TESTIMONY TO THE UNITED STATES SENATE COMMITTEE ON COMMERCE, SCIENCE AND TRANSPORTATION

Accuracy of the FTC Tar and Nicotine Rating System

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Introduction and Background

Mr. Chairman and Committee members, thank for you the opportunity to address the Committee on Commerce, Science, and Transportation on the matter of the accuracy of the FTC tar and nicotine rating system. This is an important public health issue, not only for the United States, but for the approximately 1.3 billion smokers in other countries. In my testimony I will speak to whether the FTC ratings and tobacco industry cigarette brand labels that have an implicit basis in them, e.g., "light" and "ultralight", have any implications for the serious risks to health caused by cigarette smoking.

In speaking to this topic, I draw on several decades of relevant research experience as well as my participation in developing a number of the major reports that have considered the FTC ratings and the implications of tar and nicotine yields for risks to health. My professional background and training is in internal medicine and the subspecialty of pulmonary diseases and in epidemiology, the scientific method used to study the health of populations. I have carried out research that examined if risks for lung diseases, including lung cancer, are associated with type of cigarette smoked and tar yield. My studies have also assessed whether levels of biomarkers of tobacco smoke exposure, particularly cotinine (the major nicotine metabolite) vary with the yield and type of cigarette smoked.

Additionally, I was a contributor to Monograph 13 of the National Cancer Institute, published in 2001, which addressed the implications of lower-yield products, as measured by machine, for human health. I was Senior Scientific Editor for the 2004 Report of the Surgeon General on active smoking and Chair of the Working Group of the International Agency for Research on Cancer (IARC) of the World Health Organization

that developed Monograph 83, *Tobacco Smoke and Involuntary Smoking*, published in 2004 . These reports also considered the information about risks provided by cigarette yield. In the Department of Justice lawsuit against the tobacco industry (*United States v. Philip Morris*), I also testified on this topic.

There is consensus that a lower machine yield has no health benefit.

The attached table provides the summary findings of the key recent reports on the topic including those prepared by the National Cancer Institute (1), the Institute of Medicine (2), the Surgeon General (3), and the International Agency for Research on Cancer (4) (Table 1). Each of these reports was developed by a multidisciplinary group of experts who evaluated the relevant evidence. There is clear consensus in their findings: machine-measured yields of tar and nicotine are not informative with regard to risks to health of smoking cigarettes; lower yields do not imply lesser health risks. As a major finding, the 2004 report of the Surgeon General states (p. 25): "Smoking cigarettes with lower machine-measured yields of tar and nicotine provides no clear benefit to health."

Epidemiological studies provide no evidence that lower yields have health benefits.

Much of the scientific evidence leading to this consensus comes from epidemiological studies. FTC reports and other information document a substantial decline since the 1950s in machine-measured tar and nicotine yields of cigarettes smoked in the United States (Figure 1). Epidemiologists have carried out research to determine whether this decline has had any consequences for risks to the health of smokers. A

substantial benefit might if anticipated, if health risks tracked with machine-measured yields.

The relevant evidence on the risk of lower tar products has been growing, but this is a difficult topic for researchers. Investigating the consequences of modifications in cigarettes is difficult because cigarettes have been changing continually over time, so that comparisons cannot be made between groups that have smoked the same cigarettes throughout their entire lives. People who started smoking in the 1950s then moved on to the cigarettes of the 1960s and 1970s, for example, if they continued to smoke. In spite of these methodological complications, epidemiological studies would be able to detect changes in risk of a magnitude that matched the changes in yields (Figure 1).

The available epidemiological evidence comes from three sources: 1) comparisons of changes in mortality rates for lung cancer and other diseases over time in relation to changes in products used by smokers; 2) case-control studies comparing disease risks in smokers of different types of products; and 3) cohort studies that have tracked smokers over substantial periods of time, as with the study of British physicians in progress from 1951 through 2001, or that have been conducted serially, as with the two very large epidemiological studies carried out by the American Cancer Society and known as Cancer Prevention Studies I and II, or CPS I and CPS II. The relevant evidence is not extensive and not fully consistent across the three sources. There is also evidence from studies that have involved measurements of levels of cigarette smoke components in biological samples from smokers of different types of cigarettes.

