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Chest 2004:126:1825-1831
DOI 10.1378/chest.126.6.1825

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Smoking Prevalence, Smoking-Related Lung Diseases, and National Tobacco Control Legislation*

Antero Heloma, MD, PhD; Markku Nurminen, PhD, DrPH; Kari Reijula, MD, PhD; and Jorma Rantanen, MD, PhD

Objectives: To review statistics on smoking prevalence and to analyze whether the implementation of national tobacco control legislation had an association with the prevalence of smoking, and thereby, with the occurrence of smoking-related lung diseases.

Design: Smoking prevalence rates (from 1960 to 2000), lung cancer incidence rates (from 1980 to 2000), and respiratory disease mortality rates (from 1980 to 1998) were obtained from Finnish national surveys and registers. Regression models with 20-year lag times for disease occurrence were applied in the statistical analysis.

Results: Daily smoking prevalence among men decreased continuously from 58 to 28% in the period from 1960 to 2000. Between 1965 and 1971, male lung cancer incidence was still on the increase, but from 1971 it decreased from 80 to 32 per 100,000 men. The male respiratory disease mortality rate declined steeply during the study period. From 1960 to 1973, women’s smoking prevalence increased from 12 to 20%. At the introduction of the tobacco control bill in 1975, the increase leveled off and female smoking prevalence slightly decreased, but then rose again after 1985 to remain at 20%. Lung cancer incidence among women increased throughout the study period, but the gradient of the curve lowered in the 1980s.

Conclusions: National legislative actions were found to be associated with a change in smoking prevalence among women from a linear rise to a plateau. The results of the present study showed a very strong association between reduced smoking prevalence and the occurrence of lung cancer.

Key words: lung cancer; smoking prevalence; tobacco control

A n increase in smoking-related diseases, particularly lung cancer, in the 1960s and 1970s, and the growing consumption of tobacco products encouraged the Finnish government to adopt legislative measures to reduce smoking among the population. The Act on Measures to Reduce Tobacco Smoking (later referred to as the Tobacco Act) was enacted in 1976, and the law was amended to include workplaces in 1994. The Tobacco Act comprised several tobacco control measures, as follows: it imposed a ban on tobacco advertising; it restricted smoking on public premises; it prohibited the selling of tobacco products to minors; it required health warnings in packages; and it allocated funds representing 0.5% of annual tobacco tax revenue for smoking prevention.

Smoking prevalence was still very high in Finland at the beginning of the 1960s, when approximately 60% of men and nearly 15% of women smoked. When the Tobacco Act came into force in 1977, 35% of men and 20% of women were smokers. From the situation of 1977, smoking decreased further. In 2001, 29% of men and 20% of women smoked daily. The current figures are among the lowest in Europe.

In Finland, smoking-attributed deaths have decreased since the mid-1960s among men, and since the mid-1980s among women. In 1995, the number of all smoking-attributed deaths among women was approximately one tenth of the deaths among men, but the gap in smoking-related deaths between men and women has constantly narrowed from 1975 onward. After 1975, ischemic heart disease mortality has more than halved in the population 35 to 64 years of age, mostly among men.
Occupational exposure to environmental tobacco smoke started to decline in the late 1980s and was accelerated by the 1994 Tobacco Act reform.\textsuperscript{8,9} Many large workplaces completely banned smoking indoors. The most recent revision of the Tobacco Act was enforced in 2000. It classified environmental tobacco smoke as a carcinogen and restricted smoking in the restaurants.\textsuperscript{10}

Few studies have been published on the effects of comprehensive national or state-wide tobacco control legislation. However, studies available on tobacco control programs in the United States and New Zealand have shown a significant reduction in smoking prevalence and tobacco consumption.\textsuperscript{11–13} These programs have comprised several tobacco control measures including a tobacco advertising ban, a price policy, appropriations for smoking prevention, and restrictions on smoking in public places and workplaces.

