39%</td>
<td>51%</td>
</tr>
</tbody>
</table>

*poorest income quintile, ◊ poorer + middle + richer income quintile, † richest income quintile
France

For France, data were obtained for two time periods 1990-1996 and 1997-1999. Analyses included 8,323 deaths over the ten year time period, with 5,193 deaths in the lowest social stratum, 2,659 deaths in the medium social stratum, and 471 deaths in the highest social stratum. Table 9 shows all-cause, smoking-attributable and non-smoking-attributable mortality rates for the two time periods. Between the two time periods, all-cause mortality rates reduced considerably in the highest social stratum with some reductions in middle stratum but for smoking-attributable rates, no significant changes were observed (Table 10).

Table 9: Annual death rates per 1000 men, attributed to smoking or not, by education, in France

<table>
<thead>
<tr>
<th></th>
<th>Smoking-attributable mortality rate/1000</th>
<th>Non smoking-attributable mortality rate/1000</th>
<th>Total mortality rate/1000</th>
<th>All-cause deaths</th>
<th>Smoking-attributable deaths</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-96</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>3.94</td>
<td>7.73</td>
<td>11.67</td>
<td>3,804</td>
<td>1,284</td>
<td>295,428</td>
</tr>
<tr>
<td>Middle</td>
<td>2.72</td>
<td>5.67</td>
<td>8.39</td>
<td>1,834</td>
<td>595</td>
<td>307,539</td>
</tr>
<tr>
<td>High†</td>
<td>0.99</td>
<td>4.47</td>
<td>5.46</td>
<td>341</td>
<td>62</td>
<td>91,683</td>
</tr>
<tr>
<td>1997-99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>3.91</td>
<td>7.58</td>
<td>11.49</td>
<td>1,389</td>
<td>473</td>
<td>111,133</td>
</tr>
<tr>
<td>Middle</td>
<td>2.61</td>
<td>4.89</td>
<td>7.50</td>
<td>825</td>
<td>287</td>
<td>154,008</td>
</tr>
<tr>
<td>High†</td>
<td>1.01</td>
<td>3.07</td>
<td>4.08</td>
<td>130</td>
<td>32</td>
<td>46,374</td>
</tr>
</tbody>
</table>

٭ primary education, ٭ lower secondary + higher secondary education, † tertiary education
Figure 3: Trends in smoking-attributable mortality in three social strata in France

![Bar chart showing trends in smoking-attributable mortality in three social strata in France.](chart.png)

Table 10: Percentage reduction in mortality rates, from 1990-96 to 1997-99, in France

<table>
<thead>
<tr>
<th></th>
<th>Low *</th>
<th>Middle ‡</th>
<th>High †</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-cause mortality rate</td>
<td>2%</td>
<td>11%</td>
<td>25%</td>
</tr>
<tr>
<td>Smoking-attributable mortality rate</td>
<td>1%</td>
<td>4%</td>
<td>-2%</td>
</tr>
</tbody>
</table>

*primary education, ‡lower secondary + higher secondary education, †tertiary education
Poland

For Poland, data were obtained for years 1995 and 2002. Analyses included 194,511 deaths in two years, with 154,846 deaths in the lowest social stratum, 29,720 deaths in medium social stratum, and 9,945 deaths in the highest social stratum. Table 11 shows all-cause, smoking-attributable and non-smoking-attributable mortality rates for two time periods. Between 1995 and 2002, all-cause and smoking-attributable mortality rates dropped for all strata but the reductions were more for higher stratum and for smoking-attributable rates (table 12).

Table 11: Annual death rates per 1000 men, attributed to smoking or not, by education, in Poland

<table>
<thead>
<tr>
<th></th>
<th>Smoking-attributable mortality rate/1000</th>
<th>Non smoking-attributable mortality rate/1000</th>
<th>Total mortality rate/1000</th>
<th>All-cause deaths</th>
<th>Smoking-attributable deaths</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>9.09</td>
<td>10.96</td>
<td>20.05</td>
<td>84,551</td>
<td>38,333</td>
<td>5,048,666</td>
</tr>
<tr>
<td>Middle</td>
<td>3.61</td>
<td>7.62</td>
<td>11.23</td>
<td>14,808</td>
<td>4,760</td>
<td>1,925,267</td>
</tr>
<tr>
<td>High</td>
<td>2.38</td>
<td>6.87</td>
<td>9.25</td>
<td>5,376</td>
<td>1,383</td>
<td>810,939</td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>7.93</td>
<td>10.01</td>
<td>18.03</td>
<td>70,295</td>
<td>30,917</td>
<td>4,580,762</td>
</tr>
<tr>
<td>Middle</td>
<td>3.18</td>
<td>6.86</td>
<td>10.04</td>
<td>14,912</td>
<td>4,723</td>
<td>2,048,280</td>
</tr>
<tr>
<td>High</td>
<td>1.15</td>
<td>4.83</td>
<td>5.98</td>
<td>4,569</td>
<td>879</td>
<td>1,003,684</td>
</tr>
</tbody>
</table>

primary education +vocational training, * secondary education, † higher education
Figure 4: Trends in smoking-attributable mortality in three social strata of Poland

![Bar chart showing annual death rate per 1000 men by education level and year (1995 vs. 2002).]

Table 12: Percentage reduction in mortality rates, from 1995 to 2002, in Poland

<table>
<thead>
<tr>
<th></th>
<th>Low(^*)</th>
<th>Middle(^\circ)</th>
<th>High(^†)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-cause mortality rate</td>
<td>10%</td>
<td>11%</td>
<td>35%</td>
</tr>
<tr>
<td>Smoking-attributable</td>
<td>13%</td>
<td>12%</td>
<td>52%</td>
</tr>
<tr>
<td>mortality rate</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^*\) primary education +vocational training, \(^\circ\) secondary education, \(^†\) higher education
Switzerland

For Switzerland, data were obtained for time periods 1991-1994, 1995-1997, and 1998-2000. Analyses included 89,077 deaths in three time periods, with 28,649 deaths in the lowest social stratum, 44,941 deaths in middle social stratum, and 15,487 deaths in the highest social stratum. Table 13 shows all-cause, smoking-attributable and non-smoking-attributable mortality rates for three time periods. From 1991-94 to 1998-2000, all-cause and smoking-attributable mortality rates dropped for all strata but the reductions were more for higher stratum and for smoking-attributable rates (table 14).