Several case-control and cohort studies have shown small reductions in risk, on the order of 20% for lung cancer, comparing smokers of filter cigarettes with smokers of

non-filter cigarettes. These were largely early epidemiological studies, carried out in the 1960s and 1970s; the comparison at the time was largely between smokers of non-filtered and filtered cigarettes. Several reports have commented on these early findings (Table 1). The relevance of these findings to current cigarettes is uncertain. In general, epidemiological studies show that tar yield of the cigarettes smoked is only a weak predictor of lung cancer risk after taking account of other aspects of the smoking history.

Some have interpreted the rapid decline in lung cancer mortality in younger males in the United Kingdom during the last decades of the 20th century as indicating a benefit of the changing cigarette. Sir Richard Peto at Oxford has proposed that the decline in lung cancer rates in the United Kingdom was too great to be explained by dropping smoking rates alone and has argued that changes in cigarettes over time also contributed to the decline. However, data from major cohort studies that cover the same time period--the British Physicians' study, and CPS I and II indicate rising relative risks of lung cancer over time in smokers generally. If the changes in cigarette yields had any benefit we would expect these relative risks to be dropping. Instead, they have risen.

Some of the most compelling evidence is from the American Cancer Society's Cancer Prevention Studies. The data from these studies show that regardless of how cigarettes changed, for smokers in CPS I (1959-1972) versus those in CPS II (1980-1986), relative risks of lung cancer (and other diseases) went up (Table 2). Over the time interval separating these two studies, there was a substantial drop in the tar and nicotine yields of the cigarettes that were smoked in the United States (Figure 1). In fact, in more detailed analyses of the data that have been published, the mortality rates from lung cancer tend to be higher within categories defined by the numbers of cigarettes smoked

and the number of years of smoking, comparing the second study with the first (5;6). This pattern of higher risks in CPS II suggests an increase in the risk of smoking over time, comparing similar groups of smokers in CPS I and CPS II.

Also relevant are analyses of the data from the British Doctors' Study which compared risks in the first and second halves of the study after 40 years of follow-up (7). The comparison shows that the relative risk values went up comparing the first 20 years (1951-1971) to the second 20 years (1972-1991). The paper on the 50-year follow-up described progressively increasing risks for mortality among smokers over the five decades of follow-up (8). Even looking back at the older studies that found small reductions in relative risks at one particular point in time, comparing filter to non-filter cigarette use, these studies did not track how risks changed over time as more and more smokers were smoking cigarettes with lower FTC tar and nicotine yields and the sales-weighted tar and nicotine yields declined progressively (Figure 1).

While the epidemiological studies have emphasized smoking and lung cancer, findings have been generally similar for the other major diseases caused by cigarette smoking. With respect to heart disease and chronic obstructive pulmonary disease (COPD), the evidence has also consistently shown that smokers who use lower tar products obtain no benefit at all in terms of reducing their risk of acquiring these two diseases. The findings from the comparison of CPS I and CPS II are similar to those for lung cancer (see Table 2). Risks for all the major diseases caused by smoking increased in CPS II.

It is important to consider a possible additional risk to health posed by the use of low yield products: the 2004 Surgeon General's Report noted the rise in adenocarcinoma,

among the major types of lung cancer. One remarkable change in the epidemiological characteristics of lung cancer over the last 40 years approximately has been a shift in the predominant type of lung cancer. At the beginning of the epidemic of tobacco-caused lung cancer, the leading histologic type was squamous cell carcinoma, which characteristically involves the larger and more central airways of the lung. Since the late 1960s, there has been a shift so that adenocarcinoma is now the most common in both men and women. Interestingly, adenocarcinomas tend to occur more peripherally in the lung, arising from the smaller airways. One hypothesis is that changes in the cigarette have lead to deeper inhalation with a pattern of deposition of carcinogens in the lung that differed from that typically occurring with the older, higher-yield products (9;10). Some have also suggested that the mix of carcinogens in tobacco smoke may have changed, perhaps with greater concentrations of tobacco-specific nitrosamines, which cause adenocarcinoma in exposed animals.

Biomarker studies show no association of machine-measured yield with levels of smoke components in the bodies of smokers.

Researchers have studied the relationship between the FTC measurements, that is, tar and nicotine yields as reported from the FTC method, and the levels of tar components and nicotine actually entering into the bodies of smokers. Biomarker is a general term for compounds that can be measured in a biological material. With regard to cigarette smoking, we measure these biomarkers as quantitative indicators of how much a person has smoked, and of the amount of biological materials reaching the lungs, and then getting into the bloodstream.