Since the 1950s, smoking has been established as a cause of lung cancer. In 1954, Doll and Hill\textsuperscript{14} published their first large study on the mortality of British doctors in relation to their smoking habits. The epidemiologic evidence on smoking and lung cancer was already extensive in 1964 when the report of the US Surgeon General, also known as the Terry report, was published. The report included > 7,000 available articles on smoking and its harmful effects on health. A multitude of later studies and reports have confirmed the earlier findings on the serious health consequences of smoking, including lung cancer.\textsuperscript{15}

In the present article, we studied statistically the relation between smoking prevalence and lung cancer incidence as well as respiratory disease mortality. We then analyzed whether the implementation of national tobacco control legislation had an impact on the prevalence of smoking, and thereby, on the occurrence of smoking-related lung diseases.

**Materials and Methods**

Smoking prevalence figures for the period 1960 to 1977 were obtained from surveys by Suomen Gallup plc,\textsuperscript{16} and for the period 1978 to 2000 from the annual surveys conducted by the National Public Health Institute.\textsuperscript{3,5} The surveys performed from 1960 to 1973 have smoking prevalence information listed only by gender, whereas the surveys from 1974 to 1977 have ample background information on the respondents including age, occupation, length of education, income, and place of residence. There are no data available on sample sizes and the exact number of surveys performed before 1978. From 1978 on, the sample size has been 5,000 persons. Until 1974, the respondents were asked “Do you usually smoke?” and smoking prevalence was determined by a simple “yes” answer to the question. From 1974 on, answers to the question inquiring about smoking included alternatives such as “I smoke regularly” and “I smoke irregularly,” and smoking prevalence was determined by a “yes” answer to the first alternative. No sudden change in the results was noticed between 1973 and 1974, when the question was changed.

Lung cancer incidence rates (from 1980 to 2000) were available at the Finnish Cancer Registry.\textsuperscript{17} National law determines the Finnish Cancer Registry as a sole entity to collect information on cancer cases in Finland. All the doctors and hospitals are required to report the cancer cases to the Registry. Mortality data (from 1970 to 2000) on respiratory diseases were published by Statistics Finland,\textsuperscript{7} which is the national body for the registering of data on mortality.

To test time trends, we applied a statistical (Gaussian) model for smoking prevalence. As predictors, we entered an indicator signifying the year (1976) in which the Tobacco Act was passed, a second-degree polynomial for calendar year to represent the annual trend, and their product term to test whether the trends before and after 1976 were different. The analysis of deviance\textsuperscript{18} (ie, testing the statistical significance of the deviance between observed values and those predicted by the model) produced $\chi^2$ test statistics, which were used for testing the significance of the predictor terms. The modeling was done separately for men and women because of the interaction by sex. To study statistically the relation of lung cancer incidence and respiratory disease mortality to smoking prevalence, we applied a log-linear (Poisson) model to the aggregate data (S-Plus system; MathSoft Inc; Seattle, WA).\textsuperscript{19} Description of and justification for using the Poisson regression for time series in epidemiologic studies have been given.\textsuperscript{20,21} We also allowed for a 20-year time delay for lung cancer incidence\textsuperscript{22} and respiratory disease mortality. The model fitted to the data very well, as judged from the residual deviance measures (ie, no overdispersion or heteroscedasticity). Smoking disease relations were depicted as scattergrams with a fitted smooth (spline) regression function.\textsuperscript{18} The quantification of the studied relations was performed in terms of statistical significance ($p$ value) because there are no natural measures of the effect size for trend tests.

**Results**

To analyze the time trends, the following predictor terms were entered in the model for men: the intercept (the mean prevalence); an indicator variate for the year when the Tobacco Act was passed (1976); a linear and quadratic polynomial term for the calendar year; and an interaction (product) term for the indicator and the polynomial terms. The proportion of daily smokers among Finnish men declined monotonously from 58 to 32\% between 1960 and 1983, after which the decline slowed down (Fig 1). In the statistical modeling (Table 1), the time trends (polynomial terms) were statistically significant. (Note that in large population groups even a small difference becomes statistically significant, whereas in small samples a clinically significant observation can remain statistically nonsignificant. Causal inference is not statistical in nature, rather it strives to provide scientific explanations or criticisms of proposed explanations that would describe the observed data pattern. A finding may not be medically important, or a causal hypothesis may even not be true, even if a study shows a significant $p$ value.\textsuperscript{23}) This declining development was statistically associ-
ated with the lung cancer incidence 20 years later (p < 0.001) [Fig 2] and explained most of the variance in the incidence (\( r^2 = 0.947 \)) [Fig 3].