Table 13: Annual death rates per 1000 men, attributed to smoking or not, by education, in Switzerland

<table>
<thead>
<tr>
<th></th>
<th>Smoking-attributable mortality rate/1000</th>
<th>Non smoking-attributable mortality rate/1000</th>
<th>Total mortality rate/1000</th>
<th>All-cause deaths</th>
<th>Smoking-attributable deaths</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991-94</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>3.76</td>
<td>6.40</td>
<td>10.16</td>
<td>13,158</td>
<td>4,869</td>
<td>1,394,770</td>
</tr>
<tr>
<td>Middle</td>
<td>2.54</td>
<td>5.91</td>
<td>8.45</td>
<td>18,099</td>
<td>5,440</td>
<td>2,755,872</td>
</tr>
<tr>
<td>High†</td>
<td>1.21</td>
<td>5.04</td>
<td>6.25</td>
<td>6,194</td>
<td>1,199</td>
<td>1,415,100</td>
</tr>
<tr>
<td>1995-97</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>3.11</td>
<td>6.40</td>
<td>9.51</td>
<td>8,198</td>
<td>2,681</td>
<td>959,091</td>
</tr>
<tr>
<td>Middle</td>
<td>2.69</td>
<td>5.18</td>
<td>7.87</td>
<td>13,580</td>
<td>4,642</td>
<td>2,147,573</td>
</tr>
<tr>
<td>High†</td>
<td>0.93</td>
<td>4.77</td>
<td>5.70</td>
<td>4,687</td>
<td>765</td>
<td>1,126,584</td>
</tr>
<tr>
<td>1998-00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>3.08</td>
<td>6.04</td>
<td>9.12</td>
<td>7,293</td>
<td>2,463</td>
<td>906,748</td>
</tr>
<tr>
<td>Middle</td>
<td>1.97</td>
<td>5.34</td>
<td>7.31</td>
<td>13,262</td>
<td>3,574</td>
<td>2,205,704</td>
</tr>
<tr>
<td>High†</td>
<td>0.87</td>
<td>4.33</td>
<td>5.20</td>
<td>4,606</td>
<td>771</td>
<td>1,158,064</td>
</tr>
</tbody>
</table>

*compulsory schooling, †vocational training, †tertiary education +university education
Figure 5: Trends in smoking-attributable mortality in three social strata in France

Table 14: Percentage reduction in mortality rates, from 1991-94 to 1998-00, in Switzerland

<table>
<thead>
<tr>
<th></th>
<th>Low ¹</th>
<th>Middle ²</th>
<th>High ³</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-cause mortality rate</td>
<td>10%</td>
<td>13%</td>
<td>17%</td>
</tr>
<tr>
<td>Smoking-attributable</td>
<td>18%</td>
<td>22%</td>
<td>28%</td>
</tr>
<tr>
<td>mortality rate</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ compulsory schooling, ² vocational training, ³ tertiary education + university education
4.3 Proportion of all-cause male mortality attributed to smoking

The proportion of total mortality attributed to smoking was substantially greater in the lowest social stratum than in the highest social stratum. Indeed, in the lowest social stratum in each country, at any time period, smoking-attributed mortality accounted for about 40% of total male mortality in the middle age (with the proportions ranging from 33% [3.11/9.51] in Switzerland in 1995-97 to 45% [9.09/20.05] in Poland in 1995). In the highest social stratum, proportion of smoking-attributable mortality accounted for about 22% of total mortality (with the proportions ranging from 16% [0.93/5.70] in Switzerland in 1995-97 to 29% [2.22/7.70] in Canada in 1986).
Canada

In fifteen year time period proportion of all-cause mortality attributed to smoking reduced in all social strata with maximum declines in higher social stratum, followed by lower and middle strata, respectively. Table 15 shows the smoking-attributable mortality proportions of three strata in four years.

Table 15: Proportion of all-cause mortality attributed to smoking in low, middle and high social strata, by neighborhood income quintile, in Canada

<table>
<thead>
<tr>
<th>Year</th>
<th>Low</th>
<th>Middle◊</th>
<th>High†</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>43%</td>
<td>31%</td>
<td>29%</td>
</tr>
<tr>
<td>1991</td>
<td>42%</td>
<td>34%</td>
<td>28%</td>
</tr>
<tr>
<td>1996</td>
<td>38%</td>
<td>31%</td>
<td>26%</td>
</tr>
<tr>
<td>2001</td>
<td>36%</td>
<td>28%</td>
<td>22%</td>
</tr>
</tbody>
</table>

Low – poorest income quintile, Middle – poorer + middle + richer income quintile, High – richest income quintile

Figure 6: Trends in proportion of all-cause mortality attributed to smoking in low, middle and high social strata, by neighborhood income quintile, in Canada
France

In ten year time period, proportion of all-cause mortality attributed to smoking did not change in lower social stratum rather increased in higher and middle social strata. The reason behind this increase was reduction in overall mortality rates in higher social strata but no change in smoking attributable rates, thereby increasing the burden of such deaths. Table 16 shows the smoking-attributable mortality proportions of three strata in time periods.

Table 16: Proportion of all-cause mortality attributed to smoking in low, middle and high social strata, by education, France

<table>
<thead>
<tr>
<th></th>
<th>Low (^\dagger)</th>
<th>Middle (^\ddagger)</th>
<th>High (^\ddagger)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-96</td>
<td>34%</td>
<td>32%</td>
<td>18%</td>
</tr>
<tr>
<td>1997-99</td>
<td>34%</td>
<td>35%</td>
<td>25%</td>
</tr>
</tbody>
</table>

\(^\dagger\) primary education, \(^\ddagger\) lower secondary + higher secondary education, \(^\ddagger\) tertiary education

Figure 7: Trends in proportion of all-cause mortality attributed to smoking in low, middle and high social strata, by education, France
Poland

In the seven year time period, proportion of all-cause mortality attributed to smoking reduced in higher social stratum with a slight reduction in lower stratum and no change in middle stratum because in higher stratum smoking-attributable rates reduced more compared to all-cause mortality rates but for lower stratum almost similar reductions were observed for all-cause and smoking-attributable rates. Table 17 shows the smoking-attributable mortality proportions of three strata in two years.

Table 17: Proportion of all-cause mortality attributed to smoking in low, middle and high social strata, by education, in Poland

<table>
<thead>
<tr>
<th></th>
<th>Low*</th>
<th>Middle◊</th>
<th>High†</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>45%</td>
<td>32%</td>
<td>26%</td>
</tr>
<tr>
<td>2002</td>
<td>44%</td>
<td>32%</td>
<td>19%</td>
</tr>
</tbody>
</table>

* primary education + vocational training, ◊ secondary education, † higher education

Figure 8: Trends in proportion of all-cause mortality attributed to smoking in low, middle and high social strata, by education, in Poland
Switzerland

In ten year time period proportion of all-cause mortality attributed to smoking reduced in all strata as more reductions were observed for smoking-attributable rates compared to all-cause rates. Table 18 shows the smoking-attributable mortality proportions of three strata in three time periods.