Using these methods, researchers have explored the relationship between the FTC-yield measurements and the levels of biomarkers in smokers. If the FTC measurements are providing meaningful information, the levels of biomarkers should track with the measured yields. A number of studies have used biomarkers of dose for specific tobacco smoke components, including carboxy-hemoglobin (hemoglobin bound to carbon monoxide rather than to oxygen) and cotinine (a metabolite specific to the breakdown of nicotine).

In general, research using these biomarkers has indicated little, if any, correlation between the FTC-yield of tar or nicotine, and the levels of the biomarkers measured in smokers. These studies have been conducted both in the population context and in laboratory settings. For example, in a study that my group conducted in New Mexico (11), we collected saliva for the analysis of cotinine levels, and breath samples for measurement of carbon monoxide levels in a population survey sample of Hispanic persons. After taking account of the numbers of cigarettes smoked, the levels of biomarkers were not associated with the yields of tar and nicotine of the current brand of cigarette. Another study (12) evaluated smoking patterns and biomarkers in the laboratory setting, contrasting smokers of medium-yield and low-yield cigarettes. The smokers had greater puff volumes and puff frequencies than are specified in the FTC protocol and had substantially greater intakes of tar and nicotine than those implied by the brand yield listings. More recently, we measured the cotinine level in saliva samples from smokers in four countries (Brazil, China, Mexico, and Poland) (13). Cotinine concentration per cigarette smoked did not differ between smokers of light and regular cigarettes (Figure 2). Figure 2 shows the data for each country with two curves for

country, one showing the cotinine level for smokers of regular cigarettes and the other for smokers of light cigarettes. The curves are essentially identical in each of the countries.

These and other results suggest that there is little difference in the levels of biomarkers comparing smokers of higher yield tar/nicotine cigarettes and lower yield tar/nicotine cigarettes, as measured by the FTC method. This finding implies that doses of carcinogens or other toxic materials that smokers inhale have little relationship, if any, to the FTC tar yield. This finding further implies that the gradual reduction in tar yield over the past several decades has not resulted in a reduction in smokers' exposure to carcinogens and other toxic agents, and that the FTC test method is not informative with respect to lung cancer risk or to the risks of smoking-caused diseases generally.

There are several explanations for this lack of correlation. First, the smoking pattern of the machine is not representative of how people smoke; in other words, the machine does not smoke like a person, or even the average person. It uses a pattern of puffing that is based on very old information. Second, the ventilation holes in the filter, which are not covered when the end of the cigarette is inserted into the machine, are generally covered by smokers as they hold the cigarette and puff. Third, smokers tend to compensate for the reduced yield of nicotine by increasing the volume of puffs (that is, the volume of smoke they pull into their mouths), the number of puffs per cigarette, and the number of cigarettes smoked. This compensation is not replicated by the test machine. In this manner, smoking cigarettes produces similar levels of biomarkers, regardless of whether the cigarettes smoked are labeled as "Low Tar" or "Low Nicotine."

Summary and Overall Conclusions

Beginning in the 1950s, following the initial epidemiological studies showing very strong associations of smoking with risk for lung cancer and other diseases, the tobacco industry has continually altered cigarettes, adding filters and making other changes that have led to reduced yields of tar and nicotine as measured by a machine (Figure 1). Both epidemiological studies and evidence from studies using biomarkers show no parallel changes in risks for the major smoking-caused diseases. All recent authoritative reports, developed by multidisciplinary teams of experts, have concluded that there is no indication of benefit to the health of smokers from smoking lower yield products. The FTC tar and nicotine ratings provide no meaningful information about risks to smokers. The numbers provided are potentially misleading to smokers, as are product labels that attempt to convey messages based on yield.

Table 1. Summary findings of the key reports on machine-measured cigarette yields and health