The test of the main hypothesis, that the smoking prevalence was not different before and after the tobacco control legislation was enacted (i.e., the “null” hypothesis that the indicator variate equals zero), was statistically significant (p = 0.006), but the direction of the change in the smoking prevalence ran counter to our “alternative” hypothesis. Moreover, the shape of the smoking prevalence curve before 1976 was different (steeper) from that after the year of enactment (interaction term).

From 1960 to 1973, the prevalence of smoking for women increased from approximately 12 to 20%. After the introduction of the Tobacco Act bill in 1975, the increase stopped, and prevalence decreased slightly. In the late 1980s, female smoking prevalence increased again to remain at a plateau of 20% from 1997 to 2000. In the statistical modeling (Table 2), the time trends (polynomial terms) were both highly significant. Paralleling this temporal development, the lung cancer incidence in women rose linearly throughout the study period (p < 0.001), but the gradient of increase was only positive in the period from around 1960 to 1975 and from 1985 to 1990. For women, the effect of the Tobacco Act (the indicator variate) reached statistical significance (p = 0.012), and, importantly, the effect was to lower smoking prevalence temporarily. The analysis indicated that the increase in lung cancer incidence was significantly associated with the smoking prevalence 20 years previously (p < 0.001) [Fig 2], and the correlation was high (\( r^2 = 0.642 \)) [Fig 3].

Concurrently with the reduction of lung cancer incidence among men, male mortality from respiratory diseases declined steeply (p < 0.001) [Fig 4].

Table 1—Regression Analysis for the Smoking Prevalence of Men

<table>
<thead>
<tr>
<th>Model Term</th>
<th>Regression Coefficient</th>
<th>SE</th>
<th>t Test</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>22.88</td>
<td>4.80</td>
<td>4.77</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Year (linear term)</td>
<td>-179.06</td>
<td>33.34</td>
<td>-5.37</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Year (quadratic term)</td>
<td>-35.45</td>
<td>14.45</td>
<td>-2.45</td>
<td>0.019</td>
</tr>
<tr>
<td>Tobacco Act (indicator term)</td>
<td>14.37</td>
<td>4.99</td>
<td>2.88</td>
<td>0.0062</td>
</tr>
<tr>
<td>Year (linear) ( \times ) Tobacco Act</td>
<td>136.74</td>
<td>34.92</td>
<td>3.92</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Year (quadratic) ( \times ) Tobacco Act</td>
<td>44.00</td>
<td>15.68</td>
<td>2.81</td>
<td>0.0076</td>
</tr>
</tbody>
</table>
Figure 2. The incidence rate (per 100,000 people) of lung cancer among Finnish men and women from 1965 through 2000.

Figure 3. The incidence rate (per 100,000 people) of lung cancer among Finnish men from 1980 through 2000 vs the prevalence of smoking with a 20-year lag time.
The latter reduction was statistically related to the declining smoking prevalence 20 years previously (p < 0.001) \( r^2 = 0.732 \). A slight downward slope in smoking prevalence was also found for women, but the trend was not statistically significant.

**Discussion**

In the Finnish statistics that were studied, lung cancer incidence and mortality from respiratory diseases declined with the decreasing prevalence of smoking among men. The occurrence of these diseases from 1980 to 2000 were related to smoking prevalence 20 years earlier (ie, from 1960 to 1980), a period that includes the year 1976, in which the Tobacco Act was passed by parliament. These data permitted an examination of the relationship between the factors noted above.