Table 18: Proportion of all-cause mortality attributed to smoking in low, middle and high social strata, by education, in Switzerland

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991- 94</td>
<td>37%</td>
<td>30%</td>
<td>19%</td>
</tr>
<tr>
<td>1995- 97</td>
<td>33%</td>
<td>34%</td>
<td>16%</td>
</tr>
<tr>
<td>1998- 00</td>
<td>34%</td>
<td>27%</td>
<td>17%</td>
</tr>
</tbody>
</table>

٭ compulsory schooling, ◊ vocational training, † tertiary education + university education

Figure 9: Trends in proportion of all-cause mortality attributed to smoking in low, middle and high social strata, by education, in Switzerland
4.4 Rate ratios and rate differences

From the perspective of absolute differences, for all-cause mortality, rate differences between the lowest and the highest social stratum decreased in Canada by 26% (6.64 to 4.89), increased in France by 19% (6.31 to 7.41) and in Poland by 12% (10.80 to 12.05), and almost remained the same in Switzerland. For smoking-attributable mortality, rate differences decreased in Canada by 39% (3.92 to 2.40) and in Switzerland by 13% (2.55 to 2.21) and almost remained the same for France and Poland.

In terms of relative differences, for all-cause mortality, rate ratios between the lowest and highest social stratum increased in all countries over the comparative time periods. It increased from 1.86 to 2.00 (8%) in Canada, 2.14 to 2.82 (32%) in France, 2.17 to 3.02 (39%) in Poland and 1.63 to 1.75 (7%) in Switzerland. For smoking-attributable mortality as well, rate ratios increased for all countries except France. Rate ratios increased from 2.77 to 3.20 (16%) in Canada, 3.82 to 6.90 (81%) in Poland, and 3.11 to 3.54 (14%) in Switzerland.
Canada

From 1986 to 2001, absolute differences, between the highest and the lowest stratum, reduced for all-cause as well as smoking-attributable mortality rates. Social inequalities in smoking-attributable rates reduced more than all-cause, resulting in reduction of proportion of total difference attributed to smoking, by 10%, over this time period. However, rate ratios for both all-cause as well as smoking-attributable, between the lowest and the highest, slightly increased over the fifteen years. Table 19 shows the rate ratios and rate differences for the four years analyzed.

Table 19: Rate ratio and rate difference between the lowest and the highest social strata for all cause, smoking-attributable, and nonsmoking-attributable mortality rates, in Canada

<table>
<thead>
<tr>
<th>Year</th>
<th>SAMR (Low* / High†)</th>
<th>Rate difference (Low* – High†)</th>
<th>Proportion of all-cause rate difference attributed to smoking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>2.77</td>
<td>3.92</td>
<td>59%</td>
</tr>
<tr>
<td></td>
<td>1.50</td>
<td>2.72</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.86</td>
<td>6.64</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>2.92</td>
<td>3.50</td>
<td>57%</td>
</tr>
<tr>
<td></td>
<td>1.58</td>
<td>2.68</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.95</td>
<td>6.18</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>2.85</td>
<td>2.76</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>1.63</td>
<td>2.73</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.94</td>
<td>5.49</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>3.20</td>
<td>2.40</td>
<td>49%</td>
</tr>
<tr>
<td></td>
<td>1.65</td>
<td>2.49</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.00</td>
<td>4.89</td>
<td></td>
</tr>
</tbody>
</table>

* poorest income quintile, † richest income quintile, ‡ smoking-attributable mortality rate, ^ non smoking-attributable mortality rate
Figure 10: Rate ratio and rate difference between the lowest and the highest social strata for smoking-attributable mortality rates, in Canada
France

In the observed time period, absolute differences, between the highest and the lowest stratum, increased for all-cause mortality but not for smoking-attributable mortality rates. This resulted in reduction of proportion of total difference attributed to smoking, by 9%, over this time period. Rate ratios also increased for all cause mortality but almost remained same for smoking-attributable rates. Table 20 shows the rate ratios and rate differences for the two time periods analyzed.

**Table 20: Rate ratio and rate difference between the lowest and the highest social strata for all cause, smoking-attributable and nonsmoking-attributable mortality rates, in France**

<table>
<thead>
<tr>
<th></th>
<th>Rate ratio (Lowprimary education / Hightertiary education)</th>
<th>Rate difference (Lowprimary education – Hightertiary education)</th>
<th>Proportion of all-cause rate difference attributed to smoking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMR‡</td>
<td>3.98</td>
<td>2.95</td>
<td>48%</td>
</tr>
<tr>
<td>NSAMR‡</td>
<td>1.73</td>
<td>3.26</td>
<td></td>
</tr>
<tr>
<td>All-cause mortality rate</td>
<td>2.14</td>
<td>6.21</td>
<td></td>
</tr>
<tr>
<td>1997-99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMR</td>
<td>3.87</td>
<td>2.90</td>
<td>39%</td>
</tr>
<tr>
<td>NSAMR</td>
<td>2.47</td>
<td>4.51</td>
<td></td>
</tr>
<tr>
<td>All-cause mortality rate</td>
<td>2.82</td>
<td>7.41</td>
<td></td>
</tr>
</tbody>
</table>

*primary education, †tertiary education, ‡smoking-attributable mortality rate, ^non smoking-attributable mortality rate
Figure 11: Rate ratio and rate difference between the lowest and the highest social strata for smoking-attributable mortality rates, in France
Poland

In Poland, in seven year time period, absolute differences, between the highest and the lowest stratum, increased for all-cause but not for smoking-attributable mortality rates. This resulted in reduction in proportion of all-cause mortality attributed to smoking, by 6%, over the comparative time period. Relatively, the social inequalities increased further for all-cause as well as smoking-attributable because the percentage reduction of rates was much more in highest stratum as compared to the lowest stratum. Table 21 shows the rate ratios and rate differences of the two years analyzed.

Table 21: Rate ratio and rate difference between the lowest and the highest social strata for all cause and smoking-attributable mortality rates, in Poland

<table>
<thead>
<tr>
<th>Year</th>
<th>Rate ratio (Low / High)</th>
<th>Rate difference (Low – High)</th>
<th>Proportion of all-cause rate difference attributed to smoking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMR</td>
<td>3.82</td>
<td>6.71</td>
<td>62%</td>
</tr>
<tr>
<td>NSAMR</td>
<td>1.60</td>
<td>4.09</td>
<td></td>
</tr>
<tr>
<td>All-cause mortality rate</td>
<td>2.17</td>
<td>10.80</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMR</td>
<td>6.90</td>
<td>6.78</td>
<td>56%</td>
</tr>
<tr>
<td>NSAMR</td>
<td>2.09</td>
<td>5.27</td>
<td></td>
</tr>
<tr>
<td>All-cause mortality rate</td>
<td>3.02</td>
<td>12.05</td>
<td></td>
</tr>
</tbody>
</table>

* primary education +vocational training, † higher education, ‡ smoking-attributable mortality rate, ^ non smoking-attributable mortality rate
Figure 12: Rate ratio and rate difference between the lowest and the highest social strata for smoking-attributable mortality rates, in Poland

3.82 Rate ratio

6.71 6.78 Rate difference

0 1 2 3 4 5 6 7
Rate ratios and rates differences between the lowest and the highest social strata

1995 2002
Years
Switzerland

In Switzerland, during the ten year time period, absolute differences, between the highest and the lowest stratum, decreased for smoking-attributable but almost remained the same for all-cause mortality rates. This resulted in reduction in proportion of all-cause mortality attributed to smoking, by 9%, over this time period. However, rate ratios for both all-cause as well as smoking-attributable, between the lowest and the highest, slightly increased over the ten year time period. Table 22 shows the rate ratios and rate differences of the time periods analyzed.