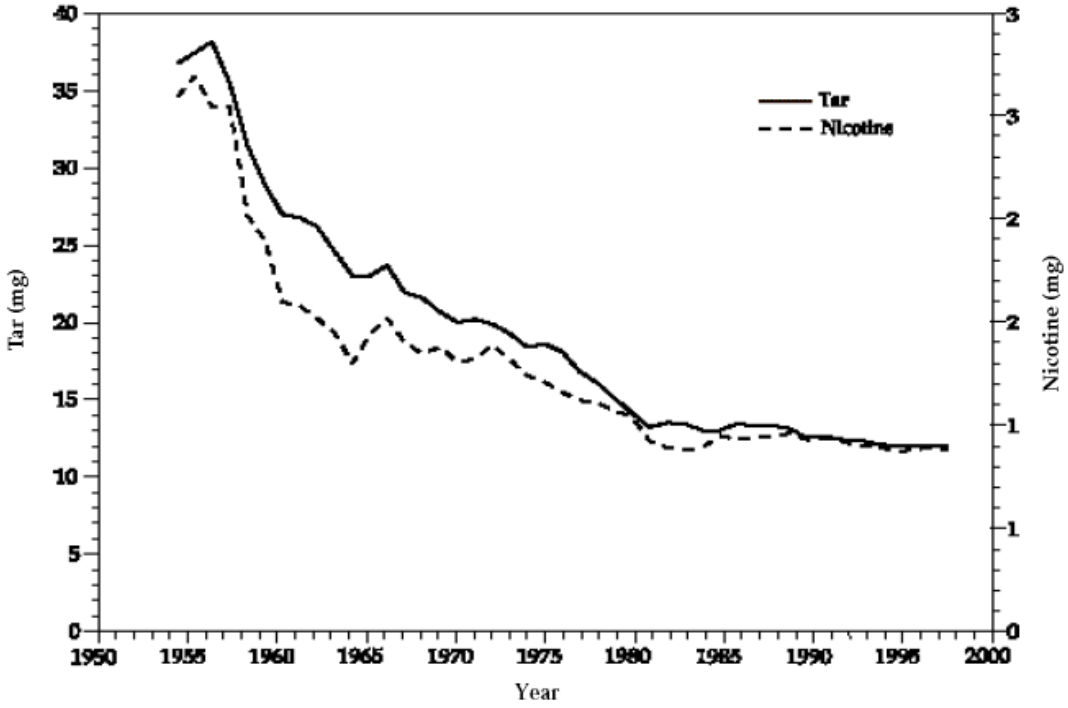
Report and Conclusion	Page number	Year
NCI Smoking and Tobacco Control Monograph 13 (1)		**2001**
"Epidemiological and other scientific evidence, including patterns of mortality from smoking-caused diseases, does not indicate a benefit to public health fro changes in cigarette design and manufacturing over the last fifty years."	p. 10	
"Widespread adoption of lower yield cigarettes by smokers in the United States has not prevented the sustained increase in lung cancer among older smokers."	p. 10	
"Measurements of tar and nicotine yields using the FTC method do not offer smokers meaningful information on the amount of tar and nicotine they will receive from a cigarette. The measurements also do not offer meaningful information on the relative amounts of tar and nicotine exposure likely to be received from smoking different brands of cigarettes."	p. 10	
"Epidemiological studies have not consistently found lesser risk of diseases, other than lung cancer, among smokers of reduced yield cigarettes. Some studies have found lesser risks of lung cancer among smokers of reduced yield cigarettes. Some or all of this reduction in lung cancer risk may reflect differing characteristics of smokers of reduced-yield compared to higher-yield cigarettes."	p. 146	
"There is no convincing evidence that changes in cigarette design between 1950 and the mid 1980s have resulted in an important decrease in the disease burden caused by cigarette use either for smokers as a group or for the whole population."	p. 146	
Clearing the Smoke: Assessing the Science Base for Tobacco Harm Reduction, Institute of Medicine (2)		**2001**
"Most current assessments of morbidity and mortality suggest that low-yield products are associated with far less health benefit, if any, than would be predicted based on estimates of reduced toxic exposure using FTC yields."	p. 2	
"The weight of the evidence indicates that lower-tar and nicotine yield cigarettes have not reduced the risk of disease proportional to their FTC yields, in part because smokers compensate to obtain more nicotine and in part because the products themselves contain higher concentrations of selected carcinogens."	p. 67	
"There is no evidence of a threshold for tobacco smoking and cancer risk. This conclusion is consistent with the knowledge that there are many carcinogens in tobacco smoke, the aggregate would work to increase risk at any level. Modeling for low-dose indicates increased risk with less than one cigarette per day. Thus persons who initiate smoking with PREPS that contain tobacco would increase their risk for cancer, and there is unlikely	p. 431	