The analysis indicated that there was a change in smoking prevalence among both men and women in the 10-year period from 1976 to 1985. After the introduction of the Tobacco Act, the decrease in male smoking prevalence continued without change, but in the mid-1980s it slowed down. After the prevalence among men had decreased to near 30%, the declining trend did not continue at the same rate. In the mid-1970s, at the time of the introduction of the Tobacco Act bill in parliament, the rate of increase in female smoking prevalence first ceased and then slightly decreased. Male lung cancer incidence has decreased almost linearly since the mid-1970s, as shown in Figure 2. Among women, the increase in lung cancer slowed down in the 1980s.

The impact of the Tobacco Act on smoking prevalence cannot be explained by any single element of the law, which includes various measures. Although the law did not include any specific regulations on tobacco taxes, there was a considerable cigarette price increase before the enforcement of the Tobacco Act. The introduction of the Tobacco Act between 1975 and 1976 was accompanied by massive antismoking campaigns and other publicity, and the demand for cigarettes fell permanently by 7%. The

**Table 2—Regression Analysis for Smoking Prevalence of Women**

<table>
<thead>
<tr>
<th>Model Term</th>
<th>Regression Coefficient</th>
<th>SE</th>
<th>t Test</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>19.46</td>
<td>0.61</td>
<td>31.83</td>
<td>&lt; 0.001</td>
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<tr>
<td>Year (linear term)</td>
<td>20.70</td>
<td>3.00</td>
<td>6.91</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Year (quadratic term)</td>
<td>-6.79</td>
<td>1.59</td>
<td>-4.27</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Tobacco Act (indicator term)</td>
<td>-2.53</td>
<td>0.97</td>
<td>-2.62</td>
<td>0.012</td>
</tr>
</tbody>
</table>

![Respiratory Disease Mortality in Finland](image-url)
extra fall in tobacco consumption was interpreted as a reflection of a combined shock effect caused by price increases for tobacco and the introduction of the strictly restrictive Tobacco Act.24

The increase in female smoking prevalence started to level off as early as 1975, when the bill for the Tobacco Act was introduced. This effect was maintained until around the mid-1980s, suggesting that the effect of legislation was largest just after the introduction of the Tobacco Act. This is consistent with earlier findings.24 Among men, the decline in smoking prevalence continued until 1984, and thereafter it slowed down. In the 1960s, the health hazards of smoking were the subject of a lively debate in Finland following the publication of the Terry report in 1964. A similar debate preceded the passing of the Tobacco Act bill in 1976. Both of these events seem to have suppressed tobacco smoking.24

Few data are available for the assessment of how significant each different component of the Tobacco Act has been in reducing smoking prevalence. However, some insufficiency has been reported in the overall implementation of the Tobacco Act.25 In particular, the advertising ban did not work fully as intended. Although direct advertising ceased almost entirely, the indirect advertising increased.26 The appropriation of funds for antitobacco activities appeared to be too small to have a substantial impact on smoking prevalence. Moreover, a part of the appropriation of funds was later directed to health-promotion activities other than smoking prevention.29 Although the Tobacco Act was supported by an effective price policy in the beginning, things soon changed, and in the 1980s the price policy was more contradictory to the legislation than supportive of it. The restrictions on smoking on public premises were well-received, and no difficulties were encountered in their implementation.27

Many factors contributed to the reductions in smoking prevalence in Finland between 1960 and 2000. However, our data have shown that the leveling off of the increase in smoking prevalence in women from 1975 to 1986 was associated with the passage of the Tobacco Act. This reduction in smoking prevalence in turn was associated with a later reduction in lung cancer incidence. Most importantly, the results of the present study show very clearly the dramatically strong association between smoking prevalence and the occurrence of lung cancer and respiratory diseases. This correlation can be seen in both genders, but among men the change is more conspicuous due to the large reduction in male smoking prevalence between 1960 and 2000.

ACKNOWLEDGMENT: The authors thank Kristian Taskinen, MSc, and Lotta Autio, MD, for their help in the collection and processing of the data. We also thank Taula Nurminen for her advice in the statistical modeling.

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