Table 22: Rate ratio and rate difference between the lowest and the highest social strata for all cause and smoking-attributable mortality rates, in Switzerland

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Rate ratio (Low / High)</th>
<th>Rate ratio difference (Low – High)</th>
<th>Proportion of all-cause rate difference attributed to smoking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991-94</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMR‡</td>
<td>3.11</td>
<td>2.55</td>
<td>65%</td>
</tr>
<tr>
<td>NSAMR</td>
<td>1.27</td>
<td>1.36</td>
<td></td>
</tr>
<tr>
<td>All-cause mortality rate</td>
<td>1.63</td>
<td>3.91</td>
<td></td>
</tr>
<tr>
<td>1995-97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMR‡</td>
<td>3.34</td>
<td>2.18</td>
<td>57%</td>
</tr>
<tr>
<td>NSAMR</td>
<td>1.34</td>
<td>1.63</td>
<td></td>
</tr>
<tr>
<td>All-cause mortality rate</td>
<td>1.67</td>
<td>3.81</td>
<td></td>
</tr>
<tr>
<td>1998-00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMR‡</td>
<td>3.54</td>
<td>2.21</td>
<td>56%</td>
</tr>
<tr>
<td>NSAMR</td>
<td>1.39</td>
<td>1.71</td>
<td></td>
</tr>
<tr>
<td>All-cause mortality rate</td>
<td>1.75</td>
<td>3.92</td>
<td></td>
</tr>
</tbody>
</table>

* compulsory schooling, † tertiary education + university education, ‡ smoking-attributable mortality rate, ^ non smoking-attributable mortality rate
Figure 13: Rate ratio and rate difference between the lowest and the highest social strata for smoking-attributable mortality rates, in Switzerland
4.5 Risk of dying at ages 35-69 years

Probability of a 35 year old man dying within next 35 years due to smoking or any cause reduced in all strata in all four countries except France where risk of dying due to smoking remained constant. Figure 14-17 show these trends in respective countries.

**Canada:** Between 1986 and 2001, the probability of dying due to smoking significantly reduced in all strata. It reduced by 42% (19 to 11), 40% (10 to 6) and 43% (7 to 4) in low, middle and high strata, respectively. The proportion of risk of dying due to smoking also reduced in all strata. It reduced from 50% (19:39) to 40% (11:29) in the lowest stratum, 36% (10:28) to 30% (6:20) in the middle stratum, and 30% (7:24) to 25% (4:16) in the highest stratum. Social inequalities in male risk of deaths due to smoking reduced as well from 1986 to 2001. In 1986, the absolute difference in the risk of dying due to any cause between the lowest and the highest social strata was 15% and due to smoking was 12% (smoking accounted for 80% of the social inequalities in male risk of deaths). The absolute difference in risk of death reduced by 2001, as it was 13% due to any cause and 7% due to smoking (proportion of social inequalities in male risk of deaths due to smoking reduced to 54%).
Figure 14: Trends in risk of death attributed to smoking or any cause in various social strata
France: Between 1990-96 and 1997-99, overall risk of dying in France reduced, in all strata, but there was no change in risk of dying attributed to smoking. This resulted in increased proportion of smoking-attributable risk of dying. It increased from 36% (13:36 and 9:25) to 39% (13:33 and 9:23) in the lowest and the middle stratum, and from 18% (3:17) to 23% (3:13) in the highest stratum. Social inequalities in male risk of deaths due to smoking remained almost same between 1990-96 and 1997-99.

Figure 15: Trends in risk of death attributed to smoking or any cause in various social strata
Poland: Between 1995 and 2002, the probability of dying due to smoking although reduced in all strata but the reductions were much more significant for the highest stratum. It reduced by 11%, 8% and 50% in low, middle and high strata, respectively. The proportion of risk of dying due to smoking also reduced in all strata. It reduced from 54% (27:50) to 51% (24:47) in the lowest stratum, 38% (12:32) to 37% (11:30) in the middle stratum, and 29% (8:28) to 21% (4:19) in the highest stratum. Social inequalities in male risk of deaths due to smoking reduced as well from 1995 to 2002. In 1995, the absolute difference in the risk of dying due to any cause between the lowest and the highest social strata was 22% and due to smoking was 19% (smoking accounted for 86% of the social inequalities in male risk of deaths). Although the risk of dying due to any cause or smoking reduced from 1995 to 2002, the absolute difference in risk of death between the lowest and the highest social strata increased; 28% due to any cause and 20% due to smoking were reported. However, proportion of social inequalities in male risk of deaths due to smoking reduced to 71%.
Figure 16: Trends in risk of death attributed to smoking or any cause in various social strata.
Switzerland: Between 1991-94 and 1998-00, the probability of dying due to smoking significantly reduced in all strata. It reduced by 17%, 22%, and 25% in low, middle and high strata, respectively. The proportion of risk of dying due to smoking also reduced in all strata. It reduced from 40% (12:30) to 37% (10:27) in the lowest stratum, 35% (9:26) to 30% (7:23) in the middle stratum and 20% (4:20) to 18% (3:17) in the highest stratum. Social inequalities in male risk of deaths due to smoking reduced as well from 1991-94 to 1998-00. Between 1991-94, the absolute difference in the risk of dying due to any cause between the lowest and the highest social strata was 10% and due to smoking was 8% (smoking accounted for 80% of the social inequalities in male risk of deaths). Although the risk of dying due to any cause reduced from 1991-94 to 1998-00, the absolute difference between the lowest and the highest social strata remained constant at 10%. Difference in risk due to smoking reduced to 7% (proportion of social inequalities in male risk of deaths due to smoking reduced to 70%).
Figure 17: Trends in risk of death attributed to smoking or any cause in various social strata
5 DISCUSSION

Changes in socially stratified mortality rates, over the comparative time period, were calculated by calculating the percentage change. Social inequalities in mortality rates were assessed by using rate ratios and rate difference as the measure of inequality. Some of the key results are reported here followed by the limitations of the study, conclusions, implications and future directions.

5.1 Summary of key findings:

Analyses included 377,878 deaths, at ages 35-69 years, from a total population of 13,482,210 males of Canada, France, Poland, and Switzerland. Smoking-attributable male mortality rates, at any time, were around 3 to 7 times higher in the lowest social stratum compared to the highest social stratum in all countries.

Absolute smoking-attributable mortality rates reduced in all social strata in Canada, Poland and Switzerland except France where no changes were observed in any of the stratum. More reductions were observed in higher stratum as compared to the lower ones.