to be a “safe” cigarette. Former smokers who resume smoking with such products would increase their risk further.”		
“The available data are suggestive, but not sufficient, to conclude that smokers of so-called low-tar cigarettes have lower cancer risk compared to those who smoke higher tar cigarettes, with the same caveats as for filter smoking studies.”	p. 432	
IARC Monograph 83, Tobacco smoke and involuntary smoking (4)		**2004**
“….after considering the limitations of the evidence, the Working Group concluded that changes in cigarettes since the 1950s have probably tended to reduce the risk for lung cancer associated with the smoking of particular numbers of cigarettes at particular ages.”	p. 171	
“The yields of tar, nicotine and carbon monoxide from cigarettes, as measured by standard machine-smoking tests, have fallen over recent decades in cigarettes sold in most parts of the world, but have remained higher in some countries. The tar and nicotine yields as currently measured are misleading and have only little value in the assessment of human exposure to carcinogens.”	p. 1179 (Summary)	
The Health Consequences of Smoking: A Report of the Surgeon General (3)	p. 25	**2004**
“Smoking cigarettes with lower machine-measured yields of tar and nicotine provides no clear benefit to health.”		

Table 2. Changes in cigarette-related mortality risks between Cancer Prevention Study 1 (1959 through 1965) and Cancer Prevention Study II (1982 through 1988) and percentage of deaths attributable to active cigarette smoking. Source: (14)

	CPS I		CPS II	
	Males			
	Relative Risk	Percent	Relative Risk	Percent
Overall Mortality	1.7	42.2	2.3	57.1
Lung Cancer	11.9	91.6	23.2	95.7
Coronary Heart Disease	1.7	41.5	1.9	46.2
Chronic Obstructive Pulmonary Disease	9.3	89.2	11.7	91.4
Stroke	1.3	21.9	1.9	46.8
Other Smoking Related Cancers	2.7	63.4	3.5	71.2
	Females			
Overall Mortality	1.2	18.7	1.9	47.9
Lung Cancer	2.7	63.4	12.8	92.2
Coronary Heart Disease	1.4	27.0	1.8	45.1
Chronic Obstructive Pulmonary Disease	6.7	85.0	12.8	92.2
Stroke	1.2	15.2	1.8	45.7
Other Smoking Related Cancers[a]	1.8	45.0	2.6	60.8

[a] Sites include larynx, oral cavity, esophagus, bladder, kidney, other urinary, and pancreas.



*Values before 1968 are estimated from available data.

Figure 1. Sales weighted average tar and nicotine deliveries, US, 1953-1993 Source: (15).