The largest reductions in smoking-attributable mortality rates in the lowest social stratum were observed in Canada (43% between 1986 and 2001) followed by Switzerland (18% between 1991-94 and 1998-00), and Poland (13% between 1995 and 2002). The largest reductions in smoking-attributable mortality rates in the highest social stratum were observed in Poland (52% between 1995 and 2002) followed by Canada (51% between 1986 and 2001), and Switzerland (28% between 1991-94 and 1998-00).
Proportion of all-cause mortality attributable to smoking reduced in all strata of Canada and Switzerland. In Poland, it only reduced in the highest social stratum and in France it remained almost stable; rather increased in the highest stratum.

Smoking-attributable mortality rate differences between the lowest and the highest social strata reduced in Canada and Switzerland and remained almost same in France and Poland. Proportion of all-cause mortality rate differences attributed to smoking reduced in all countries with maximum declines in Canada and France (17%) followed by Switzerland (13%), and Poland (10%). Smoking-attributable mortality rate ratios increased in Poland, Canada and Switzerland and remained almost stable in France.

Probability of a 35 year old man dying due to smoking, at ages 35-69 years, reduced in all strata of Canada, Poland and Switzerland but remained almost the same in France. Over half of the social inequalities in male risk of dying was due to smoking in any time period; results similar to another study done for the year 1996 for Canada, US, England and Wales and Poland (11). However, proportion of smoking in these social inequalities reduced over the comparative time periods.

Study designs for four countries were different; for France and Switzerland cohorts were analyzed and as for Canada and Poland, cross-sectional data were observed. Results of the study were robust as France cohort showed no reduction in absolute smoking attributable mortality rates although Swiss cohort having almost same mortality rates as France, showed declines.

After quantifying the inequalities, the question arises about their evaluation. How much change is important from public health perspective? Frameworks, such as the U.S. Department of Health and Human Services’ Healthy People 2010 (126) and the World
Health Organization’s *Commission on the Social Determinants of Health* (127), draw attention of governments and international organizations to create better social conditions of health by reducing health inequalities. However, they seldom specify precise numerical targets (128) for every outcome.

According to “Healthy people goals and objectives for 2010”, US department of Health and Social Security (DHSS) had set a target of reducing tobacco use to 12%, which was not achievable as the smoking prevalence was 20.6% in 2008 (129), therefore, for 2020 the same goal of 12% has been set again (130), which is aiming for 40% reduction in smoking prevalence in 13 year time period. Reduction observed in smoking-attributable mortality rates in these four countries can be assessed on the same parameters.

Statistical significance of the observed trends in smoking-attributable mortality rates were not assessed using any method like weighted regression analysis, as the motive was not to look at the statistically significant change over the comparative time periods. However, comparison with goals of DHSS reflected the importance of change from public health perspective.

**Canada:** In Canada, the absolute number and rates of male deaths attributable to smoking declined over the fifteen year time period (from 1986 to 2001), the largest time period studied among all countries. Even if data are observed for ten year time period (1991-2001) for which data are available for most of the other countries as well; significant reductions were observed for all strata (40%, 37%, and 34% for the highest, middle and the lowest income quintile, respectively). In terms of healthy people goals and objectives, smoking attributable mortality rates have significantly dropped for all
social strata in Canada. Social inequalities in smoking-attributable mortality rates reduced consistently for every time point at intervals of five years. Canada is recognized for taking an early and continual initiative in international leadership role in combating smoking by implementing policies to control marketing, labeling, and sales of tobacco products (131). Smoking rates among Canadians reduced from 1960s to early 1990s (131); however, the momentum of reduction in smoking rates have stalled since then, might be because of tobacco taxes, which reduced from 1994 to early 2000s (to combat contraband cigarettes) resulting in increased smoking prevalence among youths (132). Smoking-attributable mortality rates in recent years will be of interest to confirm the trends.

For Canada, analyses relied on neighborhood income as a measure of social stratification, which is assessed from the postal address of the deceased noted on death certificate, the address where the person lived at the time of death, which might be different from the address where that person has spent the rest of the life. Urquia et al suggest that neighborhood based measure, usually, but not always produces attenuated effect estimates (133). Studies done in the past using neighborhood rather than individual income as an indicator for all-cause mortality concluded disparities in mortality rates between socio economic groups to be quite reasonable although bit conservative (18).

**France:** Although smoking-attributable mortality rates were quite comparable to other countries in 1990s but they remained stable for all social strata in ten year time period of 1990-1999, resulting in no change in social inequalities in these rates. Tobacco prices in France have been continuously increasing since 1992 (134). Between 2003 and 2004,
cigarette prices increased approximately by 40%, in three increments (135). Cigarette consumption has reduced from 5.5 per adult per day in 1992 to 3 per adult per day in 2005 (134). On February 1, 2007, workplaces and educational and healthcare facilities became smoke-free and on January 1, 2008, bars, nightclubs, restaurants and cafes became smoke-free (135). Further reductions in smoking prevalence were reported after 2008, when bans on public smoking appeared (134).

Effect of tobacco control initiatives started showing up around 1997 when lung cancer deaths for males ages 35-44 years started declining and reduced 50% (4.4 to 2.2 per 100,000) by 2006 (65). Smoking-attributable mortality rates of recent years will be of interest to observe the trends.

**Poland:** In Poland, smoking-attributable rates for higher and middle social strata were similar to other countries analyzed but the rates for poor social stratum were quite higher for both the years observed. From 1995 to 2002, absolute number of deaths attributable to smoking as well as their rates reduced for all strata (52%, 12%, and 13% in the highest, middle and the lowest educational strata, respectively) but social inequalities in smoking-attributable mortality rates did not reduce, as more reductions were observed in the highest stratum, which particularly performed much better in terms of healthy people goals and objectives.

In the 1980s, Poland had the highest rate of smoking in the world. Nearly three-quarters of Polish men aged 20 to 60 smoked every day. In 1995, the Polish parliament passed groundbreaking tobacco-control legislation, which included: the requirement of the largest health warnings on cigarette packs in the world; a ban on smoking in health
centers and enclosed workspaces; a ban on electronic media advertisement; and a ban on tobacco sales to minors (136).

Smoking-attributable mortality rates of recent years in Poland would be of interest to assess the effects of tobacco control policies implemented in 1995.

**Switzerland:** Smoking-attributable mortality rates were lower in time period of 1990-94 as compared to other observed countries in early 1990s and reduced further over the ten year time period. Reductions were observed for all strata (28%, 22%, and 18% for the highest, middle and the lowest educational strata, respectively). Social inequalities in smoking-attributable mortality rates reduced from 1991-94 to 1998-00. In Switzerland, a comprehensive tobacco prevention program exists, but nationwide implementation of anti-smoking policies is not possible, as this is the responsibility of the cantons. Hence, differences regarding anti-smoking legislation exist between cantons. Initiatives are taken to assess opinions regarding different smoking policies in representative samples of Swiss adult population (137). Policies implemented at federal level might reduce smoking prevalence rate and smoking-attributable mortality rates further in future.
5.2 Limitations

This was a descriptive study with an intention to identify trends in the mortality rates attributed to smoking among different social strata in developed countries.

Risk ratios of smoking-attributable diseases were considered same across all social strata; although, there are many factors other than smoking that differ between different social strata in these countries, perhaps involving both the causes, and the diagnosis and treatment of some of the chronic diseases of middle age (138). As smoking interacts with other risk factors (102), the hazard for the individual smoker must also be expected to be different across various social strata. Michael Thun determined whether controlling for other risk factors like education, occupation, race, alcohol consumption, and various dietary factors, in addition to age and sex, substantially alters the relative and attributable risk estimates associated with tobacco smoking (17). Multivariate adjustments decreased the smoking-attributable deaths in the US by just 1% per year.

Methods of estimation used were indirect; however, the inherent uncertainties affect all social strata similarly, and therefore should not significantly affect the trends found in these results.

Direct comparisons among countries could not be made due to differences in the comparative time periods and social stratification systems; however, social stratification remained consistent within countries and therefore the objective of observing trends in social inequalities within countries was met successfully.

Method used in the calculation of population-attributable fractions included current smokers and non-smokers and did not include past smokers as the intention was not to over-estimate smoking-attributable proportions of smokers.
In France, Poland, and Switzerland education status (an individual measure) was considered as the indicator of social status but for Canada, analyses relied on a neighborhood based measure and not on individual or family income. The use of neighborhood level information, instead of family or individual, and applying to individuals, forces consideration of the ecological fallacy. However, past studies have argued for the validity of using income quintiles as a proxy for individual socioeconomic status (18, 139).

For Canada, data were obtained from metropolitan areas, which constitute 60% of Canadian population. For France, data were obtained from a permanent demographic random sample, which constitute 1% of French population. Although, data analyzed for France were smaller in numbers as compared to other countries but it is the true representation of France.

This analysis was restricted to males as relative risks estimates used for this analysis were from CPS II study, which was conducted in 1980’s, when smoking epidemic for males was at its peak but for females was still on rise. Probability of calculating conservative estimates of female smoking-attributable mortality rates using relative risks of CPS II is high, which might not reflect their actual burden of smoking.

### 5.2.1 Assumptions

In the absence of nationally representative studies of socially stratified smoking and mortality rates, CPS II study was considered as reference population with the following assumptions.
- Diagnostic standards of lung cancer and other diseases are comparable in the United States and all the target countries.
- Non-smoker lung cancer rates of any population at any given time would be same as CPS II study population.
- All of the excess of lung cancer seen in smokers was due to their smoking and not due to any environmental or any occupational exposures.

5.2.2 Bias

Analyses of this study can be subjected to measurement bias, because in an attempt of not overestimating the smoking epidemic, excess risk was halved for all the diseases except lung cancer mortality. This modification does not have any formal theoretical justification and is admitted by the authors to be “crude and arbitrary”(12). This modification substantially lowers the excess risk when the proportions of smokers are less but do not affect the estimates when the proportions are higher (12). For United Stated, in 1985, this method gave similar results as US Surgeon-General did, using a different method (by utilizing not only national mortality rates but prevalence of smoking as well) (12).
5.3 Strengths

Prevalence of smoking in the study population was estimated indirectly rather than considering prevalence rates from various health surveys. The prevalence (49) and the intensity (140) of smoking is generally more in lower than in higher social strata; however, concern arises about the reliability of these estimates, which depend on survey methods used in determining true rates of smoking in communities (66) and sample selection of population (67). The method used in this study calculates prevalence of smoking indirectly from lung cancer death rates of the population studied (used as an indicator of the population’s cumulative smoking exposure), which may in fact be a more reliable index of the damage from smoking than directly measured self reported smoking behavior. This indirect method substitutes observed current exposure prevalence estimates with prevalence that is considered necessary for causing the current lung cancer mortality burden (141). This prevalence, which is considered necessary for causing death due to lung cancer, is actually of any tobacco exposure which has been considered sufficient to cause existing lung cancer deaths. This exposure includes past smokers, second-hand smoke or smoke from pipes or cigars. Any such exposure, which was not considered sufficient enough to result in effect, has been considered as non-smoker. This indirect calculation escapes reporting bias of different tobacco exposures as well. For most smoking-related outcomes, the current burden of disease is largely influenced by the past smoking exposure in the population (76, 77). The prevalence estimates calculated through this method avoids the potential error resulting from the lag time between population changes in smoking prevalence and the resulting change in disease outcome (141).
Above discussed limitations of the study are minor and are only subjected to attenuation bias, which means that the smoking-attributable mortality rates calculated in this study are not over estimated; especially for the lower strata, rather has given conservative estimates.

This work is quite relevant to research priorities identified by various tobacco control programs and organizations. This work filled the gap in knowledge about whether tobacco control has reached the men of poor or lower social strata in developed countries. This study will enable follow up research including quantification of effects of the specific tobacco control policies in each country on social inequalities. In addition, it also renews public health attention to disadvantaged populations. Finally, it enabled use of large scale population data, including mortality, to evaluate public policies.
5.4 Conclusions

This study was an endeavor to assess trends in social inequalities in smoking-attributable mortality rates in Canada, France, Poland, and Switzerland. An indirect method developed by Peto et al was used to assess smoking-attributable mortality rates of various social strata of these four countries. Mortality data were obtained from national death registries and the population counts were census based.

These results reveal that smoking-attributable mortality rates reduced over time not only among the rich but even among the poor in Canada, Poland and Switzerland; however, more reductions were observed in the highest stratum. Smoking-attributable rates remained almost constant in France over the comparative time period. Overall life expectancy, of a 35 year old man, increased in these countries as probability of dying due to smoking (except in France) or any cause, in ages 35-69 years, reduced. These results imply that although absolute social inequalities (rate differences) in smoking-attributable mortality rates reduced in Canada and Switzerland, which in itself is an achievement; however, relative social inequalities (rate ratios) further increased among countries analyzed. At any given time, smoking-attributable mortality rates were 3 to 7 times higher in the lowest social stratum compared to the highest social stratum. This prompts the need of a more comprehensive approach towards tobacco control.

This was the first known study, which assessed social inequalities in smoking-attributable male mortality, across countries, in recent time periods and looked at time trends of such social inequalities. This analysis directly answered that absolute social inequalities in smoking-attributable adult male mortality rates, aged 35-69 years, have reduced in recent years in the context of declines in smoking prevalence in these countries. Results
revealed that although higher social strata are benefited more but the poor are not left behind.