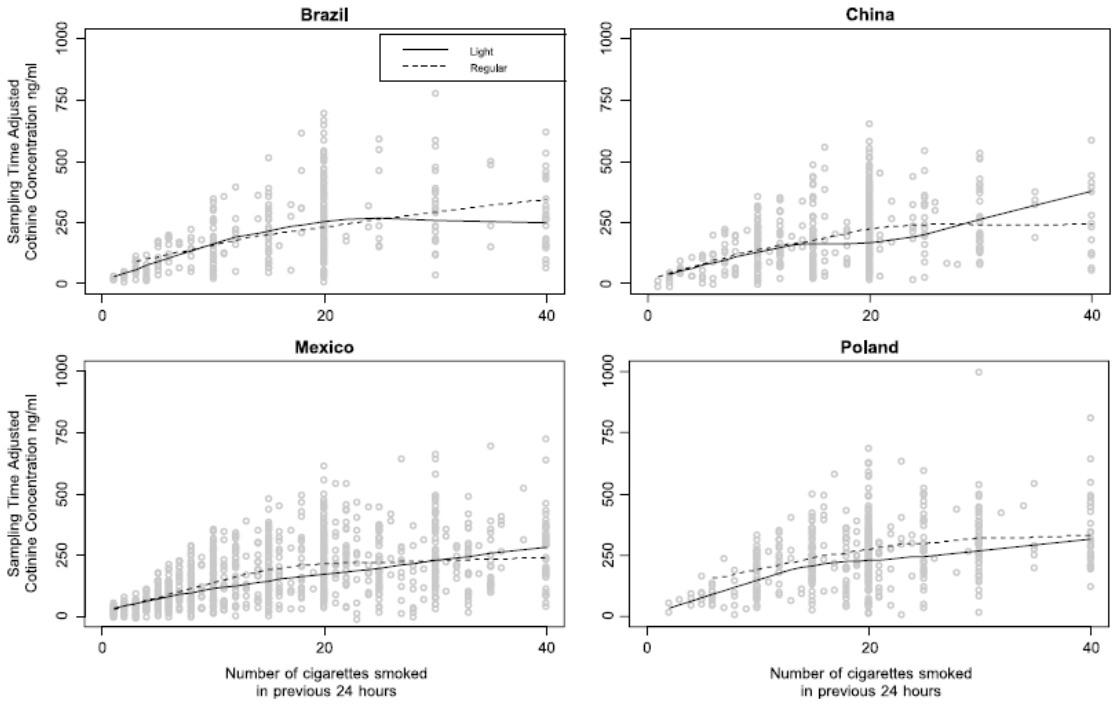


Figure 2. Scatter plots of time-adjusted cotinine concentration (ng/mL) and number of cigarettes smoked in the previous 24 hours by country with LOESS smoothers by type of cigarette. Source: (13).

Reference List

(1) US Department of Health and Human Services (USDHHS), National Cancer Institute. Risks associated with smoking cigarettes with low machine-measured yields of tar and nicotine. Bethesda, MD: National Institutes of Health, 2001.

(2) Stratton K, Shetty P, Wallace R, Bondurant S, eds. Clearing the smoke: assessing the science base for tobacco harm reduction. Washington,D.C.: National Academy Press, 2001.

(3) US Department of Health and Human Services (USDHHS). The health effects of active smoking: A report of the Surgeon General. 2004. Washington, D.C., U.S. Government Printing Office.

(4) International Agency for Research on Cancer (IARC). Tobacco smoke and involuntary smoking. IARC monograph 83. 2004. Lyon, France, International Agency for Research on Cancer.

(5) US Department of Health and Human Services (USDHHS), Public Health Service, National Cancer Institute (NCI). Changes in cigarette-related disease risks and their implication for prevention and control. Burns DM, Garfinkel L, Samet JM, editors. [8]. 1997. Bethesda, Maryland, U.S. Government Printing Office (NIH Publication No. 97-4213). Smoking and Tobacco Control Monograph.

(6) Thun MJ, Heath CW, Jr. Changes in mortality from smoking in two American Cancer Society prospective studies since 1959. *Prev Med* 1997; 26(4):422-426.

(7) Doll R, Peto R, Wheatley K, Gray R, Sutherland I. Mortality in relation to smoking: 40 years' observations on male British doctors. *Br Med J* 1994; 309(6959):901-911.

(8) Doll R, Peto R, Boreham J, Sutherland I. Mortality in relation to smoking: 50 years' observations on male British doctors. *Br Med J* 2004; 328(7455):1519-1527.

(9) Alberg AJ, Ford JG, Samet JM. Epidemiology of lung cancer: ACCP evidence-based clinical practice guidelines (2nd edition). *Chest* 2007; 132(3 Suppl):29S-55S.

(10) Thun MJ, Lally CA, Flannery JT, Calle EE, Flanders WD, Heath CW, Jr. Cigarette smoking and changes in the histopathology of lung cancer. *J Natl Cancer Inst* 1997; 89(21):1580-1586.

(11) Coultas DB, Stidley CA, Samet JM. Cigarette yields of tar and nicotine and markers of exposure to tobacco smoke. *Am Rev Respir Dis* 1993; 148(2):435-440.

(12) Djordjevic MV, Stellman SD, Zang E. Doses of nicotine and lung carcinogens delivered to cigarette smokers. *J Natl Cancer Inst* 2000; 92(2):106-111.

(13) Blackford AL, Yang G, Hernandez-Avila M, Przewozniak K, Zatonski W, Figueiredo V et al. Cotinine concentration in smokers from different countries: relationship with amount smoked and cigarette type. *Cancer Epidemiol Biomarkers Prev* 2006; 15(10):1799-1804.

(14) Thun MJ, Day-Lally C, Myers DG, Calle EE, Flanders WD, Zhu B-P et al. Trends in tobacco smoking and mortality from cigarette use in Cancer Prevention Studies I (1959-1965) and II (1982-1988). In: Burns DM, Garfinkel L, Samet JM, editors. Changes in Cigarette Related Disease Risks and Their Implication for Prevention and Control. Bethesda, Maryland: U.S. Government Printing Office, 1997: 305-382.

(15) Hoffmann D, Hoffmann I, El Bayoumy K. The less harmful cigarette: a controversial issue. a tribute to Ernst L. Wynder. *Chem Res Toxicol* 2001; 14(7):767-790.