The four countries analyzed here revealed different trajectories of mortality rates attributed to smoking, which prompts the need to do such kind of analyses for more countries. This will help in quantifying inequalities in other developed nations and might help in identifying the needs of their most disadvantaged populations.
5.5 Future directions

These analyses predominantly included data of the last decade of the twentieth century.
In context of implementation of different tobacco control policies, in the countries analyzed, in the past two decades, assessment of smoking-attributable rates of recent years would be of interest.
In this study, relative risks of different diseases were considered from the CPSII study, as a reference population, which was conducted in 1980’s. Analyses of same countries using relative risk ratio from a recent study like National Health Interview Survey, a nationally representative health survey, conducted in the United States (142) will be of interest to confirm the results.
As these analyses were restricted to only males of four developed countries, further analyses for more countries and for females will be of interest.
13. Prez-Ros M, Montes A. Methodologies used to estimate tobacco-attributable mortality: a review. BMC public health. 2008;8:22-.
86. Levy R, Marimont R. Lies, damned lies, & 400,000 smoking-related deaths. 1998;21(24-29).


139. Roos NP, Mustard CA. Variation in health and health care use by socioeconomic status in Winnipeg, Canada: does the system work well? Yes and no. Milbank Q. 1997;75(1):89-111.
## APPENDICES

Appendix I: Template for mortality data and population count

<table>
<thead>
<tr>
<th>Male Mortality By Cause</th>
<th>9th ICD</th>
<th>10th ICD</th>
<th>Educational Status</th>
<th>Age group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35-39</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40-44</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>45-49</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50-54</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>55-59</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60-64</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>65-69</td>
</tr>
<tr>
<td>ALL CAUSES</td>
<td>001-999</td>
<td>A00-Y89</td>
<td>Higher Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational Primary</td>
<td></td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>010-018, 137</td>
<td>A15-A19,B90</td>
<td>Higher Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational Primary</td>
<td></td>
</tr>
<tr>
<td>HIV</td>
<td>279.5, 279.6</td>
<td>B20-B24</td>
<td>Higher Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational Primary</td>
<td></td>
</tr>
<tr>
<td>Other infective and</td>
<td>Rest of 001-</td>
<td>Rest of A00-</td>
<td>Higher Secondary</td>
<td></td>
</tr>
<tr>
<td>parasitic</td>
<td>139</td>
<td>B99 excl. A33, A34</td>
<td>Vocational Primary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALL CANCER</td>
<td>140-208</td>
<td>C00-C97</td>
<td>Higher Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational Primary</td>
<td></td>
</tr>
<tr>
<td>Mouth and Pharynx</td>
<td>140-149</td>
<td>C00-C14</td>
<td>Higher Secondary</td>
<td></td>
</tr>
<tr>
<td>cancer</td>
<td></td>
<td></td>
<td>Vocational Primary</td>
<td></td>
</tr>
<tr>
<td>Oesophagus Cancer</td>
<td>150</td>
<td>C15</td>
<td>Higher Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational Primary</td>
<td></td>
</tr>
<tr>
<td>Stomach Cancer</td>
<td>151</td>
<td>C16</td>
<td>Higher Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational Primary</td>
<td></td>
</tr>
<tr>
<td>Colorectal Cancer</td>
<td>153,154</td>
<td>C18-C21</td>
<td>Higher Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational Primary</td>
<td></td>
</tr>
<tr>
<td>Liver Cancer</td>
<td>155</td>
<td>C22 excl C221</td>
<td>Higher Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational Primary</td>
<td></td>
</tr>
<tr>
<td>Pancreas cancer</td>
<td>157</td>
<td>C25</td>
<td>Higher Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational Primary</td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>Code</td>
<td>Stage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>----------</td>
<td>--------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Larynx cancer</td>
<td>161 C32</td>
<td>Higher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lung Cancer</td>
<td>162 C33, C34</td>
<td>Higher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malignant Melanoma</td>
<td>172 C43</td>
<td>Higher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prostate Cancer</td>
<td>185 C61</td>
<td>Higher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bladder Cancer</td>
<td>188 C67</td>
<td>Higher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other and ill-defined cancer sites</td>
<td>Rest of 140-199</td>
<td>Rest of C00-C80,C97</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td>Hodgkins disease</td>
<td>201 C81</td>
<td>Higher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myeloma and non-hodgkin's lymphoma</td>
<td>200, 202-203 C82-C90, C96</td>
<td>Higher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leukaemia</td>
<td>204-208 C91-C95</td>
<td>Higher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>250 E10-E14</td>
<td>Higher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALL VASCULAR DISEASES</td>
<td>390-459 100-199</td>
<td>Higher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rheumatic Heart Disease and Fever</td>
<td>390-398 100-109</td>
<td>Higher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertensive disease</td>
<td>401-405 110-115</td>
<td>Higher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnosis</td>
<td>ICD-9 Codes</td>
<td>ICD-10 Codes</td>
<td>Class</td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-------------------</td>
<td>--------------------</td>
<td>--------------------</td>
<td></td>
</tr>
<tr>
<td>Ischaemic heart disease</td>
<td>410-414</td>
<td>120-125</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>Pulmonary embolism &amp; other venous diseases</td>
<td>415.1, 451-453</td>
<td>126, 180-182</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>430-438</td>
<td>160-169</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>Other Vascular disease</td>
<td>Rest of 390-459</td>
<td>Rest of 100-199</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>Chronic Obstructive pulmonary disease</td>
<td>490-496</td>
<td>J40-J47, J67</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>Other respiratory disease</td>
<td>Rest of 460-519</td>
<td>Rest of J00-J98</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>Peptic Ulcer</td>
<td>531-533</td>
<td>K25-K27</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>Liver Cirrhosis</td>
<td>571</td>
<td>K70, K74</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>Renal disease</td>
<td>580-590</td>
<td>N00-N19</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>Congenital and Perinatal disease</td>
<td>740-779</td>
<td>A33, P00-P96, Q00-Q99</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>Ill defined causes</td>
<td>780-799</td>
<td>R00-R99</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>Other Medical causes</td>
<td>Rest of 001-799</td>
<td>Rest of A00-R99</td>
<td>Higher</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vocational</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Code Range</td>
<td>Code Range Description</td>
<td>Higher Education Level</td>
<td>Secondar</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------------</td>
<td>-------------------------------</td>
<td>------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>ALL NON-MEDICAL CAUSES</td>
<td>E800- E999</td>
<td>V01-Y99</td>
<td>Higher</td>
<td>Secondary</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road Traffic Accidents</td>
<td>E810-E819,</td>
<td>part of V01-V99, Y850</td>
<td>Higher</td>
<td>Secondary</td>
</tr>
<tr>
<td></td>
<td>E826-E829</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire</td>
<td>E890- E899</td>
<td>X00-X09</td>
<td>Higher</td>
<td>Secondary</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suicide</td>
<td>E950- E959</td>
<td>X60-X84</td>
<td>Higher</td>
<td>Secondary</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homicide</td>
<td>E960- E969</td>
<td>X85-X99, Y00-Y09</td>
<td>Higher</td>
<td>Secondary</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POPULATION (1000s)</td>
<td></td>
<td></td>
<td>Higher</td>
<td>Secondary</td>
</tr>
</tbody>
</table>
Appendix II: SAS program for analysis of smoking-attributable mortality

Program for analysis

```sas
proc print data= COUNTRY;
run;

DATA LUNG; SET COUNTRY;
IF AGE = 1 THEN SMOKER = 2414.89806;
IF AGE = 1 THEN N_SMOKER = 144.19609;
IF AGE = 2 THEN SMOKER = 2414.89806;
IF AGE = 2 THEN N_SMOKER = 144.19609;
IF AGE = 3 THEN SMOKER = 2414.89806;
IF AGE = 3 THEN N_SMOKER = 144.19609;
IF AGE = 4 THEN SMOKER = 2414.89806;
IF AGE = 4 THEN N_SMOKER = 144.19609;
IF AGE = 5 THEN SMOKER = 2414.89806;
IF AGE = 5 THEN N_SMOKER = 144.19609;
IF AGE = 6 THEN SMOKER = 374.79;
IF AGE = 6 THEN N_SMOKER = 15.86276;
IF AGE = 7 THEN SMOKER = 599.01876;
IF AGE = 7 THEN N_SMOKER = 21.84877;
RUN;
PROC PRINT DATA = LUNG;
VAR AGE SES LUNG SMOKER N_SMOKER;
RUN;

DATA LUNG_1; SET LUNG;
F = (LUNG - N_SMOKER)/(SMOKER - N_SMOKER);
RUN;
proc print data = lung_1;
VAR AGE SES LUNG SMOKER N_SMOKER F;
run;

DATA LUNGS_1; SET LUNG_1;
RR = 23.21574;
CAUSE = 1;
E = F * RR;
B = E/(E + 1);
ATTR_NUMBER = LUNGCAN* B;
D = ROUND (ATTR_NUMBER);
ATTR_RATE = D/POPULATION *100000;
RUN;
PROC PRINT DATA = LUNGS_1;
VAR AGE SES LUNGCAN F RR E B ATTR_NUMBER D ATTR_RATE;
RUN;

DATA VASCULAR_1; SET LUNG_1;
IF AGE = 1 THEN RR = 2.04665;
IF AGE = 2 THEN RR = 2.04665;
IF AGE = 3 THEN RR = 2.04665;
IF AGE = 4 THEN RR = 2.04665;
IF AGE = 5 THEN RR = 2.04665;
IF AGE = 6 THEN RR = 1.30782;
IF AGE = 7 THEN RR = 1.09193;
```
CAUSE = 2;
E = F * RR;
B = E / (E + 2);
ATTR_NUMBER = VASCULAR * B;
D = ROUND (ATTR_NUMBER);
ATTR_RATE = D/POPULATION*100000;
RUN;
PROC PRINT DATA = VASCULAR_1;
VAR AGE SES VASCULAR RR E B ATTR_NUMBER D ATTR_RATE;
RUN;

DATA COPD_1; SET LUNG_1;
RR = 12.82058;
CAUSE = 3;
E = F * RR;
B = E / (E + 2);
ATTR_NUMBER = COPD_ * B;
D = ROUND (ATTR_NUMBER);
ATTR_RATE = D/POPULATION *100000;
RUN;
PROC PRINT DATA = COPD_1;
VAR AGE SES COPD_ RR E B ATTR_NUMBER D ATTR_RATE;
RUN;

DATA UAERO_1; SET LUNG_1;
RR = 6.87035;
CAUSE = 4;
E = F * RR;
B = E / (E + 2);
ATTR_NUMBER = U_AERO_CANCER_ * B;
D = ROUND (ATTR_NUMBER);
ATTR_RATE = D/POPULATION *100000;
RUN;
PROC PRINT DATA = UAERO_1;
VAR AGE SES U_AERO_CANCER_ RR E B ATTR_NUMBER D ATTR_RATE;
RUN;

DATA OCANCER_1; SET LUNG_1;
RR = 0.69104;
CAUSE = 5;
E = F * RR;
B = E / (E + 2);
ATTR_NUMBER = OTHER_CANCER_ * B;
D = ROUND (ATTR_NUMBER);
ATTR_RATE = D/POPULATION *100000;
RUN;
PROC PRINT DATA = OCANCER_1;
VAR AGE SES OTHER_CANCER_ RR E B ATTR_NUMBER D ATTR_RATE;
RUN;

DATA ORESPL_1; SET LUNG_1;
IF AGE = 1 THEN RR = 2.04665;
IF AGE = 2 THEN RR = 2.04665;
IF AGE = 3 THEN RR = 2.04665;
IF AGE = 4 THEN RR = 2.04665;
IF AGE = 5 THEN RR = 2.04665;
IF AGE = 6 THEN RR = 1.30782;
IF AGE = 7 THEN RR = 1.09193;
CAUSE = 6;
E = F * RR;
B = E/(E + 2);
ATTR_NUMBER = OTHER_RESPI_ * B;
D = ROUND (ATTR_NUMBER);
ATTR_RATE = D/POPULATION * 100000;
RUN;
PROC PRINT DATA = ORESPI_1;
VAR AGE SES OTHER_RESPI_ RR E B ATTR_NUMBER D ATTR_RATE;
RUN;
DATA OMEDICAL_1; SET LUNG_1;
IF AGE = 1 THEN RR = 2.04665;
IF AGE = 2 THEN RR = 2.04665;
IF AGE = 3 THEN RR = 2.04665;
IF AGE = 4 THEN RR = 2.04665;
IF AGE = 5 THEN RR = 2.04665;
IF AGE = 6 THEN RR = 1.30782;
IF AGE = 7 THEN RR = 1.09193;
CAUSE = 7;
E = F * RR;
B = E/(E + 2);
ATTR_NUMBER = OTHER_MEDICAL * B;
D = ROUND (ATTR_NUMBER);
ATTR_RATE = D/POPULATION * 100000;
RUN;
PROC PRINT DATA = OMEDICAL_1;
VAR AGE SES OTHER_MEDICAL RR E B ATTR_NUMBER D ATTR_RATE;
RUN;
DATA CUMULATIVE; SET LUNGS_1 VASCULAR_1 COPD_1 UAERO_1 OCANCER_1 ORESPI_1 OMEDICAL_1;
RUN;
PROC PRINT DATA = CUMULATIVE;
VAR SES AGE CAUSE ATTR_RATE;
RUN;
PROC SORT DATA = CUMULATIVE;
BY SES;
RUN;
PROC PRINT DATA = CUMULATIVE;
VAR SES AGE CAUSE ATTR_RATE;
RUN;
PROC MEANS DATA = CUMULATIVE mean clm alpha = 0.05;
VAR ATTR_RATE;
BY SES;
RUN;